

# Former Landfill and Disposal Site Investigations

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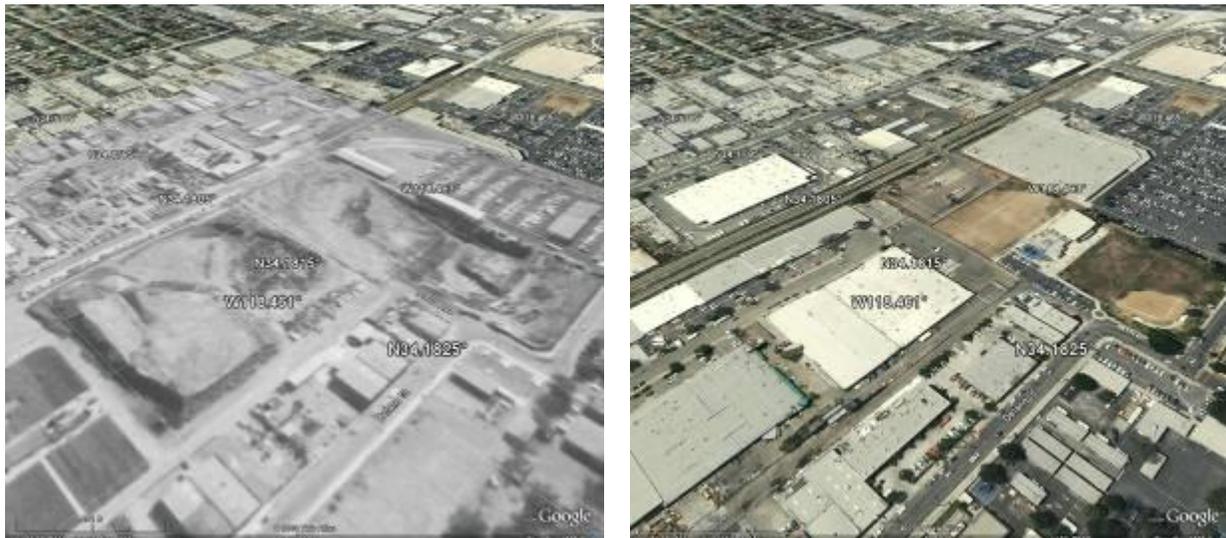


Figure 1: Historical Aerial Photograph Overlay in Google Earth of a Former Landfill in the City of Los Angeles; note Geo-Referencing grid

# Abstract

*Former landfills and disposal sites, particularly undocumented sites in developed areas, can pose several hazards to public health and safety. Explosive or oxygen-deficient conditions can occur when landfill gas migrates through permeable soils into building structures and utility corridors. Landfill settlement may cause unstable conditions for building foundations and utilities. The Closed, Illegal and Abandoned Site program at the Department of Resource Recovery and Recycling (DRRR) provides technical assistance to local public health officials in investigating former landfills and disposal sites. The CIA section has performed several “high-priority” landfill and disposal site investigations in developed areas of California to include Los Angeles, Orange, San Diego, the San Francisco Bay Area and the Sacramento Valley. Several case studies presented in this paper illustrate how investigations were conducted to determine the approximate horizontal and vertical extents of former landfills and disposal sites using historical aerial photographs and mapping software; geophysical methods for non-intrusive delineation of waste extents; and finally intrusive investigation methods including drilling, direct-push and trenching.*

**Key Words:** *Landfill Investigation, Waste Extents Delineation, Historical Aerial Photograph Review, Google Earth Overlay Tool, Geophysical Survey, Intrusive Investigation, Non-intrusive Investigation, Drilling, Trenching, Direct-push, Topographic Drawing, Sample Location Map, Sampling and Analysis Plans, Remedial Work Plans and Remedial Cost Estimates.*

## Introduction

Former landfills and disposal sites can pose public health and safety threats to development occurring on or adjacent to these sites. Some of these threats include explosive or oxygen deficient conditions caused by landfill gas migrating through soils into building structures and utilities; differential settlement of the disposal area causing instability in foundations and structures built over the fill; human or wildlife exposure to potential chemical, biological, radiological and physical hazards of uncovered waste at the site. Landowners and developers may not be aware that a disposal site exists on their property and may purchase properties without understanding the risk posed by former disposal sites and the potential costs or liabilities to remedy these risks. California law holds the current landowner responsible for any threats or nuisance to public health and safety caused by former landfills and disposal sites.

[California regulations \(14 & 27 CCR\)](#) give authority to State and Local agencies to enforce minimum standards for former landfills and disposal sites, where a threat to public health and safety exists. Some of these standards include covering and maintaining disposal areas to prevent public contact, and [monitoring and controlling landfill gas migration](#) to protect public health and safety from explosion hazards associated with landfill gas. Other standards may include securing sites to prevent trespassing and illegal disposal and controlling drainage and erosion of cover soils to

prevent waste exposure and surface water infiltration into the disposal site. These standards are minimum standards designed to protect public health and safety from the contents of former landfills and disposal sites, which did not have federal and state final closure and financial assurance requirements until 1989, when state and federal regulations were promulgated that addressed final closure of landfills and disposal sites to protect public health and safety.

A well-planned and coordinated disposal site investigation is necessary to determine the scope of work and costs for potential actions taken to remedy site conditions. ***One of the most important objectives of any landfill investigation is to determine the horizontal and vertical extent of waste.*** Determining the physical extents of waste allows regulators, consultants, attorneys and responsible parties to:

- Determine properties impacted by the waste disposal area
- Study and consider different remedial options and their costs
- Estimate a volume of waste and determine costs to clean-close the disposal site
- Estimate the areal extent of the disposal site to determine soil-capping (cover) costs
- Locate perimeter gas monitoring wells to detect off-site gas migration

The [Closed, Illegal and Abandoned Site program](#) at the California Department of Resource Recovery and Recycling (DRRR), provides technical assistance to local environmental health departments in conducting investigations of former landfills and disposal sites to determine if a threat to public health and safety exists. The CIA program has conducted over thirty investigations of “high-priority” former landfills and disposal sites in cities and counties throughout California to include Los Angeles, San Diego, Orange, the San Francisco Bay area and the Sacramento region. Two key objectives of these investigations is to: determine the approximate horizontal and vertical extents of the disposal site; generally characterize the content of the fill as Resource Conservation and Recovery Act (RCRA) hazardous, California Hazardous or non-hazardous waste, both to determine potential costs for clean-closure and also for appropriate regulatory agency oversight.

Based on practical experience from conducting over 40 former landfill investigations throughout the State of California, the following guidance is suggested:

- Obtain and review historical aerial photographs for the periods prior to disposal, during disposal and during development
- Obtain and review historical operational records and documents, if any are available (as part of Phase I Office Investigation/Site Assessment effort)
- Import historical aerial photograph images into mapping software, e.g. Google Earth to both obtain geo-referencing and check historical aerial photograph indications of disturbance and current property boundaries, structures and landmarks.

- Obtain and review effected assessor parcel maps
- Obtain and review effected property's title history and ownership
- Hire a consultant or surveyor to prepare a current topographic map of the disposal area and vicinity to document observations and findings
- Prepare a sample location map to define the approximate limits of waste based on historical aerial photographs
- Perform an on-site reconnaissance to determine any surface evidence of the disposal area (a magnetometer (metal detector) survey can be used during this reconnaissance)
- Hire a consultant to conduct a geophysical survey of the disposal site area and survey the suspected boundary determined by the historical aerial photograph analysis and the surface reconnaissance; request that the geophysical consultant determine the most effective methods for determining horizontal and areal extent based on site conditions, e.g. physical properties of geology, development and the fill area.
- Update the topographic map with the results of the geophysical survey; delineate potential area(s) of disposal fill
- Prepare and coordinate an intrusive investigation work plan that explores the horizontal and vertical extents of wastes using trenching, drilling or direct-push equipment
- Conduct an intrusive investigation - perform sampling and analysis and document the results of exploration on a topographic drawing for the disposal area which will depict the waste boundary, property lines, structures and other investigation information necessary for remedial scoping and estimating, e.g. in-place fencing, monitoring wells, natural and man-made barriers, existing remedial infrastructure (caps, gas monitoring and controls systems, water monitoring wells, water production wells, survey benchmarks, disposal site observations, etc.)



Figure 2: Former Landfill in Southern California Developed into Golf Course and Residential Land-use

## Purpose of Landfill and Disposal Site Investigations

The purpose of performing landfill and disposal site investigations is to determine a site's conditions with respect to regulatory disposal site state minimum standards for the protection of public health and safety. An investigation should provide the necessary information and field data to develop work scopes and cost estimates for remedial measures needed to bring the site into compliance with state minimum standards, e.g. placement of a remedial cover, construction of drainage and erosion control measures, installation of a gas monitoring network or gas collection and control system, etc. USEPA has published [guidance](#) that establishes investigation information requirements for presumptive remedies for CERCLA landfills.

In 1995, the California Integrated Waste Management Board (CIWMB) undertook an investigation and remediation project for the abandoned Sand City Dump in Monterey California due to site conditions that represented public health and safety issues (exposed waste and burn ash eroding from the dump onto an adjacent sand bluff and public beach). The CIWMB worked with the Monterey Department of Environmental Health, Regional Park District and Waste Management District to investigate the site and propose a remediation to remove the exposed landfill materials and reconfigure and cover the disposal site. The project was required to meet 50-year coastal erosion standards; Highway 1 view shed requirements, CALTRANS and Water district easement restrictions, local grading requirements and Storm Water Pollution Prevention (SWPP) requirements. The investigation included a phase I office investigation that included collection and summary of all previous investigation reports, and a CIWMB directed field investigation, which confirmed previous data (boring logs) on the horizontal and vertical extents of the disposal site. From the field data collected, a remedial work plan was

prepared that would reconfigure the disposal site to meet local and state requirements. A remediation project, costing \$1.1 million was completed in May 1996 which included removing all waste from the bluff adjacent to the site, excavating a 120,000 cubic yard cell, placing and compacting over 100,000 cubic yards of waste materials and placing a 10 foot soil cap over the new cell. The final grading plans included the placement of a dune restoration project and regional bike trail.

## Case Study: Sand City Dump Remediation Project



Figure 3: Photograph of Sand City dump before remediation; note front slope of dump toward public beach which contained rubbish, cans, glass and burned materials; photograph on the right shows completed final grades and wastes removed from front slope.

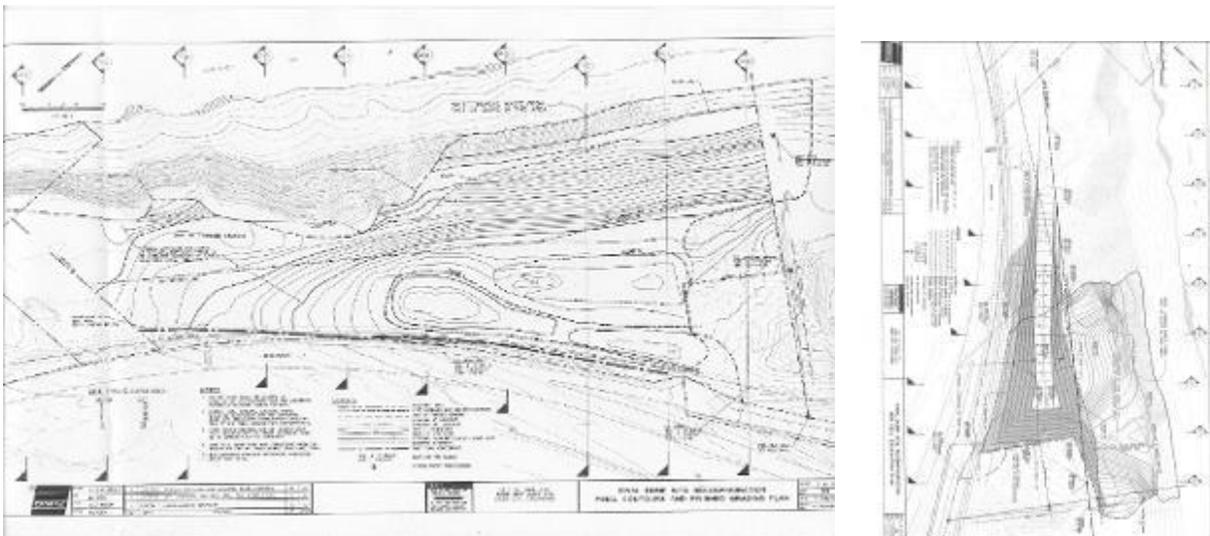


Figure 4: Final Grading Plan for a Disposal Site showing plan view of final topography; second drawing shows plan view of proposed waste cell to hold all reconfigured waste behind a 50-year coastal erosion setback.

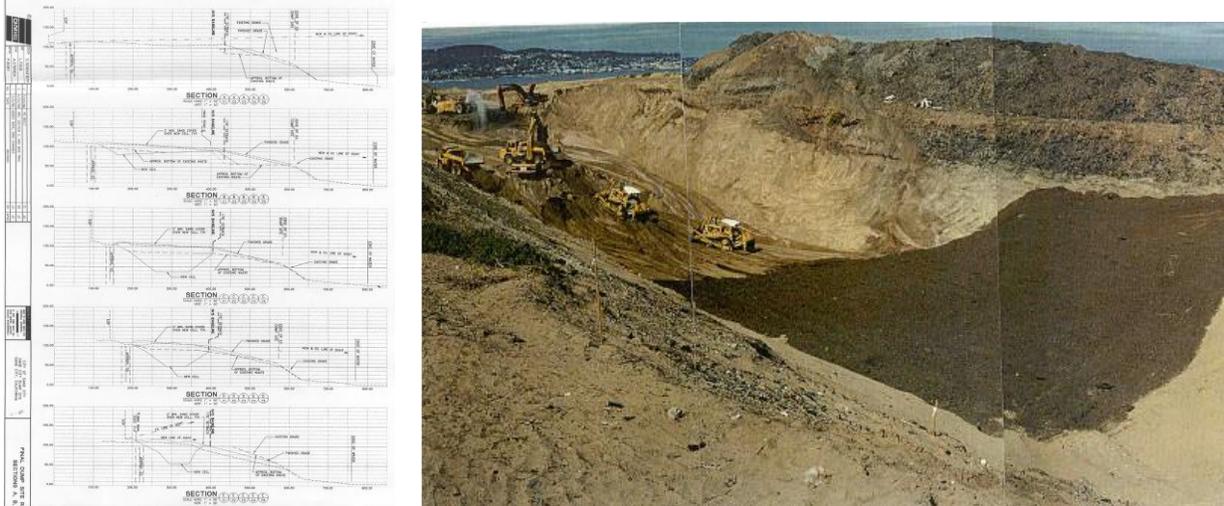


Figure 5: Cross-sections of Existing Waste Fill and Reconfigured Waste Cell; right photo shows waste placement into constructed cell

## Phase I Investigation

Performing a well-planned and coordinated phase I office investigation for a former landfill or disposal site can reduce the scope of work for the phase II field investigation. A Phase I Office investigation should include obtaining:

- Property ownership information to include the assessor parcel number(s), parcel maps, and property deeds or titles from properties where disposal activities occurred (this may be an iterative process if the boundary of waste is unknown);
- Title search for former property owners
- Previous site investigation reports (Air and Water Solid Waste Assessment Tests, Report of Waste Discharge Requirements, Environmental Site Assessments, Site Characterization Reports, Water well testing, Geotechnical Testing, Soils Testing, etc.)
- File reviews from local government agencies with responsibility for land-use and disposal activities, e.g. health department, public works, planning, sanitation district, etc.
- Any operator historical design drawings or operational records, if any exist.
- Historical Aerial Photographs for years prior to, during, and after disposal site operations/activities

- Interviews with property owners and local government agencies (environmental health department, fire department, Water Board, Air District, Solid Waste Management Authorities and/or Districts, Public Works Departments, etc.)

All information collected from the Phase I Investigation should be organized, documented and summarized in a report (or included in the Phase II field investigation work plan); the Phase I report information should support the data quality objectives (purpose) of the Phase II field investigation. The Closed, Illegal and Abandoned Sites Program generally incorporate the Phase II Office Investigation information into the background portion of the Phase II Field Investigation Work Plan. Additional information and on-line resources for Phase I Office Investigations can be found at:

<https://www.calrecycle.ca.gov/SWFacilities/CIA/Office/>

## Historical Aerial Photograph Study

The objective of reviewing historical aerial photos is to develop and document a “maximum” boundary of study for disposal site operations and activities. The “maximum” boundary would represent the maximum areal extent of the disposal operation or activity for subsequent field investigation methods using geophysical survey methods and intrusive investigation methods such as drilling, direct-push or trenching exploration.

Obtaining, reviewing and analyzing historical aerial photographs during a landfill investigation or Phase I Site Assessment Study is one of the most important and cost effective methods for determining the approximate areal (or horizontal) extents of a disposal site operation and can reduce the scope of work for intrusive field investigation work, e.g. using intrusive investigation to close boundary data gaps. A comprehensive and chronologically indexed collection of historical aerial photographs for many developed areas of California beginning as early as the 1920s can be found in University of California Libraries such as [UC Santa Cruz](#), [UC Santa Barbara](#), [UC Berkeley](#), CSU Fullerton, etc. The UC library system can provide aerial photographs for specified locations, dates and resolutions. Aerial photographs can be ordered and purchased as hardcopies and scanned digital copies for a nominal cost, (10 scanned images for \$300-\$500). Resolution of historical aerial photographs for performing an overlay analysis in Google Earth of waste extent boundaries should be one-meter resolution (1-meter object visible on the ground). Higher resolution aerial photography generally can be obtained from National Aerial Photography Program (NAPP) aerial photographs. Most black and white historical aerial photographs shot from the 1920s-1980s for mapping purposes (1:40,000) generally will have a high enough resolution to identify ground features.

The [United States Geological Survey \(USGS\)](#) is also a good source for historical aerial photographs. Private historical aerial photograph collections may be more expensive, but may yield important information or higher resolution photographs for specific years of operations. Aerial photography services may also have historical aerial photograph

collections; however, the location dates and resolution may be limited. Cartwright Aerial, Inc., a Sacramento based Aerial Photography Services business, has a comprehensive collection of historical aerial photographs for the entire state of California.

Web-based on-line resources, such as [HistoricAerials.com](http://HistoricAerials.com), allow historical aerials to be researched using interactive mapping software that can reduce the time and effort of manual searches of historical aerials photographs typically found in libraries.

Prior to obtaining aerial photographs, research should be performed to determine the years of operations for a disposal site; defining the start and end dates of disposal activities, as well as any development on or adjacent to the site are important. If no information is available, generally beginning in the 1920s and reviewing photographs every 5 years may yield approximate dates for significant disposal site operation; however some disposal sites may have been operated less than five years.

In reviewing historical aerial photographs, visual evidence of disposal areas may include, land disturbance, grading and scarification, open excavations (pits and trenches), visible surface debris (piles of rubble (concrete & asphalt), tires or litter, soil and waste stockpiles, windrowing, etc.), heavy equipment, etc. These features are defined by shadows and discoloration from surrounding areas (depending on lighting conditions). Historical aerial photograph reviews should check current landmark features such as roads, trees, waterways, and building structures as location references. This is important when importing unscaled aerial photograph digital images into mapping software, such as Google Earth, and using the overlay function to scale the image to the current view. After adjusting the image to the correct scale, features in the image, such as the boundary areas of the waste can be located by latitude and longitude (known as “georeferencing”).



Figure 6: Historical Aerial Photograph of Former Landfill (Gravel Mining Pit) over-lain (left photo) on recent color aerial photograph (right photo) in Google Earth. By using

the opaqueness function in Google Earth the historical aerial can be manually scaled to coincide with the existing site features (requires that a common landmark feature, e.g. building, street, exists between the historical aerial and the current site conditions). By using the latitude and longitude grid as a reference, historical features can be located with respect to existing features, e.g. streets, structures and landmarks and compared to former disposal site features. In the above left historical photograph, the gravel pit boundaries can be located with respect to the existing commercial structures in the right photograph.

Once the historical aerial photograph review and analysis has been performed, a scaled topographic engineering drawing should be prepared in AutoCAD or other engineering drawing program that will allow notes and other field information to be added to develop a scaled drawing depicting the boundary of the disposal area (s). This drawing can be used to develop remedial work scopes and estimates, e.g. capping and grading, drainage and erosion control improvements, locating gas monitoring network wells, etc. and eventually be included as an exhibit work plans and bid documents

## **Using Google Earth to Analyze Historical Aerial Photographs (and the Overlay Image tool)**

[Google Earth](#) is a powerful on-line digital 3-D cartographic model that allows aerial photographs of the earth's surface to be geo-referenced, e.g. referenced to latitude and longitude. The Google Earth program can be used to perform a variety of cartographic analysis, such as mapping, land surveying, locating GPS coordinates, etc.

In using Google Earth to locate and map former landfills and disposal sites, the [Google Earth Image Overlay tool](#) allows an un-scaled image, such as a historical aerial photograph to be imported, placed and manually scaled over the current Google Earth Aerial Image. By using a “transparency (or opaqueness)” function, a user can locate features from the historical aerial photograph, such as land disturbances, excavations, or other benchmarks on the Google Aerial photograph, which reflects relatively current land-uses.

Once the historical aerial image (generally a .jpg or .bmp file) is imported, overlaid and scaled to the Google Earth Aerial Map, the opaqueness tool (slide-bar) can be used to compare historical and current features. The primary information to be collected from this “interference” analysis is the approximate horizontal extent of the disposal area, the parcels and properties effected (a parcel map can also be imported and overlaid on the Google Earth Map) and location of any structures located on or adjacent to disposal areas. Additional information that can be useful includes pit and excavation boundaries, land-scarification and disturbances, former drainage features, waterways and other topographic features. These features may provide an explanation or understanding of gas migration pathways, water intrusion/moisture conditions, and provide the basis for field investigation objectives or locating intrusive sampling points. This “interference”

analysis can be useful in siting initial locations for landfill gas monitoring wells in native soils outside the landfill or disposal site boundary (requirement of 27 CCR 20925).



Figure 7: Former Landfill (Gravel Mining Pit) with Current Residential and Golf Course Land-use in Los Angeles, CA

## Site Investigation Map Development

A site investigation map can be developed from a USGS Topographic Map and an aerial photograph. A site investigation map will be used to document former landfill boundaries, current land-uses and property ownership, environmental monitoring points, drainage features, topography, and other notes important to the site investigation or documenting a site's conditions with respect to disposal site minimum standards.

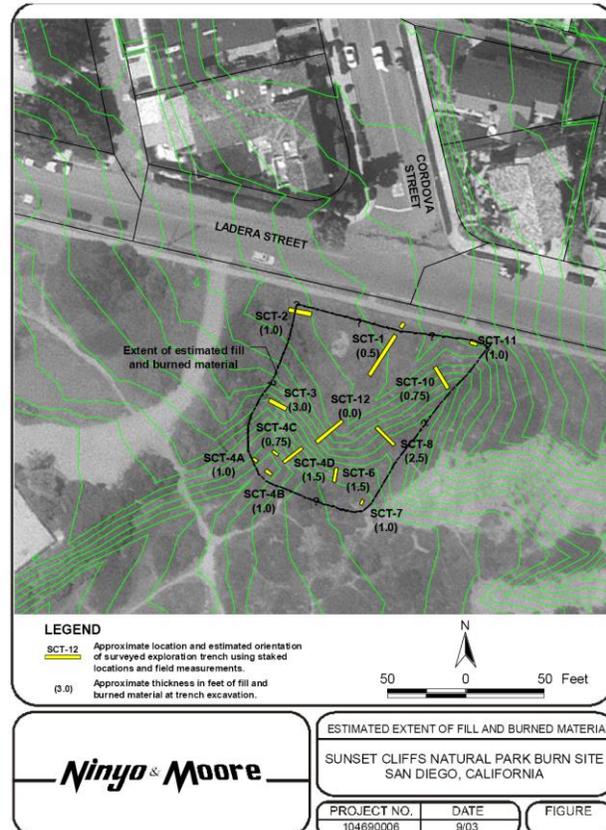
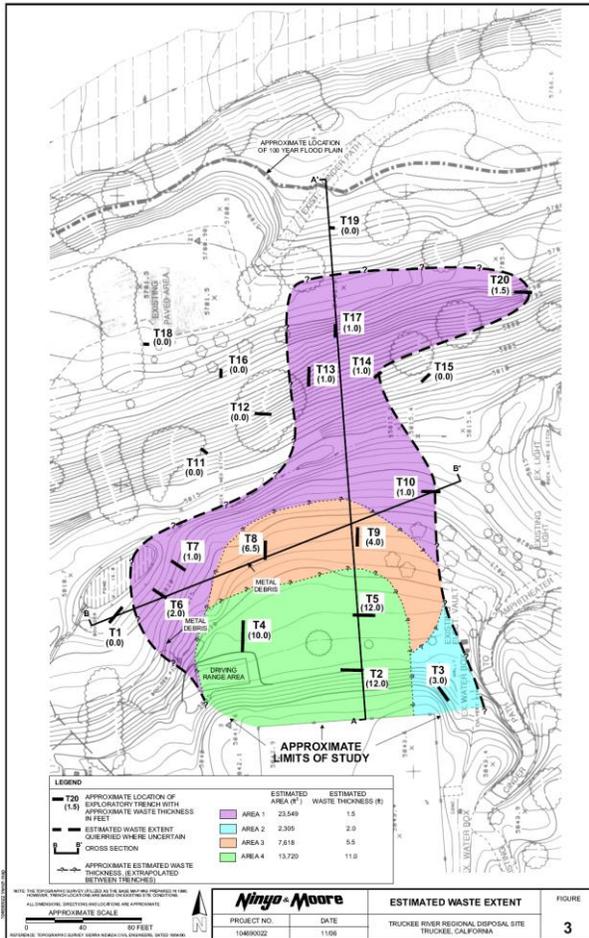


Figure 8: Trench Location Map Showing Exploration Trenches based on Historical Aerial Photo & Geophysical Survey Data

As an investigation transitions from an office investigation to a field investigation, an aerial survey should be flown to photograph the site and a ground survey should be performed to develop a scaled topographic map in AutoCAD format. It should be determined if the site had been “flown” recently for other mapping purposes or whether a ground survey conducted as this may reduce the cost of developing the topographic map in AutoCAD file format. Topographic maps can be developed for between \$5,000 and \$10,000 (depending of complexity of site and ground survey required); this is a critical cost work element in an investigation as it will provide the basis for scoping, feasibility analysis and estimating cost for different remedial options for the disposal site.

If possible, a topographic map of the site prior to disposal site operations should be obtained, especially if the site was excavated (mining pits) or topographic depressions (canyons and ravines) were filled. The pre-disposal site topographic map data should be transposed into an AutoCAD file format; this will allow a “fill area” map to be generated from AutoCAD software (Civil 3D) that can analyze and compare topographic

data, e.g. for a “cut and fill analysis” or produce a bank (or in-place) volume estimate. The topographic map can be used to plan, locate and depict the following information:

- Sample/Trench/Direct Push/Drill Exploration Locations
- Geophysical Survey Limits and Sections
- Property Boundaries
- Waste Area Boundaries
- Cover Boundary & Thickness
- Topographic Relief & Elevations
- Surface Water/Drainage Patterns
- Gas Monitoring Well locations
- Groundwater Monitoring Well locations
- Gas Control System (Blower/Flare Station, Well-field, Header)
- Structures & Utilities
- Site Access Roads
- Continuous Monitoring System Sensor and Controller layout

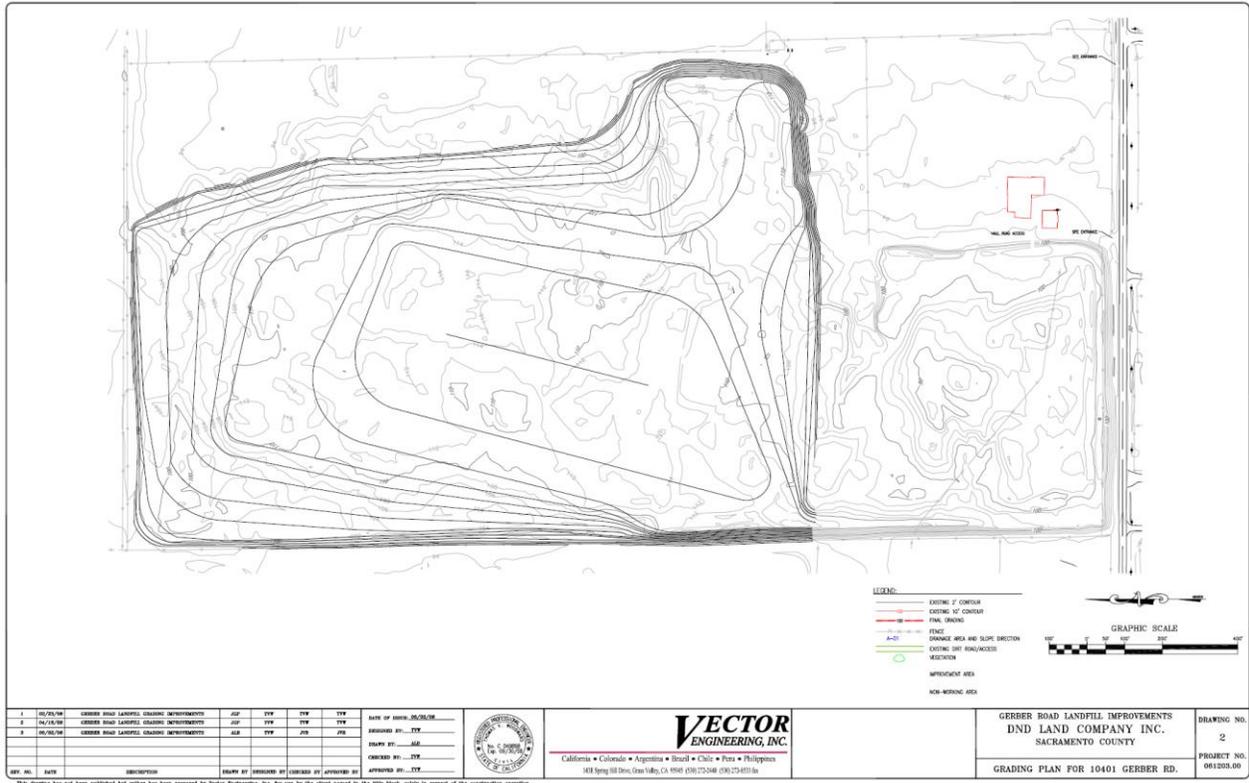


Figure 9: Final Grading Plan for Capping a former Landfill

**Typical Specifications for Topographic Maps:**

- Aerial Photograph Resolution: 1 meter resolution
- Engineering Drawing Program: AutoCAD Format (.dwg files)
- Ground Contour Intervals (elevation): 2 ft change in elevation
- Engineering Drawing Scale (standard 24 in x 36 in drawing size): 1 inch = (50-200 feet depending on size of site, e.g. 10 acre site, 1 inch = 50 feet, 60 acre site 1 = 200 feet)
- Specified Information on Drawing: Elevation Contours, Drainage Features, Cover Thickness, Waste Boundaries, Sample Locations, Drilling and Trenching Locations, Environmental Monitoring Points (wells), Structures, property boundary, fencing or barriers, waterways, access roads, other notes significant to disposal area concerns (day lighting of waste, surface debris locations, etc.)

# Using Geophysical Surveys to Estimate Waste Boundaries

Once a historical aerial photograph analysis has been performed and a topographic map in AutoCAD developed; a geophysical survey of the disposal site and surrounding areas should be performed to develop subsurface cross-sections that can be used to determine intrusive investigation (drilling, trenching or direct push) locations and depths to sample and delineate native and fill horizontal and vertical boundaries. Various Geophysical Survey methods may be employed based on site conditions; the following summary provides conditions under which different methods may be employed to optimize results.



Figure 10: Using Trimble GPS Surveying Equipment to locate Geophysical Survey Results; Resistivity Survey on a Burn Dump in San Diego County

## Types of Geophysical Survey Methods:

- “STING” Resistivity Survey – good for “sectional profiles” and deep fills (>30 feet) for disposal sites where the disposal fill material’s electrical resistance/conductance is significantly different from surrounding geologic formations and deposits. Resistivity surveys may have limited value in areas with high water/moisture content or soils with high salinity, e.g. tidal areas, marshlands, bay fills, etc.
- Electromagnetic (Magnetometer) – good for horizontal extents, where a disposal site contains ferromagnetic debris.
- Electrical Conductivity – resolution depends on difference in electrical conductivity properties between disposal fill material and subsurface geology.

- Ground-penetrating Radar – resolution depends on difference in material density between waste fill and surrounding geology
- Case Studies: Benton Dump, World Enterprises, Franklin Field

PC software programs that allow geophysical data (conductivity, electromagnetic, time-domain data, etc.), to be graphically represented provide spatial correlation of data which can improve delineation of subsurface features such as fill areas, pipelines and utilities, buried objects, etc. It should be noted that a combination of one or more geophysical methods, e.g. resistivity (depth) and ferromagnetic (areal), may provide a more complete “picture” of a site’s subsurface characteristics.

It should be noted that geophysical surveys are relatively expensive (up to \$5000 per day for an electrical resistivity survey depending on number of survey “lines” (or sections) and distance (number of survey nodes) and may not yield data of value to the investigation. Site-specific conditions, such as metal objects or structures, fences, above or below ground metal pipelines, etc. can cause electrical interference with some of the methods (resistivity and conductance) which may degrade the results of the survey. A site walk and estimate should be done before determining if a geophysical survey would yield useful data for a site investigation.

A geophysical survey is not a substitute for an intrusive investigation, and should be used to complement an intrusive investigation. The intrusive investigation will yield the most reliable information (trench, boring, direct push logs) on the location of the horizontal and vertical extents of the landfill or disposal site. In some cases, where an intrusive investigation may not be possible due to vehicle access constraints, a geophysical survey may be the only method available to determine extents.

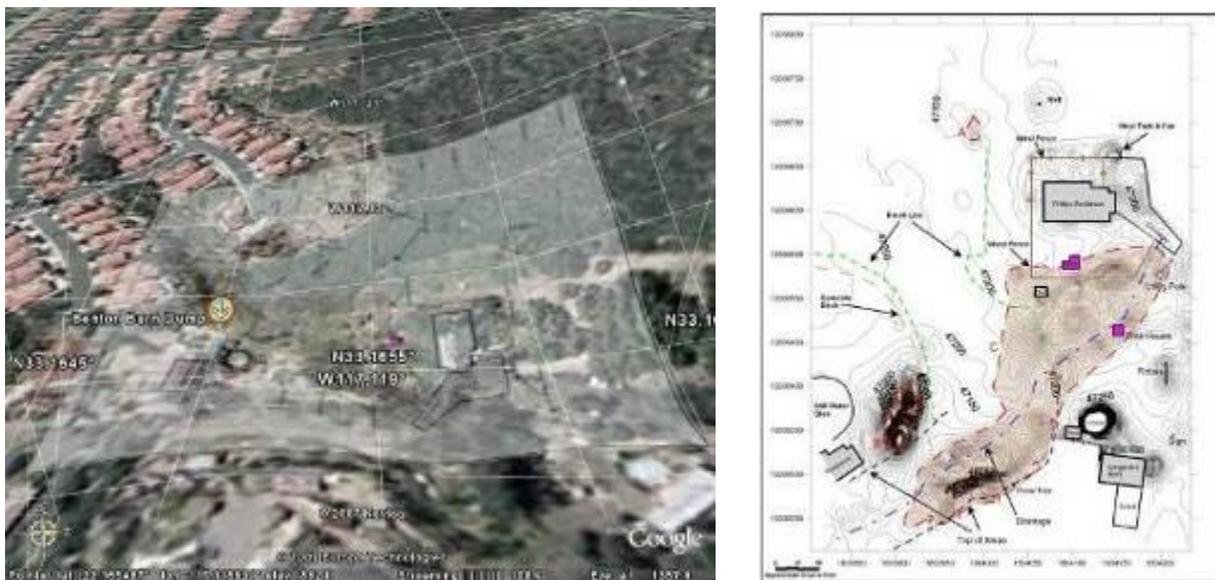


Figure 11: Geophysical Survey Map Overlaid on Aerial Map in Google Earth—Geophysical Survey Conducted using Electrical Conductivity

# Intrusive Investigation of Disposal Sites

The use of intrusive investigation methods such as drilling, trenching or direct push can provide visual and physical confirmation and documentation (drilling and trenching logs) of the approximate horizontal and vertical boundaries of a disposal site. Intrusive investigations should be planned and conducted after a thorough non-intrusive investigation has been performed, e.g. historical aerial photograph study, geophysical survey and site walk with individuals knowledgeable of the site's history and conditions (owner, disposal site operator or user, previous disposal site employee, neighbors, etc.).



Figure 12: Intrusive or Invasive Investigation may include: drilling, direct push (Geoprobe) and trenching

An intrusive investigation should be designed to fill-in investigation data gaps or verify features of the site observed during the Historical Aerial Photograph study and/or Geophysical Survey. For example, if a disposal site began as the filling of a gravel pit excavation; the intrusive investigation may focus on verifying the pit excavation boundary and thickness of final cover. If historical aerial photographs show that several trenches had been excavated and filled, the intrusive investigation may focus on delineating the trench lengths and depths. If a disposal site's history shows only surface or area filling, the intrusive investigation may focus on delineating the original ground surface conditions and areal extent of waste deposits.

Intrusive investigation data (borings, trenching, direct push field logs) can then be used to develop disposal site boundaries on a scaled topographic map and cross-sections depicting top and bottom of final cover and waste elevations. This disposal site topographic drawing and cross-sections then becomes the basis for developing remedial scopes of work and cost estimates for clean-closure and/or consolidation and capping.

# Types of Intrusive Investigation Methods

Trenching and “Potholing” investigation methods can provide cost-effective and valuable field data on the horizontal and vertical extents and characteristics of a disposal site. Trenching allows a trained and experienced geologist to visually observe and take direct measurements on the cover thickness, the depth of waste and determine contacts between waste fill and native geology. Open trenches can be photographed and disturbed soil and waste samples can be taken from trench spoils from different approximate depths for laboratory analysis. A trained, experienced and registered field geologist should log Trenches. Directional trenching provides a geologist with a method for exploring and verifying waste boundaries.

Trench Logs should contain the following information: Site Location Name, date/time, Name of Qualified Geologist logging trench, Trench Location, Trench Number or Designation, Length, Width and Depth of Trench, depth of cover, depth of fill, depth to bottom or native, sample locations and description of waste and soils.



Figure 13: Trenching Investigation with a tracked-backhoe for Investigating Fills 15-25 feet in depth

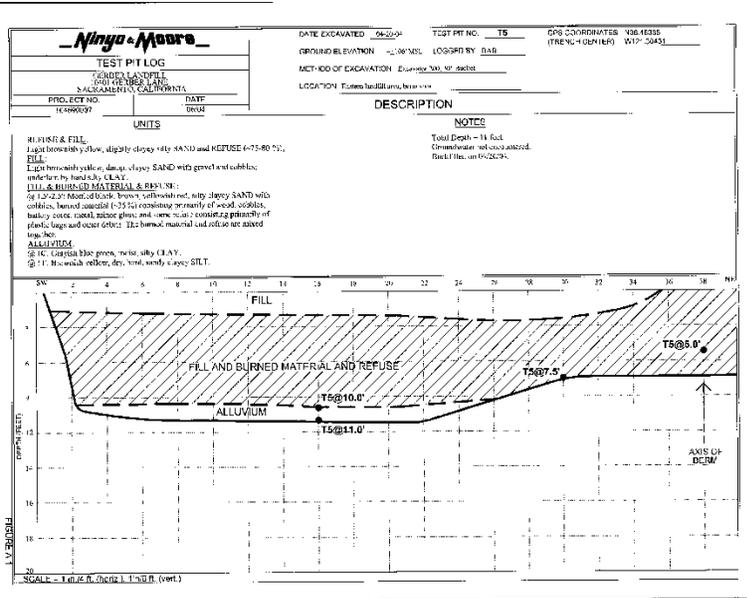


Figure 13a: Trench Log Example

Drilling Investigation methods are widely accepted and [standardized](#) for subsurface exploration for environmental and geotechnical investigations. Drilling can provide a geologist with detailed, discrete information on subsurface formations and fills. Drilling methods can also provide discrete and undisturbed soil and waste samples for laboratory analysis. Standardized methods and procedures (ASTM) are available for determining soil and waste properties, e.g. classification, density, compaction, shear strength. Drilling (or direct push) should be used to determine the vertical extent of waste fills that are over 30 feet in depth; generally many canyon-fills or mining pit fills require the use of drilling or direct push methods to define the vertical extents. Drilling equipment needs for investigations may vary depending on site geology –Air Percussion or Air Rotary rigs may be necessary where geology contains cobbles and rocks that may present refusal conditions. Hollow-stem auger drill rigs can generally be used in geology classified as soil.

Boring Log information should include: name of site, date/time, name of person logging (and certification no.), name of firm/drillers license no., boring location number or designation, cover thickness, waste and soil descriptions/classification, geologic strata identification, depth of fill, depth to native geology contact (bottom of waste), depth to groundwater, monitoring instrument measurements (PID, FID, OVA, CGI, etc), sample locations and other important field information of significance to investigation.



Figure 14: Drilling Equipment for exploration and sampling and gas monitoring well construction. Depending on geology and landfill materials a hollow-stem auger may suffice or site conditions may dictate the use of an air rotary or air-percussion drill rig; a local drilling company or geologist familiar with well installation in the area should be consulted

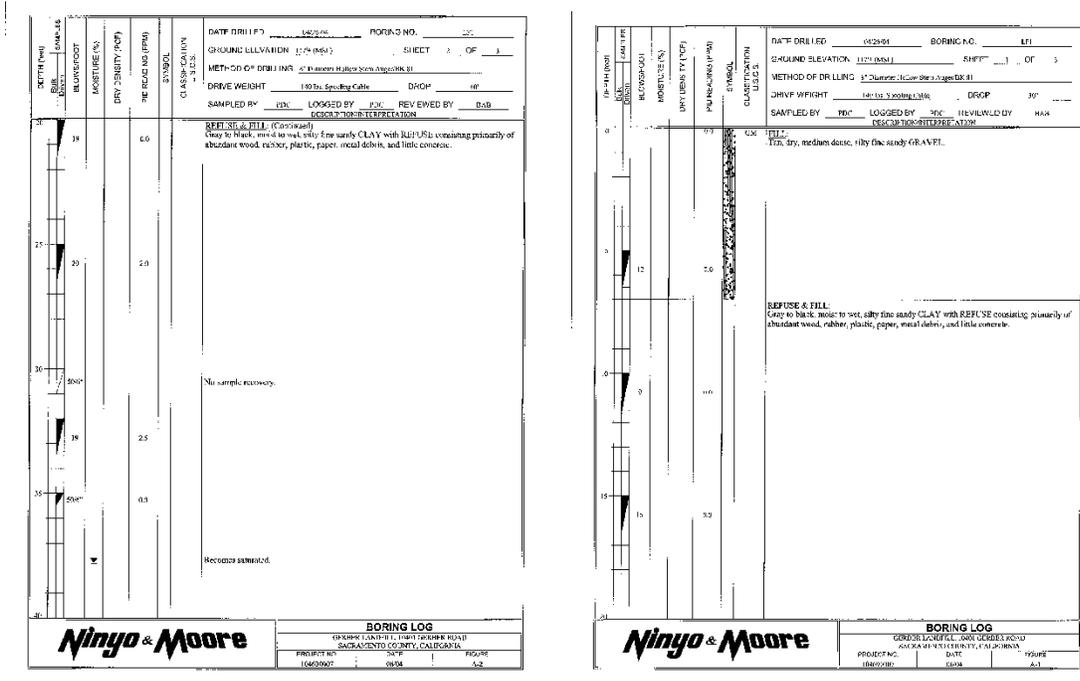


Figure 15: Boring Logs from Gas Monitoring Well installation

Direct push investigation methods, such as “[Geoprobe](#)” hydraulic direct push equipment, has gained popularity within the environmental investigation field for conducting subsurface investigations, particularly in developed areas where drilling or

trenching are difficult to conduct due to dense subsurface utilities. Direct push offers a small diameter (2" diameter) investigation boring, but still provides in-situ, discrete soil and soil-vapor gas samples.

Direct Push Logs should include the following information: name of site, date/time, name of person logging (and certification number), name of firm and license number, name and type of equipment, location number or designation, cover thickness, waste and soil descriptions/classification, geologic strata identification, depth of fill, depth to native geology contact (bottom of waste), monitoring instrument measurements (PID, FID, OVA, CGI, etc), sample locations and other important field information of significance to investigation.



Figure 16: Direct Push Exploration and Sampling Methods (push core sampler into geologic strata)—Investigation disturbance is a nominal 2-inch diameter hole (important consideration in developed areas with dense subsurface utilities)

Some advantages and disadvantages of trenching, drilling and direct push methods include:

### **Advantages**

- Trenching costs per day of operated backhoe or excavator is less than Drill Rig or Direct Push Rig
- Backhoes and excavators require only one operator
- Excavators and Backhoes are common construction heavy equipment (greater availability than drill or direct push rigs)
- Trenching can allow visual observation of in-situ cover thickness and waste materials; visual identification of stratigraphy (layers) in trench
- Trenching and potholing can cover larger areas in a relatively short time; good for horizontal extents investigations;

- Minimal set-up time needed between investigation locations
- Tracked equipment can access areas not accessible to heavy wheeled equipment
- Generally – “refusal” conditions not as problematic as drilling or direct push.

### **Disadvantages**

- Trenching may be difficult in developed areas with buried utilities; developed areas may require a higher degree of inspection and coordination (Geophysical Clearance and Underground Service Alert)
- Samples obtained from trenching for analysis are disturbed and not discrete, e.g. drilling and direct push coring type samplers, e.g. split-spoon sampler, can provide both undisturbed and discrete samples (generally, this is more of a sampling procedure issue if volatile organic compound (VOC) analysis is required).
- Depth of trenching excavation is subject to equipment limitations – generally a standard tracked excavator is capable of excavating a 25-30 foot deep by 2 foot wide trench; also – difficult to visually log bottom of trenches over 15 feet in depth;
- Disposal sites greater than 25-30 feet in depth require drilling or direct push equipment to define the vertical extent
- Safety hazards associated with trenching such as caving, side-wall collapse, etc.; OSHA standards for trenching must be identified, observed and followed and included in the field investigation work plan and site specific health and safety plan



Figure 17: Sampling and analysis of waste and soil within landfill to determine physical and chemical characteristics; Removal of sampling core from split-spoon sampling tool used in a hollow stem auger drill rig

## Sampling and Analysis Plan for Waste and Soil Characterization

The Phase II Field Investigation Work Plan that provides the scope of work and tasks for completing an investigation of the horizontal and vertical extents of the waste should include sampling and analysis procedures that will describe and document how waste and soil characterization data quality will be controlled and to support the collection of defensible data that will support investigation data quality objective (DQOs) for waste characterization/classification. For instance if a disposal site is a burn dump and the responsible party is interested in clean-closing the site, a DQO may be to determine the statistical average and confidence interval for lead concentrations to determine if the waste will go to a Class I, II or III disposal facility. If the disposal site is to remain in place, overseeing regulatory agencies may want to know the lead concentrations and distributions to determine cover specifications for the disposal fill areas. The sampling and analysis plan elements should include the following:

- Sampling Plan & References (EPA One Time Sampling Event, [SW-846 Chapters 9 & 10](#))
- Data Quality Objectives (DQOs)
- Sample Location Map
- Sampling Procedures and Equipment (standardized methods, e.g. ASTM, EPA, etc)
- Sample Handling Procedures (labeling, packaging, preservation, holding, chain-of-custody)

- Field Sampling Quality Assurance and Control Procedures (splits, duplicates, field blanks, etc)
- Analytical Requirements ([Process for Evaluating and Remediating Burn Dump Sites – Attachment 1](#)/T.O.-15 and ASTM 1946 for LFG)
- Laboratory QA/QC requirements

Example sampling and analysis plans for closed, illegal and abandoned sites can be found at: <http://www.calrecycle.ca.gov/SWFacilities/CIA/Field/SamplingPlan/>

## Disposal Site Volume Estimates.

An important analysis performed during a technical and economic feasibility study for remedial options at a disposal site is the estimation of volume of waste in-place and the cost to remove or “clean-close” waste materials. The volume estimate can be obtained by knowing the horizontal (or areal) and vertical extent of the waste disposal site, which can be determined through an office and field investigation. There are two common methods for determining the volume of a bank fill, the “end area method” and “Prismoidal formula” (Harbin, 1998). The end area method formula calculates the volume, V as follows:

$$V = L (A1 + A2)/(2 \times 27) = (L/54) \times (A1 + A2)$$

Where, V is volume in (yd<sup>3</sup>)

A1 is the area of the first section (ft<sup>2</sup>)

A2 is the area of the second section (ft<sup>2</sup>)

L is the distance between the first and second section (ft)

The “Prismoidal” method assigns a square grid system over a disposal site, and the average depth of each grid square is determined through investigation (geophysical, drilling, trenching, etc.). The volume is determined by multiplying the area of each square by the average depth of waste for that grid square and summing the volumes of the grid squares.

A common volume estimation method, known as the “[average end area method](#)” uses “cross sections” for the disposal area and the distance between cross sections to calculate the volume of the fill. The cross section data is developed from trench or boring logs, which provide the depth of the fill along a specified line that transects the fill. In the example volume estimate below, Section 1, 2 and 3 are taken along the long side of the disposal area – the distance L1 is measure between Section 1 and 2 and L2 between Section 2 and 3. The accuracy of the estimate can be increased by using more cross sections to estimate the volume. After completing the volume estimate, a cost

estimate can be developed for clean-closure of the waste material in place. An example of a volume estimate using “method of sections” and a cost estimate for clean-closure is provided below from the Bryte Landfill, located in Yolo County, California.

Volume estimates can also be performed using engineering software ([AutoCAD Civil 3D Volume Estimation](#)) by using volume estimating utilities that compare pre and post disposal site topographic surfaces and calculating the volume using finite element algorithms.

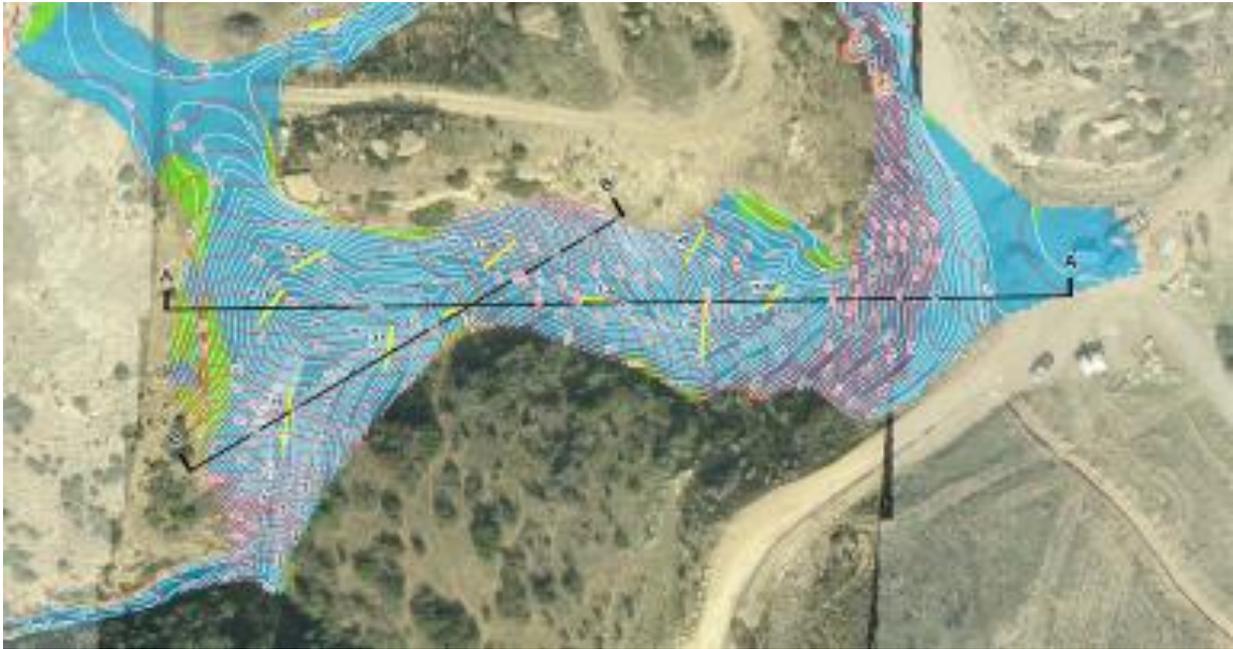
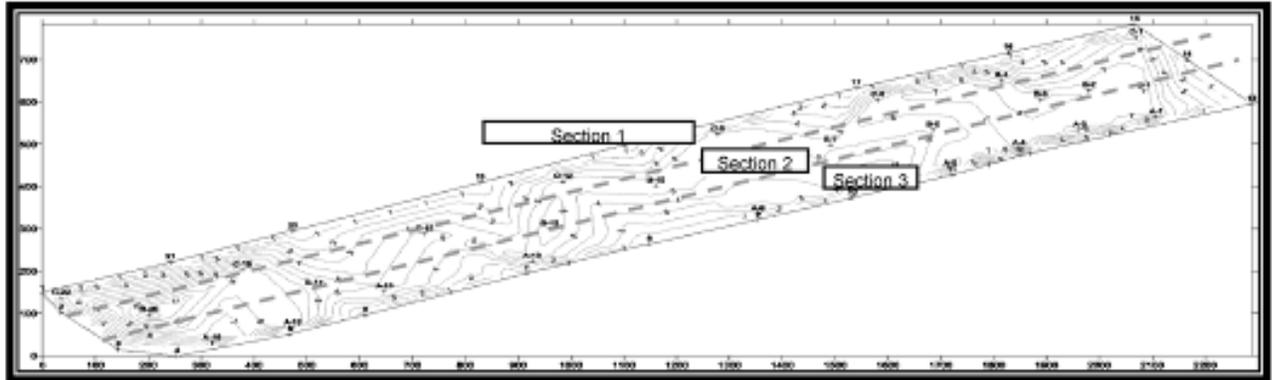


Figure 18: Topographic lines depict original and current grades; shaded area represents areal extent of fill

## Example of Volume Estimation Using Method of Sections



Drawing of Disposal area divided into 3 sections; Trench Locations are determined by location on X-Axis

Trench ID	X-Location	Depth	Trench ID	X-Location	Depth	Trench ID	X-Location	Depth
C22	18.12	6	B20	109	13	A19	72.5	5.25
C18	353.43	9	B17	417	6.25	A18	217.5	9
C12	981.76	6.25	B16	652	5.25	A16	416.8	5
C9	1280.82	6	B13	878	7	A13	706.8	5
C6	1588.94	7	B10	1095	6	A9	1141.8	2.5
B4	1820.03	8.25	B7	1430	5.5	A7	1295	4
C1	2091.9	6	B5	1620	5	A5	1512.5	8
			B3	1837	8.25	A4	1648	8.9
			B2	1927	8	A3	1774	7
			B1	2026	8	A1	1919	7
Average		6.93 ft			7.23			5.93

Total Volume = Volume of Section 1 + Volume of Section 2 + Volume of Section 3

Volume of Section 1 = Area of Section 1 x Average Depth of Section 1 = 14,799 ft<sup>2</sup> x 6.93 ft = (1,136,004 ft<sup>3</sup>)/27 ft<sup>3</sup>/CY = 42,074 CY

Volume of Section 2 = Area of Section 2 x Average Depth of Section 2 = 15,238 ft<sup>2</sup> x 7.23 ft = (1,109,926 ft<sup>3</sup>)/27 ft<sup>3</sup>/CY = 41,108 CY

Volume of Section 2 = Area of Section 3 x Average Depth of Section 3 = 12,388 ft<sup>2</sup> x 5.93 ft = (950,902 ft<sup>3</sup>)/27 ft<sup>3</sup>/CY = 35,219 CY

Total Volume = 42,074 CY + 43,320 CY + 35,219 CY = 120,613 CY

Figure 19: Volume Estimate Using End Area Method.

ITEM	DESCRIPTION	QTY	UNIT	RATE	UNIT	EXT. COST
1	Construction Surveying	16.7	Acre	\$1,074	\$/Acre	\$17,900.00
2	Site Preparation/Clearing	16.7	Acre	\$400	\$/Acre	\$6,667.67
3	Excavate Soil to Cover Pile	13,444	CY	\$2.50	\$/CY	\$33,611.11
4	Excavate Waste to End Dump	127,722	CY	\$2.31	\$/CY	\$295,038.33
5	Haul Waste to Landfill	127,722	CY	\$10	\$/Acre	\$1,277,222.22
6	Pay Dump Tip Fee	127,722	CY	\$40	\$/CY	\$5,108,888.89
7	Perform Verification Sampling	50	EA	\$450	\$/EA	\$22,500.00
8	Backfill Cover Stockpile	13,444	CY	\$1.25	\$/CY	\$16,805.56
9	Import Fill, Grade and Compact	127,722	CY	\$10	\$/CY	\$1,277,222.22
10	Construction Management (5%)	1	JOB			\$402,792.75
11	Contingency (20%)					\$1,691,729.55
	<b>Total</b>					<b>\$10,150,377.30</b>

Table 20: Example Cost Estimate for Clean-Closure of a former Disposal Site; note that cost rates may not be up to date.

## Landfill and Disposal Site Investigation Case Studies

**Gerber Road Landfill.** The Gerber Road Landfill is a former 60-acre landfill in Sacramento County that provided disposal service for Sacramento County under a franchise agreement from 1957-1971. The site stopped receiving waste in 1971 after the County established Kiefer Landfill as its primary regional disposal site. The Sacramento County Environmental Health Department acting as the Local Enforcement Agency (LEA) for the California Integrated Waste Management Board, requested technical assistance from the CIWMB's Closed, Illegal, and Abandoned Site program to investigate the Gerber Road Landfill for compliance with state minimum standards for

final cover, grading, drainage, erosion control, gas monitoring and control and security. From February to May 2004, CIWMB staff and their environmental consultant prepared and coordinated an investigation work plan and conducted field investigation work to include: a geophysical survey of the disposal site perimeter, trenching and drilling over 29 locations (19 trenches, 10 borings) across the site, soil and waste sampling and analysis and finally the installation and sampling of eight multi-depth and 2 single-completion gas monitoring wells. The gas monitoring wells were instrument-screened monthly, and sampled and analyzed quarter for one-year after installation of the gas wells to determine if landfill gas concentrations complied with state minimum standards for landfill gas monitoring, e.g. 5% by volume in air at property boundary wells. Gas monitoring using a screening instrument was performed monthly for a one-year period and gas sampling and analytical testing was performed quarterly. Gas samples were collected in Summa canisters and analyzed by a certified laboratory using ASTM 1946 Fixed Gases and T.O.-15 Analysis. The results of gas screening and sampling activities indicated that although gas concentrations within landfill probes were 10% and 30% by volume; perimeter boundary probes did not exceed 5% during the one-year monitoring period. An aerial and ground survey were performed of the site and a topographic map was prepared in AutoCAD to document topographic conditions, property and waste boundaries, sampling and well locations and drainage features. A final report was prepared by the CIWMB that documented existing site conditions to include approximate waste extents, waste characteristics, final cover, drainage and erosion conditions and landfill gas concentrations and characteristics. The report provided recommendations and courses of action for the LEA with respect to the site's conditions and compliance with state minimum standards for disposal sites.

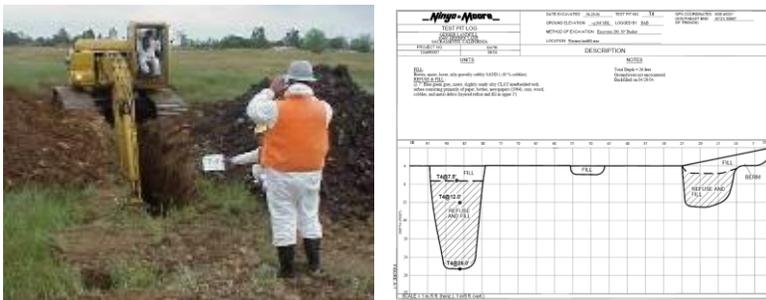
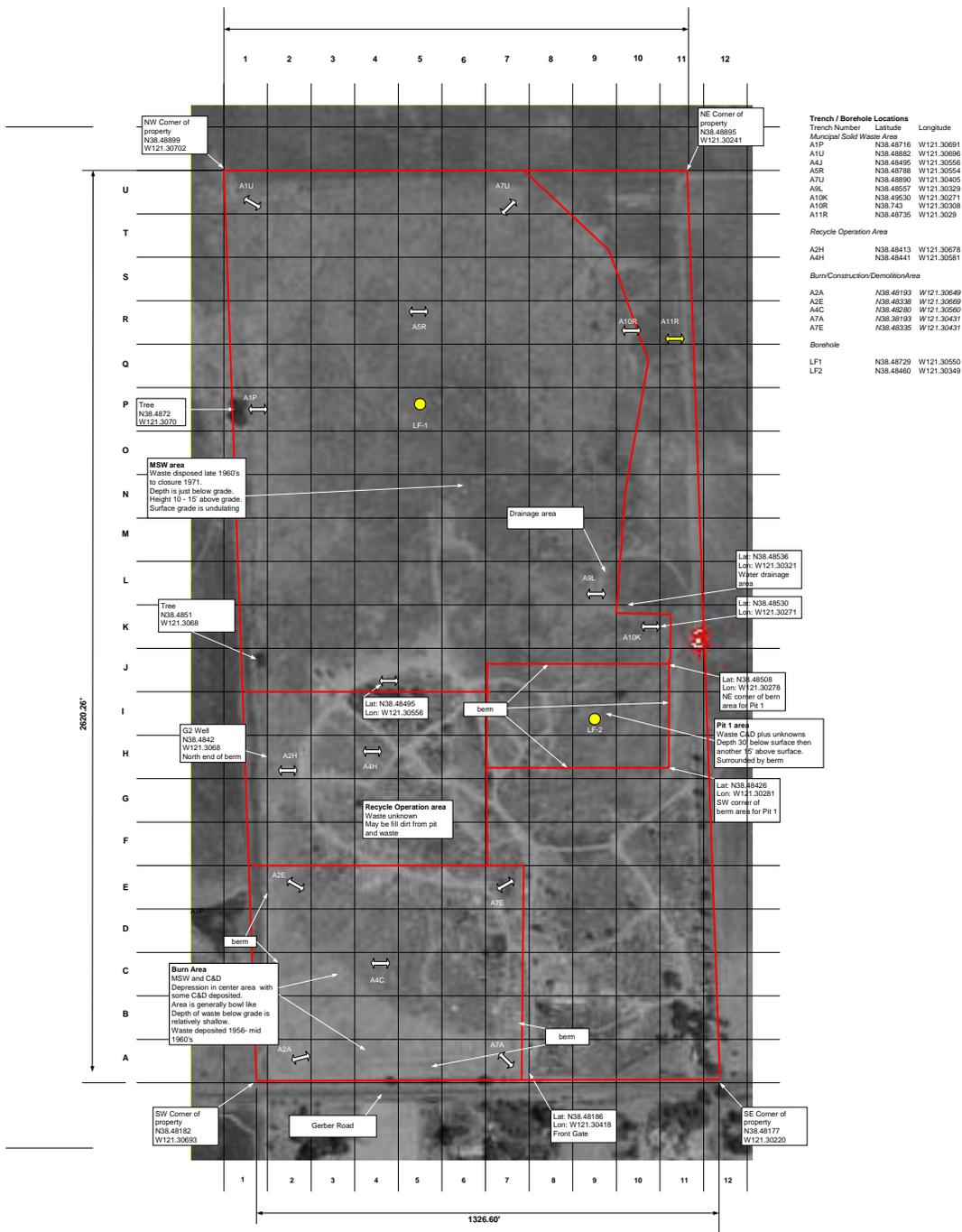


Figure 21: Trenching Photo and Trench Log Documenting Cover Thickness, Depth of Fill and Location



Figure 22: Drilling and Logging Gas Monitoring Wells. Completed Well Head Vault.



Trench / Borehole Locations		
Trench Number	Latitude	Longitude
<b>Municipal Solid Waste Area</b>		
A1P	N38.48716	W121.30691
A1U	N38.48882	W121.30696
A44	N38.48495	W121.30556
A5R	N38.48788	W121.30554
A1U	N38.48890	W121.30405
A6L	N38.48557	W121.30329
A10K	N38.49590	W121.30271
A10R	N38.743	W121.30308
A11R	N38.48735	W121.30229
<b>Recycle Operation Area</b>		
A2H	N38.48413	W121.30678
A4H	N38.48441	W121.30581
<b>Bum/Construction/Demolition Area</b>		
A2A	N38.48193	W121.30649
A2E	N38.48339	W121.30669
A4C	N38.48200	W121.30590
A7A	N38.39161	W121.30431
A7E	N38.48335	W121.30431
<b>Borehole</b>		
LF1	N38.48729	W121.30550
LF2	N38.48460	W121.30349

- ↔ Typical Trench location
- Typical Bore location
- ↔ Background Trench

### GERBER ROAD LANDFILL Trench and Bore Locations

SCALE: 1" = 125'

Latitude and longitude locations taken using global positioning instrument during 9-10 March 04 site visit. Placement of arrows depicting latitude and longitude are approximate locations and serve as reference for locating trenches and bore holes.



Figure 23: Trench and Sampling Location Map for a Disposal Site

## Santa Fe Road Disposal Site.

The Santa Fe Road disposal site was a former 60-acre disposal site in Stanislaus County that received agricultural waste from local farms and municipal waste from local communities from 1940-1960. The site was subdivided into four parcels in the 1970s. In the 1980s, one of the property owners used his parcel as an illegal disposal site for construction and demolition debris. The Stanislaus County Local Enforcement Agency (LEA) requested the assistance of the CIWMB to investigate the disposal site and illegal landfill activities. From January-April 2002, CIWMB staff prepared and coordinated a field investigation work plan to determine the approximate horizontal and vertical extents of waste at the site and provide waste characterization data for disposal and handling. Historical Aerial photographs were obtained for the site and reviewed to determine the approximate limits of disposal operations. A field investigation was conducted which utilized two farm tractor backhoes to conduct intrusive trenching and sampling at over 60 locations across the former disposal site. The purpose of the investigation was to determine the location, extent and waste characteristics of disposal areas and final cover conditions over the 60-acre site. A final report with recommendations was prepared and presented to the LEA and landowners. The final report provided field data that showed that most of the waste was located on the northern portion of the site and that a small lens of burn ash was located in the southern parcels. The investigation also showed that there was cover material on the southern portion of the disposal area, but little cover existed in the north area.



site received a SWAT rank of 6, making it a priority for further investigation. The City of San Jose Local Enforcement Agency (LEA) requested technical assistance from the CIWMB's CIA program to determine if landfill gas was migrating from the landfill to areas north, east, west of the disposal site (the initial monitoring network constructed by EMCON was located along the south boundary adjacent to the homes on Faris Drive). The CIWMB performed a Phase I Office Investigation, which included historical aerial photograph research and the installation of nine perimeter gas monitoring wells that met state requirements for a gas monitoring network (27 CCR Section 20925). The CIWMB monitored the wells monthly for a one-year period and the results of monitoring did not indicate that explosive concentrations (5 percent) of landfill gas were migrating across the western boundary of the site.



Figure 25: Historical Aerial Photograph from 1954 shows the site during mining operations; Aerial Photograph taken in 1995 shows current land-use conditions at the Hellyer site.

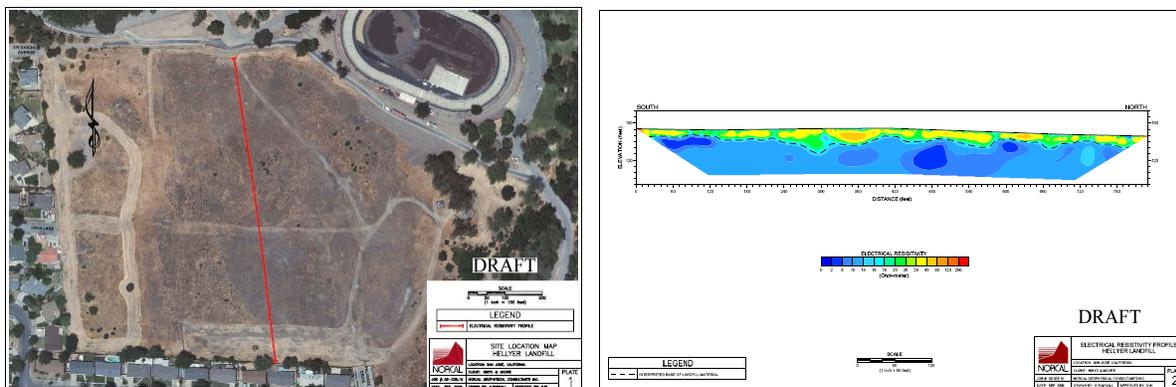


Figure 26: Geophysical Survey using electrical resistivity provides a scaled map cross-section of subsurface features. The areas of resistivity data that appear to be different from background may indicate waste deposits, which can be further investigated through drilling methods.



Figure 27: CIWMB designed and constructed a Landfill Gas Monitoring Network to determine if landfill gas migration was occurring into adjacent areas.

### La Veta Refuse Disposal Station.

The La Veta Refuse Disposal Station, located southeast of Highway 55 and Chapman Boulevard in Orange County was a County disposal site, which operated from 1946 to 1958. The site was excavated and mined for gravel and sand during the 1930s-40s and was filled with municipal waste in the late 1940s to the mid 1950s and closed in 1959. The site was developed into residential homes in the mid 1970s. In 2006, the Orange County Local Enforcement Agency (LEA) requested technical support from the CIA program to determine if landfill gas (LFG) from the disposal site was migrating off site. CIA staff conducted an office investigation, which included researching historical aerial photographs to determine the horizontal extent of the disposal site, so that gas-monitoring wells could be located and constructed outside the disposal site area. Most of the land-use information for the site and determination of approximate horizontal boundaries of the disposal site operation, was determined from a review of 17 historical aerial photographs taken from the 1930-2002. The historical aerial photographs were obtained from the University of California Santa Barbara Map Imaging Laboratory. The historical aerial photographs showed the gravel and sand mining operations (1930s), and the disposal site operation (1946-1958); the YMCA main building was shown in photographs taken in the 1970s; residential housing adjacent to the site also occurred sometime in the 1970s. A BMX racetrack was constructed adjacent to the YMCA property in the early 1980s. During drilling of the gas, monitoring wells (five total wells); it was discovered that one of the wells on the southern portion of the YMCA property was in waste. A historical aerial photo predating the landfill was over-laid In Google Earth using the “Over Lay” lay tool (Figure 28). The over laid image showed that the former disposal site intersected the residence on the southern boundary of the YMCA property. Three of the gases monitoring wells were constructed in accordance with Title 27 (Section 20925); however additional field exploration work was conducted to determine the location of waste on the residential property (figure 29). A geophysical survey using electrical resistivity and ground penetrating radar (GPR) was conducted to delineate and survey the approximate disposal site boundary. A small tracked drilling-rig was used to investigate four locations on the residential property on the south

boundary of the disposal area. It was discovered that the landfill was up to 30 feet deep below ground surface beneath the backyard (which included a pool) and that there was approximately 10 feet of soil fill above the landfill. A follow-on investigation was performed to determine if landfill gas was migrating into the residential structure; gas detection equipment was placed in the residence and YMCA building and monitored continuously (using data loggers and programmable logic control software) for a period of one year. Gas monitoring wells were monitored monthly for a period of one-year. During this period an off-gassing event was detected within the residence which was recorded at greater than 12,500 ppm (approximately 30,000 ppm).



Figure 28: Historical Aerial Photograph indicates the Boundary of Gravel and Sand Mining Operation; Aerial photograph of site with current land-use with approximate disposal site boundary depicted from 1938 historical aerial photograph.



Figure 29: Drilling Exploration in Backyard of Residence to Define Southern Extent of Former Landfill; Waste Fill Material from Boring

## Benton Dump.

The Benton Dump is located in San Diego County California in the City of Escondido and was a privately operated dump that received waste in the 1950s. The site was developed into a residential subdivision in the 1980s. The San Diego County Environmental Health Department as the CIWMB Local Enforcement Agency (LEA) requested technical assistance from the CIA program to investigate the extents of the disposal site and to determine if the site complied with state minimum standards. The CIA program conducted a phase I office investigation and phase II field investigation to determine the waste extents and characteristics. The phase I office investigation included a review of files and reports kept by the CIWMB and LEA; it also included reviewing historical aerial photographs. The phase II field investigation included a geophysical survey using resistivity and magnetometer methods and drilling and sampling (using a small tracked drilling rig with a hollow-stem auger attachment). The geophysical survey produced resistivity and magnetometer data that was located, surveyed and mapped (see figure 30). A sample location map was developed from the geophysical survey maps to perform intrusive investigation using the tracked drill rig. The results of the field investigation indicated that waste had been distributed through a ravine and was relatively shallow (2-10 feet) but uncovered. The horizontal waste was not determined as the waste “day-lighting” at the edge of the ravine appeared to be covered with over 10 feet of soil (possibly indicating that the subdivision had brought-in clean fill to build up site elevations (and in the process, covered the disposal site). The intrusive investigation using the tracked drill rig provided boring log data for over 25 locations.



Figure 30: Historical Aerial Photograph of Benton Dump Over Laid in Google Earth; Google Earth Aerial View of Benton Dump

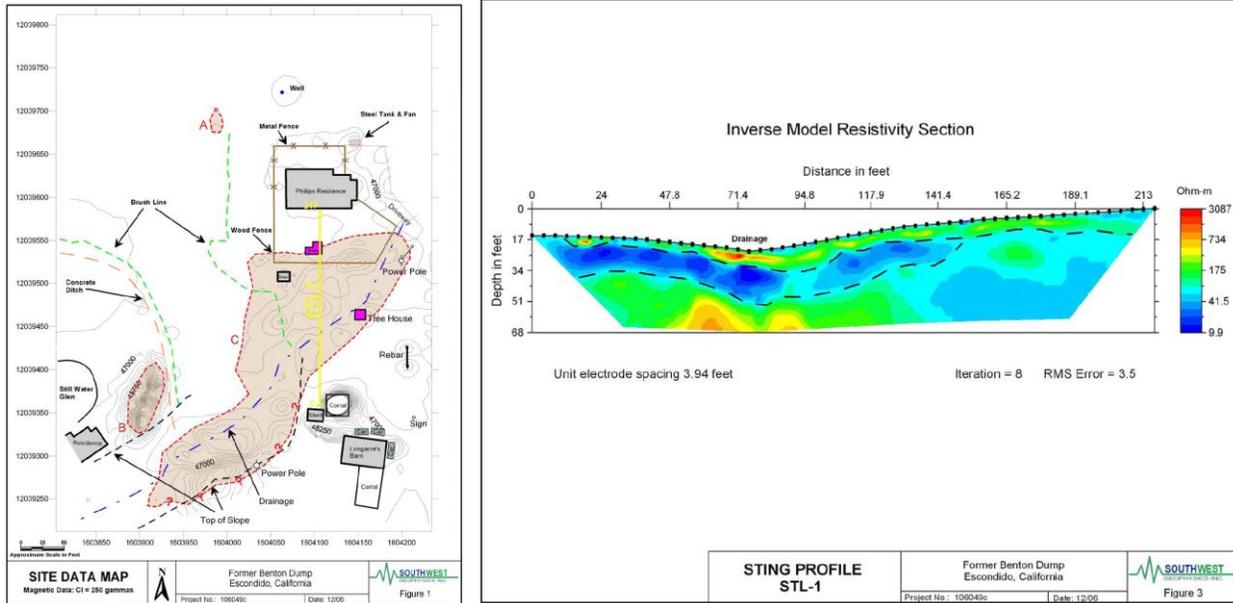


Figure 31: Map of Magnetometer Geophysical Survey depicting data; Cross section of resistance data from Geophysical Survey using Resistivity characteristics.



Figure 32: Small-tracked Hydraulic Direct-Push Rig used for intrusive investigation due to terrain and limited vehicle access

### Newport Terrace Condominium Development.

The Newport Terrace Condominium Development is located over a former landfill that was operated as an aggregate mine in the 1930-40s and used by the City of Newport in the 1950s as a municipal landfill. The disposal site was developed into residential condominiums in the 1970s. The developer had included measures, as part of the development, to address landfill gas migration issues associated with the site and



engineered soil. Direct push equipment was used to sample locations at the Newport Terrace Condominium site up to 40 feet in depth.



Figure 34: Two types of hydraulic direct push rigs were used to define the extents of waste; combustible gas instruments were used to obtain gas measurements in the direct push boring; gas samples were collected in Summa Cannisters for laboratory analysis



Figure 35: Subsurface vaults with combustible gas sensors are installed adjacent to the foundations of condominiums to detect and measure the concentration of methane gas migrating from the disposal area; a controller and data logger were used to collect gas measurements

## Bryte Landfill

The Bryte Landfill is a 16.7-acre disposal site in Yolo County California that was a leased property operated by a franchise hauler that provided disposal service to the City of West Sacramento from 1940-1970. The Yolo County Environmental Health Department requested technical assistance from the CIWMB in April 2001 to investigate the site to determine if the site complied with state minimum standards for disposal sites. The CIWMB conducted a phase I office investigation and prepared and coordinated a field investigation work plan to determine the cover waste extents and characteristics and cover thickness. Twenty-eight locations were trenched and sampled to determine the horizontal and vertical extent of wastes, the waste characteristics, the

volume of waste and the cover thickness. Upon completion of the investigation, it was determined additional investigation was required to delineate the levee boundaries and an area east of the site. The site had no cover in place and average lead concentrations at the site exceeded the Total Threshold Limit Concentration (TTLC) of 1000 mg/kg (average was 4285 mg/kg). The total in-place volume of waste estimate is 127,000 cubic yards. The CIWMB concluded that the site did not meet state minimum standards for cover, grading, drainage and erosion control and that based on the levels of lead at the site should be capped to prevent public contact. Yolo County took enforcement action against the property owner based on CIWMB investigation findings.

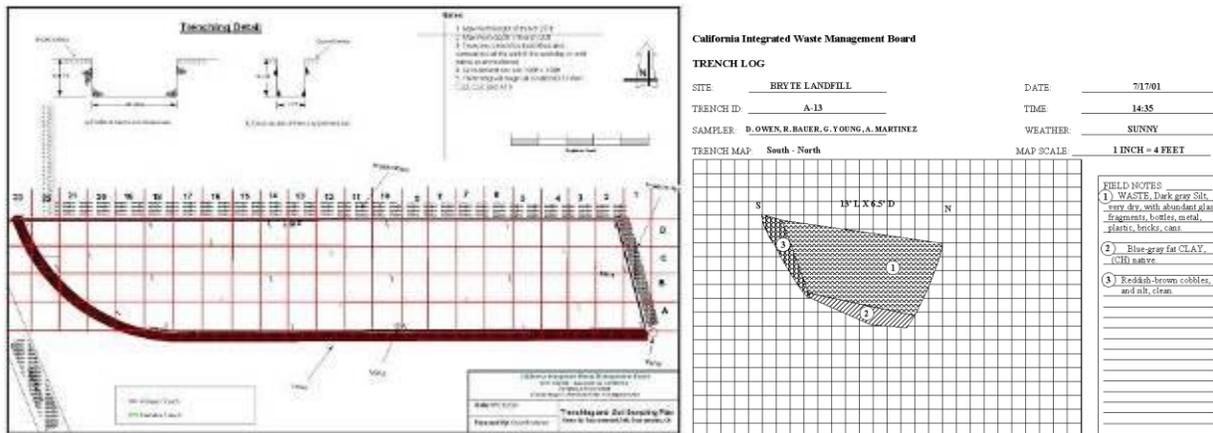


Figure 36: Site sampling location map with grid that provides the location of trenches for determining the horizontal and vertical extents of waste. The map also provides a reference system for identification of trenches (for trench logs) and for sample identification and labeling.



Figure 37: Farm-tractor backhoe conducts trenching; field staff document trench characteristics (length, depth, cover thickness, description of waste), perform instrument screening (combustible gas, oxygen levels, H<sub>2</sub>S) and also obtain samples for chemical and physical analysis.

## Franklin Field Dump

The Franklin Field Dump is a 4-acre disposal site located at a formerly used defense site (FUDS), which is now owned and utilized by the County of Sacramento as a low-security correctional facility. The Sacramento County Local Enforcement Agency (LEA) for the CIWMB requested technical assistance from the CIWMB to investigate the disposal site and its conditions as they related to state minimum standards. The CIA section prepared and coordinated a field investigation work plan to investigate the approximate horizontal and vertical extents of the disposal site, the general characteristics of the waste and to determine the thickness and quality of the cover. The CIA program conducted a field investigation at the site in October 2001, which included trenching at 32 locations across the disposal area. Thirty samples were taken from the waste (cover & waste at each location). The investigation was able to map the approximate vertical and horizontal extents of waste and provide enough characterization data to determine that the waste would be classified as California-hazardous waste. The disposal area also had nominal cover and in many locations no cover was present. The investigation provided the LEA with enough evidence to issue a notice and order to the owner to cap and grade the site. The site was graded and capped by the owner in August 2008 with matching funds provided by the CIWMB.



Figure 38: Trench Location Map; Trench Excavation & Dust Suppression

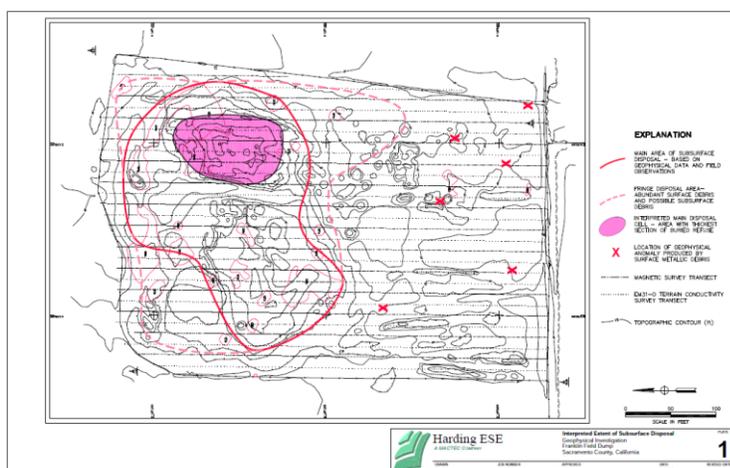


Figure 39: Topographic Map with Geophysical Survey Notes



Figure 40: Remedial Cap Construction

### Waring's Dump

The Waring's Dump Disposal Site is a 3-acre site located in a residential community in Sacramento California. The site was a former borrow pit from the construction of Highway 99 in the 1950s. The owner of the site used the borrow pit as a dump in the 1960s to dispose of municipal and commercial waste. The area was developed into residential housing in the 1970s. The Sacramento County Environmental Health Department acting as the California Integrated Waste Management Board's (CIWMB) Local Enforcement Agency (LEA) requested the assistance of the Closed, Illegal and Abandoned Site program (CIWMB) to conduct an investigation of the site to determine compliance with state minimum standards for disposal sites. The investigation included the development and coordination of an investigation work plan, which included a historical aerial photograph analysis, an intrusive investigation (trenching) and sampling and analysis of waste and soils. A total of 20 trenches were excavated during the field investigation and 28 soil and waste samples were collected and analyzed from the waste fill and cover soils. CIA staff determined through the field investigation that the disposal area extended beyond the original parcels containing the borrow pit excavation; it was also determined that the waste contained hazardous levels of lead (Soluble Threshold Limit Concentration) and that the disposal site was insufficiently covered. CIA staff prepared a final report with recommendations for the LEA with respect to the site's conditions as they related to compliance with state minimum standards.



Figure 41: Trench Location Map; Trenching using a tracked excavator

## Noah Webster Elementary School Burn Dump

The site is a former 15-acre disposal site in the City of San Diego that received municipal waste between 1934 and 1941. The site operated as a burn operation, where garbage was collected, burned and consolidated. The site was developed into an Elementary School in the early 1954 and areas surrounding the school developed into residential housing. The City of San Diego LEA requested technical assistance from the CIWMB to investigate the extents of the disposal site and determine if the site complied with state minimum standards. The CIA program prepared and coordinated an investigation work plan and conducted an office and field investigation, which included the use of diesel-powered hydraulic direct-push equipment to perform subsurface exploration of 20 locations across the site. During the office investigation, grading plans were provided by the school district that showed the original disposal site boundaries and planned excavation and relocation of waste areas. These drawings were used to develop a sample location map to delineate locations for verifying the as-built conditions of the grading plan. Locations were logged, sampled and analyzed in accordance with the investigation work plan. The results of the investigation estimated the volume of waste in place to be 15,000 bank cubic yards, which was covered with an average of 10 feet of clean fill material. Although lead levels in the waste exceeded California regulatory thresholds; the in-place cover provided adequate protection from contact with the waste.



Figure 42: Noah Webster Elementary School Aerial Image (1996). Geologist examines direct push sample (clear plastic sample sleeve) taken from location on school playground. Clear plastic sample sleeve lines the inside of the direct push core sampler which is hydraulically pushed into subsurface geology.



Figure 43: Geologist documents direct push boring observations in boring logs. Location of borings is surveyed using GPS surveying equipment. The direct push sampler has a diameter of 1.5 inches.

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