Los Angeles County
Metropolitan Transportation
Authority
One Gateway Plaza
3rd Floor Board Room
Los Angeles, CA

**File #:** 2016-0326, **File Type:** Agreement **Agenda Number:** 21.

**CONSTRUCTION COMMITTEE**
**MAY 19, 2016**

**SUBJECT: WESTSIDE PURPLE LINE EXTENSION SECTION 1 PROJECT**

**ACTION: AUTHORIZE THE CHIEF EXECUTIVE OFFICER (CEO) TO EXECUTE AN AMENDMENT TO AN EXISTING MEMORANDUM OF UNDERSTANDING**

## RECOMMENDATION

AUTHORIZE the Chief Executive Officer to execute Amendment No. 1 to the existing Memorandum of Understanding between **Metro and the Los Angeles County Museum of Natural History, including the Page Museum at the La Brea Tar Pits, for the preservation and storage of paleontological and archaeological resources associated with the Westside Purple Line Extension Section 1 Project**.

## ISSUE

Metro executed a Memorandum of Understanding (MOU) with the Los Angeles County Museum of Natural History (NHM) for the Westside Purple Line Extension Project (WPLE) in November 2011. The MOU stipulates the roles and responsibilities for encountering, protecting, recovering, preserving, transporting and curating paleontological and archeological resources. The MOU did not include roles and responsibilities for the final permanent storage of paleontological resources that were recovered as part of the WPLE. Amendment 1 of the MOU stipulates the roles and responsibilities for the final permanent storage of paleontological resources.

## DISCUSSION

The Wilshire/Fairfax Station for the WPLE is located in the vicinity of the La Brea Tar Pits. The La Brea Tar Pits contain one of the world's largest collections of Ice Age fossils, which are located in soil deposits beneath the ground surface. Metro and the NHM executed a MOU in November 2011 to protect, recover, preserve, transport and curate any paleontological and archeological resources that might be discovered while performing work in the vicinity of the La Brea Tar Pits. This MOU was developed in parallel with the Final Environmental Impact Statement/Environmental Impact Report (Final EIS/EIR) for the project, which was approved by the Metro Board of Directors in April 2012. The MOU did not include roles and responsibilities for the final permanent storage of paleontological resources, i.e. fossils, because the amount and type of storage would not be known until the excavation of the Wilshire/Fairfax Station is performed. While the final quantity of fossils is still not known at this time, Metro and the NHM agreed that it would be best to define roles and responsibilities for the final permanent storage of these resources prior to beginning the work. Metro and the NHM further agreed that that the roles and responsibilities for final permanent storage would be limited by the project budget and schedule per the Federal Funding Grant Agreement (FFGA). The roles and responsibilities for permanent storage are now included in Amendment 1.

## DETERMINATION OF SAFETY IMPACT

This Board action will not have an impact on established safety standards.

## FINANCIAL IMPACT

Funding for this action is within the Life-of-Project Budget that was approved by the Board in July 2014, under Project 865518-Westside Purple Line Extension Section 1 Project in Cost Center 8510 (Construction Project Management), and Account Number 53101 (Acquisition of Building and Structure). Since this is a multi-year project, the Executive Director of Program Management and the Westside Purple Line Extension Section 1 Project Manager will be responsible for budgeting in future years.

### Impact to Budget

The sources of funds for the recommended action are Federal 5309 New Starts, Transportation Infrastructure Finance and Innovation Act (TIFIA) Loan proceeds and Measure R 35%. These funds are designated for Westside Purple Line Extension Section 1 Project and do not have an impact to Operations. These funds were assumed in the Long Range Transportation Plan (LRTP) for the Westside Purple Line Extension Section 1 Project. This Project is not eligible for Propositions A and C funding due to the proposed tunneling element of the Project. No other funds were considered.

## ALTERNATIVES CONSIDERED

The Board may choose not to execute Amendment 1. However, the roles and responsibilities for final permanent storage of any paleontological and archeological resources that may be discovered would be undefined.

## NEXT STEPS

After Board approval, Metro and the NHM will perform work for the Westside Purple Line Extension Section 1 Project in accordance with the terms of the MOU and Amendment 1.

## ATTACHMENTS

Attachment A - Amendment 1 to the Memorandum of Understanding between Metro and the Los Angeles County Natural History Museum

Attachment B - Memorandum of Understanding between Metro and the Los Angeles County Natural History Museum (Appendix G of FEIS/FEIR: Memorandum of Understanding for Paleontological Resources).

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Phillip A. Washington
Chief Executive Officer

**AMENDMENT NO. 1**

**THIS AMENDMENT NUMBER 1 TO THE MEMORANDUM OF UNDERSTANDING** ("MOU") is entered into as of this ______day of ____________________ by and between the Los Angeles County Metropolitan Transportation Authority ("Metro") and the Los Angeles County Museum of Natural History, including the Page Museum at the La Brea Tar Pits ("Museum") (collectively, "the Parties"), for the preservation of paleontological and archaeological resources associated with the Wilshire/Fairfax Station and other portions of the Purple Line Extension Project (Project) alignment within two miles of the Wilshire/Fairfax Station.

**BACKGROUND**

**WHEREAS**, Metro has the responsibility under Federal and State law to recover and preserve for future scientific and educational use paleontological, archaeological, and historical resources that may be impacted by the Purple Line Extension Project and associated records; and

**WHEREAS**, the Parties have previously signed (November 2$^{nd}$, 2011) a Preliminary MOU governing the recently completed excavation of the Metro Exploratory Shaft near the Page Museum and also setting out the general framework for mutually beneficial Paleontological cooperation;

WHEREAS, the County of Los Angeles and the Los Angeles County Museum of Natural History Foundation (Foundation) entered into a long term operating and funding agreement dated July 12, 1994, as amended, authorizing the Foundation to perform a variety of functions for the museum and accept and expend funds for the museum;

**WHEREAS,** Metro required the principal paleontologist to prepare and submit a mitigation plan, subject to approval by Metro and Museum, to address monitoring, preservation and, recovery of any paleontological resources which shall be consistent with best practices guidelines for both field and laboratory work on project paleontological resources to meet state and federal laws and guidelines and Museum standards (Attachments 1 and 2).

**WHEREAS,** Metro has separately negotiated a contract that includes the cost of monitoring by the principal paleontologist and staff and removing fossils from the Fairfax Purple Line Station and transporting them to a site for processing:

**WHEREAS,** the Museum has made available Museum personnel to provide oversight for the qualified principal paleontologist's preparation of a mitigation plan, subject to approval by the Agency, to address monitoring, preservation and, recovery of paleontological resources. The mitigation plan is consistent with best practices guidelines for both field and laboratory work on project paleontological resources to meet state and federal laws and guidelines and Museum standards (Attachments 1, 2, and 4).

**NOW, THEREFORE**, in consideration of the terms, conditions, covenants and performances herein contained, and other consideration the receipt and sufficiency of which is hereby acknowledged, and with the intent to be legally bound hereby, the Parties agree to incorporate the above recitals into this MOU and further contract, promise and agree as follows:

1. **Metro's Duties and Obligations**:

a. Require the selected principal paleontologist to monitor all ground-disturbing activities where sub-surface soils are exposed. The areas to be examined will be determined based on project plans and in consultation with construction staff and the qualified paleontologist during pre-construction meetings and as needed throughout the construction process.

b. Ensure that if subsurface paleontological resources are identified by the principal paleontologist during construction, all construction activities in the area of identified paleontological resources will be temporarily halted so that the resources may be documented and as determined by the Museum recovered. All resources shall be documented on appropriate forms approved by the Museum and these will be placed on file in the Museum.

c. Ensure that any paleontological resources, including asphaltic deposits containing fossils and/or archaeological objects, will be recovered in accordance with best practices outlined by the Museum (Attachment 1).

d. Require that the principal paleontologist has designated and secured space sufficient to store and, if necessary, analyze and process boxed or individual fossil deposits for preparation [but see section 2.b].

e. Require that the principal paleontologist record all data and, if necessary, perform excavation of boxed deposits or individual fossils, prepare fossils and store fossils prior to curation in accordance with best practices outlined by the Museum (Attachment 2, which may be modified from time to time and agreed to by the Parties).

f. Require that the principal paleontologist provide periodic progress reports including copies of all field notes to Metro and Museum in addition to the preparation of a comprehensive final report prepared in accordance with appropriate state and federal standards. The original copies of the field notes will be archived in the Page Museum at the time that the fossils are transferred to its jurisdiction.

g. Provide funding for required fossil recovery, processing, curation and temporary storage and any other fossil-related Museum activities specified in Paragraph 2 based on an annual work plan to be submitted by Museum and agreed upon by Metro. This annual work plan will:

    1. Be based in part on the Museum's experience in processing and storage of its Project 23 materials, taking into account the possible variation in the density of fossils and in the matrix in which the fossils are found. Reflect storage

requirements based on the anticipated quantities of fossils anticipated to be recovered in the year.
2. Be subject to revision based on unanticipated greater or lesser number and size of fossils encountered.
3. This Agreement provides for Metro's total contribution to the cost of permanent storage premises in the event that significant quantities of fossils are recovered.
4. The Museum staff cost element of annual work plan will reflect payment rates agreed on in the first MOU at Metro Form 60s adjusted over time for inflation, promotions, etc.
5. This Agreement shall prevent unreasonable payment if few fossils are found, but assure payment for vital effort.
6. The Museum staff shall submit a proposal for the Annual Work Plan no later than February 28 of each calendar year

h. Provide funding to the Museum or the Foundation for final permanent storage of paleontological resource recovery, except that Metro's funding shall be limited to the approved life of project budget, the project's duration and federal funding guidelines:

    1. The funding and payment schedule will be agreed to by both Parties after the end of excavation for the Wilshire/Fairfax Station.
    2. The Parties also agree that if significant paleontological resources are discovered and recovered, but it becomes difficult to determine the full scope and timing of the permanent storage needs for the resources, and recognizing that the storage needs will run beyond the term and scope of the Project, the Parties may agree on a one-time present value payment by Metro to Museum that will equal a negotiated agreed upon cost that, when payment has been made\.
    3. The one-time payment shall satisfy Metro's obligation to provide permanent long term storage of the paleontological resources.
    4. This approach will permit the Museum to spend the appropriate time necessary to recover, restore, analyze, display or store the resources in accordance with the Museum's policies and practices.

i. Allow the Museum to be involved, in an oversight capacity, for all field and laboratory work to ensure that Museum standards are being maintained.

j. Require that paleontological resources be removed expeditiously to allow Project completion according to schedule, but in compliance with Museum standards as recently demonstrated in the construction of the new LACMA Underground Garage and corresponding Project 23 Paleontological Project.

k. Retain responsibility for compliance with all legal and regulatory provisions related to monitoring, reporting, consultation, and repatriation of Native American remains and related material, including under Native American Graves Protection and Repatriation Act and California law.

l. Assign a Metro Representative to make any further revisions or adjustments to this document necessary in the course of the project, in cooperation with the Museum.

m. Designate the Museum as the sole source for the scientific description of fossils and artifacts recovered from the Purple Line Extension Project in asphaltic deposits associated with the Wilshire/Fairfax Station and other portions of the Purple Line Extension Project alignment within two miles of the Wilshire/Fairfax Station. Publicity concerning the discovery of such fossils and artifacts shall be jointly undertaken by Metro and the Los Angeles County Museum of Natural History.

n. In the event of extraordinary need, Metro Planning shall work cooperatively with Museum to prepare grant applications to secure additional funding and resources.

2. **Museum's Duties and Obligations:**

a. Continue to make available Museum personnel to provide oversight of all field and laboratory work on paleontological resources for the duration of the project to ensure that Museum standards are being maintained, as was successfully done on the recently completed Metro Exploratory Shaft near the Museum.

b. Provide an option, dependent upon the volume and number of fossils recovered, , that the Museum will directly house boxed fossil deposits and internally perform excavation and preparation of those deposits for compensation comparable to that offered to the principal paleontologist for similar services.

c. Provide for the professional care and management of the curated paleontological resources associated with the Wilshire/Fairfax Station and other portions of the Purple Line Extension Project alignment within two miles of the Wilshire/Fairfax Station.

d. Ensure that personnel assigned responsibilities related to the Purple Line Extension Project are qualified museum professionals whose expertise is appropriate to the nature and content of the paleontological resources recovered.

e. Provide and maintain a repository facility having requisite equipment, space and adequate safeguards for the physical security and controlled environment for the paleontological resources (but see 1.h).

f. Perform those conservation treatments necessary to ensure the physical stability and integrity of the paleontological resources prepared by the principal paleontologist.

g. Curate the paleontological resources to ensure adequate scientific documentation of the circumstances of their recovery.

i. Make reference to Metro's participation when the Collection or portions thereof are exhibited, photographed or otherwise reproduced and studied in accordance with the terms and conditions of Museum policy with the statement: "In Cooperation with the

Federal Transit Administration and Los Angeles County Metropolitan Transportation Authority". The Museum agrees to provide the Agency with copies of any resulting publications.

3. **Paleontological Advisory Board**

The Parties agree to mutually appoint a three person Paleontological Advisory Board comprised of appropriately qualified paleontologists to help guide this effort as previously agreed by the Parties in their Paleontological MOUs for this site in 1983 and November 2, 2011.

**IN WITNESS WHEREOF**, the Parties hereto have executed this Amendment No. 1.

| | |
|---|---|
| _______________________________________ | __________________________ |
| Dr. Jane Pisano<br>President and Director<br>Los Angeles County Museum of Natural History | Date |

Approved as to form:

| | |
|---|---|
| _______________________________________ | __________________________ |
| MARY C. WICKHAM<br>County Counsel | Date |

By: _____________
Deputy

| | |
|---|---|
| _______________________________________ | __________________________ |
| Phillip A. Washington<br>Chief Executive Officer<br>Los Angeles County Metropolitan Transportation Authority | Date |

**ATTACHMENTS**

Attachment 1. Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

Attachment 2. Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

Attachment 3. Wilshire/Fairfax Station Construction Methodology

Attachment 4. Paleontological Resources Monitoring and Mitigation Plan

# ATTACHMENT 1

# Attachment 1—Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

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# ATTACHMENT 1

## Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

# Paleontological methods for mitigation of fossils in the vicinity of Hancock Park.



Images courtesy of ArchaeoPaleo Resource Management, Inc.

2011

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# Introduction

Rancho La Brea is the world's richest Ice Age fossil locality, yielding well over 3 million fossils and representing more than 600 species of animals and plants that lived in the Los Angeles Basin between 11,000 and 50,000 years ago. The asphaltic fossil deposits generally occur in randomly distributed inverted cone-shaped masses between 10 to 35 feet in depth. The sizes of the accumulations vary considerably from less than 5 cubic feet to more than 20 cubic feet. Flat tabular deposits such as that recovered during the construction of the Page Museum are rare. Ideally, the fossil accumulations should be carefully excavated as they are discovered. The fall back position is to remove the deposit intact, preserving it for excavation at a later date. This methodology, developed during the mitigation of the LACMA underground parking structure, preserves stratigraphic integrity, permits less hurried excavation under more optimum conditions, maximizes fossil and information retrieval, and enhances opportunities for major discoveries and new scientific contributions. All data pertaining to the location and condition of newly discovered fossil deposits must be recorded and photographed as outlined later in this document.

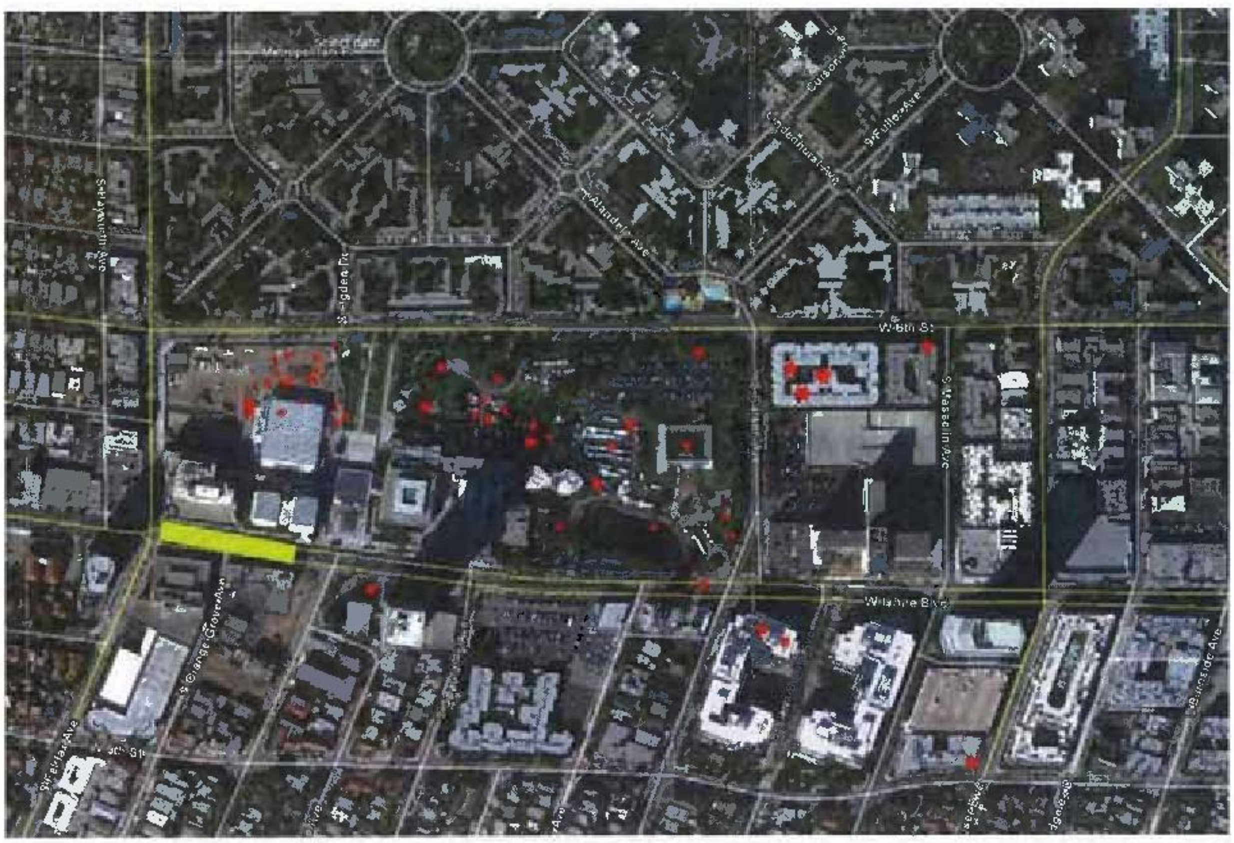

**Fig 1: Map of Hancock Park** and vicinity with known asphalt preserved fossil localities (red stars) and the approximate location of the proposed MTA subway station (yellow rectangle)

## Fig 2: Monitoring

All excavation activity must be carefully monitored. In areas of asphaltic sediment or other areas where fossils have been discovered, sediment should be removed in 4-6" levels while paleontologists monitor closely. The monitors are empowered to halt the process as soon as fossils are located.

**Fig 3: Fossils are discovered**

After a fossil deposit has been located the surrounding area must be roped off so that paleontologists can determine the extent of the deposit or if it is an isolated fossil. In the case of an accumulation deposit this may range from 5 feet to 20 or more feet across. Construction work in the immediate vicinity of the fossil deposit must be halted temporarily but may proceed normally elsewhere in the construction site. Asphalt saturated conical shaped deposits and isolated fossil mitigation are described separately below.

## Taking Field notes

Whether an accumulation of fossils are discovered or an isolated fossil is found, detailed field notes must be taken. The precise locality of each fossil deposit must be recorded with a resource-grade GPS device, its extent clearly described, mapped, and photographed on site using conventional field data collection methods, and its context including represented lithologies and depositional environments must be described. Types of geologic information to be collected should include: the nature of bounding contacts (erosional, sharp, gradational), thickness, geometry, grain size, shape, and sorting, color (fresh and weathered, use a color chart), sedimentary structures (physical and biogenic), cement type, pedogenic features (rooting, nodules, slickensides, etc.), halos, mineral crusts, microstructures around bio-clasts, and other fossils. Types of taphonomic information to be collected should include: taxonomic

representation, skeletal articulation and association, scale and geometry of assemblage, density, and orientation of bones. Bone modification information to be collected should include: weathering, polishing, abrasion, scratch/tooth marks, root traces, borings, fragmentation/breakage, and distortion. Each isolated fossil and each individual fossil deposit must be given an individual field number. This number should be written in permanent ink on individual fossils and clearly marked in permanent marker or paint on the box containing a deposit.

## Asphalt saturated conical shaped deposits

**Fig 4: Pedestal a deposit**

Once the extent of the fossil accumulation has been determined, the sediment surrounding the fossiliferous deposit is carefully removed, isolating the accumulation on a pedestal. It may be necessary for monitors to wear a SCBA, as in this image, because of the high concentrations of hydrogen sulfide.

**Fig 5: View of east end of LACMA construction site**

It is possible that there will be a number of fossil deposits within the construction site. Work may continue at non-fossiliferous locations while the deposits are being salvaged.

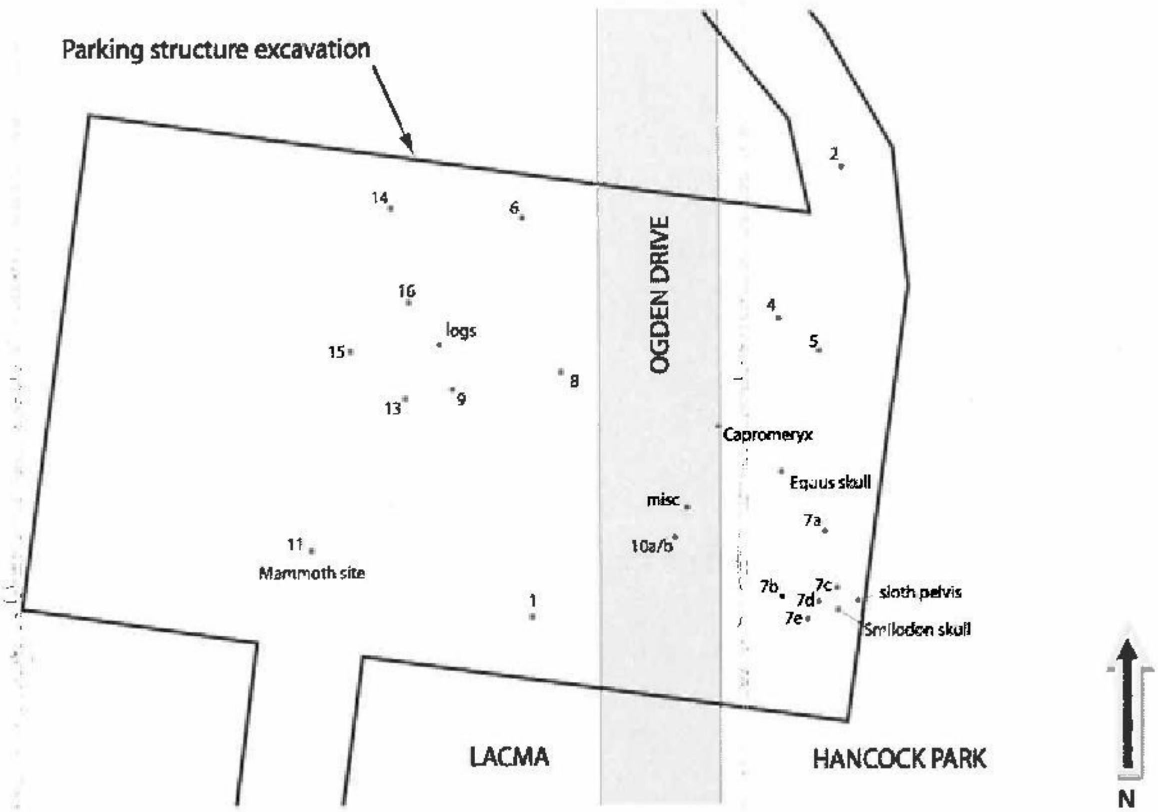


**Fig 6: Map of fossil localities from LACMA parking garage**

These were mostly asphaltic fossiliferous masses but included some occurrences of isolated bones, trees, and other fossils.

**Fig 7: Fossil accumulation pedestals before tree box**

After the deposit has been isolated it will be surrounded by metal bands to conserve its integrity before the box is built and a brightly colored strong plastic or a tarp to keep the deposit dirt separated from the 'fill' dirt.

## Fig 8: Building a tree box around a fossil deposit

A custom sized box is then built around each deposit by a 'tree boxing' company. Valley Crest was used on the LACMA project. Any space between the plastic-wrapped deposit and the edge of the box must be filled with polyurethane foam, distinctly different sediment or gravel to preserve the integrity of the deposit and to prevent its deformation during subsequent transportation and storage. It is important that the 'fill' sediment be easily recognizable from the matrix during later excavation of the deposit.

**Fig 9: Secure the tree box with metal bands**

After the sides of the box are nailed into place, metal bands are added to secure and strengthen the sides of the box.

**Fig 10: Tunnel under the tree box**

After the sides of the box are secured and banded, the sediment beneath the box is removed by tunneling so that the box floor can be constructed. The field number and locality data must be clearly written on the outside of the box in permanent marker or paint. The orientation of the box and the depth below datum of the top and bottom of the deposit must also be clearly and permanently marked on the box, as well as added to the field notes for that deposit.

**Figs 11, 12 & 13: Relocating the tree boxes by crane and truck**

A crane is used to lift the completed boxes, load them onto a flat bed truck, and to relocate them to the place where their excavation will take place.

## Isolated fossils

In addition to conical and flat tabular asphaltic accumulations, construction activities may encounter isolated fossils in non-asphaltic or asphaltic sediments such as the trees, mammoth skeleton, and bison and horse skulls that were discovered during the recent construction of the LACMA's underground parking structure. Similar procedures pertain. The area must be roped off in order for the monitors to determine the extent of the fossil occurrence, which may then be removed using conventional paleontological field techniques. Large or fragile bones must be pedestaled (with sediments immediately surrounding the fossil) and covered in a plaster and burlap jacket. The type of plaster used determines the time it takes to dry. Once the plaster is dry, it is flipped over and the other side is covered with plaster and burlap and left to dry completely. In the meantime paleontologists need to determine the extent of other isolated fossils in the area looking in particular for other elements of the skeleton of the jacketed specimen or sediments in which microfossils such as rodent, bird and reptile remains may occur.

It is crucial; that all isolated fossil occurrences be given a field number, their location recorded with a resource-grade GPS device, and these data entered into the field notes together with a map and description of the fossil, its orientation and its locality including description of the lithology in which the fossil was preserved. Standard guides such as Munsell Soil Color Charts should be used. The field number should be clearly and permanently affixed to the fossil and written on its container or jacket as appropriate. Maps must have a legend and scale to the show the orientation and depths of each fossil as well as a datum point. In addition to the field number, plaster jackets should also be marked "field side up" on the appropriate surface.

**Fig 14: Excavating isolated fossils**

Paleontologists need to excavate around large bones with hand tools before covering them with a protective plaster jacket for later removal and transport.

**Fig 15: Mammoth discovered**

This image show the mammoth locality in the context of the construction site during the LACMA underground parking garage.

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# ATTACHMENT 2

# Attachment 2—Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

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# ATTACHMENT 2

## Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

# Techniques for excavation, preparation and curation of fossils from the Project 23 salvage at Rancho La Brea.

A MANUAL FOR THE RESEARCH AND COLLECTIONS STAFF OF THE GEORGE C. PAGE MUSEUM



2011

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# Introduction

This document was compiled mid project to record and codify best practices for excavation, preparation and curation of specimens from Project 23 and other Rancho La Brea localities that are housed in the George C. Page Museum. Some of the techniques are similar to Pit 91 excavations that were reported by Shaw (1982) and others that are unique to Project 23 because of the nature of the salvage. This provides guidelines for possible future salvage efforts. Documents discussing the nature of the mitigation are available elsewhere.

# Excavation Techniques for Project 23

Excavation of Project 23 deposits began in August, 2008. The measuring techniques used to determine and record data for *in situ* specimens follow those of Shaw (1982) for Pit 91 with some modifications described here (for instance, the imperial measurement system was used prior to Project 23). New excavation procedures have also been devised as a result of the removal of the deposits from their original location due to construction.

In Project 23, a custom-sized wooden box was built around each isolated plastic-wrapped deposit by a 'tree boxing' company (Valley Crest was used for this particular project). Any space between the deposit and the edge of the box was filled with either polyurethane foam or sediment to preserve the integrity of the deposit and to prevent its deformation during subsequent transportation and storage.

Because the deposits are no longer *in situ*, all excavation grids are oriented with respect to the deposits' original north orientation. Where feasible, box walls may be removed in part or in their entirety to allow excavation from the side of the deposit rather than from the top. Each "tree box" from Project 23 is treated differently depending on the type of deposit, size of the box and integrity of the sediments in the box. Refer to paleo mitigation protocol and ArchaeoPaleo report documents for descriptions on how the 'tree boxes' were constructed.

## Preparing a tree box for excavation

First read all the field notes pertinent to that particular deposit. In a field notebook or deposit logbook document the nature of the "box" size, construction, fill, plastic, etc. If the box is taller than 5 feet, erect scaffolding for excavators to safely access the box. Depending on the size of

the tree box it may be necessary to construct a safety railing extending upward from the sides of the box. After the top of the box is safe to access, remove the metal bands that are strapped across the top of box. Use specific snips if recommended by the tree boxing company. Remove supportive fill dirt, foam and plastic to reveal deposit surface, taking care to maintain an appropriate area for excavators to work safely.

Depending on box stability and size, board walls or portions of board walls may be removed to enable excavation from the side of the deposit. Smaller boxes containing deposits with cohesive sediments may allow the removal of all sidewalls. For larger boxes, removal of one wall or a small "window" cut into a sidewall may be feasible.

Before any asphaltic sediment is removed, set up a gas monitor close to where work will be conducted. The Solaris Multigas Detector is an economical, 4-gas instrument providing simultaneous detection of CO, O2, H2S and combustible gas and costs ~$600 from Safety Tek Industries.

## Grid layout

Determine the deposit's north side from field data and data written on the box.

Establish a datum point near the top of the box and record it based on field data. The datum point should not be removed during excavation.

Lay out grids into 1m x 1m squares with origin in the SE corner of the box using an alphanumeric system (N/S = A-Z; W/E = 1, 2, 3). Gridlines can be marked with string, spray paint or chalk and need to be refurbished and maintained periodically. A map of the box showing the grid lines and a north arrow should be drawn for reference.

## Excavation and Documentation

After grids are established, clean surface to remove fill dirt, to determine sediment type and to locate fossils if exposed. Note nature and location of fossils (bones, shells, plant remains, etc.)

Excavate grids in 25 cm spits (i.e. Level 1=0cm-25cm, L2=25cm-50cm, etc). If multiple grids are worked on at the same time, ensure that this doesn't compromise the mapping of each spit wall and floor. If a deposit has been exposed from the side, the spits in any one grid may be excavated sequentially from the top to the base of the deposit.

Depending on degree of consolidation, use small hand tools (hammers, chisels, and screwdrivers as required) on non-fossiliferous areas. Pneumatic or electric hammers can be used on areas with hard matrix where there are no fossils. Use dental picks and small screwdrivers to expose and extract fossils. Hard asphaltic matrix can be softened with clamp lamps or loosened with a small amount of solvent. Measure exposed fossils *in situ* (see below) within each grid and record their data in field notes before extracting them.

Note: Clamp lamps should be placed at least 8" away from the specimens and always monitored. Never leave lamps unattended. If the sediments start to smoke immediately turn off the lamp. 150 watt incandescent unfrosted bulbs should be used.

Save all of the surrounding sediments but separate them based on sediment type into 5 gallon metal buckets with lids. The pre-designated sediment types are A= asphaltic sand, B=brown silts and C=clay. Mark each bucket with box #, grid and level data as well as the sediment type (A, B or C). Note the number of buckets of each sediment type from each grid on an inventory list kept by the lead excavator. This is important because it determines how each bucket is processed later (see matrix processing section).

Keep daily documentation in field notes of who is excavating, a list of the grid or grids being excavated and describe the type of matrix being removed, what is being found within each grid, and any challenges encountered with the excavation. Geologic and paleobiological data should be recorded in field notes for later use to constrain and further refine taphonomic, paleoenvironmental, and paleobiological interpretations. A description of each lithology (soil type) should include color (fresh and weathered), lithologic composition, grain size, sorting and shape, sedimentary structures, induration, type of cement, fossil content, and pedogenic features (rooting, nodules, slickensides, etc.). As excavation proceeds note unit thickness, nature of the bounding contacts (erosional, sharp, gradational), and inferred depositional setting. Note nature and location of fossils (bones, shells, plant remains, etc.). Any visible modifications to the bones (weathering, polish, abrasion, scratch/tooth marks, root traces, borings, pitwear, breakage, distortion) and gross orientation should be recorded. Features of the matrix surrounding the bones, such as alteration halos, mineral crusts, micro-structures, fine root traces (small burrows or borings), and localized invertebrate bioturbation should be noted. The degree and nature of articulated, semi-articulated, associated, and dissociated skeletal elements should be described. Notes should also be taken on the general geometry of the fossil deposit (vertical pipe, tabular, etc.) drawings and/or photographs should be taken when appropriate.

## Measurement system

The most common types of macrofossils recovered from asphaltic deposits are isolated bones. The following measurement system has been devised for capturing data for individual bones.

See the Special Cases section for the treatment of associated skeletons, dermal ossicles, plant masses, etc.

*In situ* measurements are taken from specific anatomical points on each bone (see Table 1 and 2 Appendix A) to define its spatial orientation with reference to its depth below an established datum point (BD), its distance north (N) of the southern grid line and its distance west (W) of the east grid line using the metric system (see Fig 1. of Shaw (1982) but note this uses the imperial measurement system). Recording this data at the time of excavation will facilitate studies of stream current energy and direction, deposition, and taphonomy.

All identifiable bones from 1 cm to 2 cm in size should be measured *in situ* as a 1-point measurement before being excavated. Each Standard Measurement (BD, N, W) is taken to the center point of the longest dimension (Fig. 3)

Bones larger than 2cm in minimum length or diameter should be measured as either a 2-point or a 3-point measurement. The 3-point measurement is used on all bones in which three predetermined identifiable anatomical points are visible. The 2-point measurement is used if the bone lacks three distinct reference points and records the orientation of the long axis of the specimen (proximal-distal, anterior-posterior, medial-lateral, etc.). Detailed instructions for measuring out specimens are provided by Shaw (1982), which also lists the elements that generally fall into each of these categories.

All the data pertinent to the specimen should be recorded in the field notebook and should also accompany the specimen until its preparation and curation have been completed. One method of doing this is to duplicate the field notebook entries onto a 3" x 5" card using carbon paper (Fig 1, 2 and 3 below). This card then accompanies the specimen throughout its preparation, curation, and final cataloging. Only when the data have been recorded in the catalog are they separated.

In addition to measurements on individual bones, the dip of all limb bones and skulls should be recorded with a Brunton compass. Recording these data at the time of excavation will assist with interpretation of stream current energy and direction, and taphonomy which may include possible vertical movement in a vent, trampling, etc.

The soil type surrounding each measured bone should also be noted on the 3" x 5" card by a letter using a pre-designated lettering system. The pre-designated sediment types are A= asphaltic sand, B=brown silts and C=clay.

After a bone has been measured *in situ*, it is placed in an appropriate sized clear plastic bag. The 3" x 5" data card is placed in its own small clear plastic bag for safety and then placed in the bag with the bone.

**Fig 1: Example of excavation data for a 3-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-14 B3/L4

| | GT | Px | Dt |
|---|---|---|---|
| BD = | 58cm | 53cm | 64cm |
| N = | 31cm | 35cm | 31cm |
| W = | 13cm | 10cm | 90cm |

*Canis dirus* femur

Soil type= A
Dip=30°SW
Excavator initials and date

**P23-14 = Project 23-Box 14**
**B3/L4 = grid B3/level 75cm-100cm**

**GT = Greater Trochanter is 58cm below datum, 31cm from the south grid axis and 13cm for the east axis**
**Px = Proximal end is 53cm below datum, 35cm from the south grid axis and 10cm from the east axis**
**Dt = Distal end is 64cm below datum, 31cm from the south axis and 90cm from the east axis**

**Soil type A= asphaltic sand**

**Fig 2: Excavation data for a 2-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-1 B1/L2

| | Px | Dt |
|---|---|---|
| BD = | 53cm | 64cm |
| N = | 35cm | 31cm |
| W = | 10cm | 90cm |

Canid juv. radius

Soil type= B
Dip=1°SW
Excavator initials and date

**P23-1 = Project 23-Box 1**
**B1/L2 = grid B1/level 25cm-50cm**

**Px = Proximal end is 53cm below datum, 35cm from the south grid axis and 10cm from the east axis**
**Dt = Distal end is 64cm below datum, 31cm from the south axis and 90cm from the east axis**

**Soil type B= brown silt**

**Fig 3: Excavation data for a 1-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-5B D3/L7

BD = 20 cm
N = 10cm
W = 15cm

Rodent tooth

Soil type=C
Excavator initials and date

**P23-5B = Project 23-Box 5B**
**D3/L7 = grid D3/level 150cm-175cm**

**20cm below datum**
**10cm from south gridline**
**15cm from east gridline**

**Soil type=clay**

Specimens smaller than 1 cm, fragments, or unidentifiable smaller bones are placed into "bulk matrix bags" together with field data cards (P23-deposit # and grid/level information, excavator initials and date). Because they are known to contain fossils, the bulk matrix bags will be processed before the rest of the matrix samples. Keep associated fragments together in capsules or envelopes within the bag. Be sure to always place delicate bones into snap cap vials first and then into a clear plastic bag with their data. If a fossil is not in place, identify it and label it "not *in situ*"

## Special cases

Each special case requires consultation by lab and collections staff to assess the best way of documenting each potentially unique occurrence.

- An articulated or associated skeleton should be extensively photographed. If, after consultation with Lab and collection staff this is removed as a small block, be sure to place a white pin in the top surface along the northern middle portion of the block so that it can be oriented later. Draw and annotate a diagram of the block and the elements that are visible on each surface before it is removed. Measure out the block as a 2-point measurement. Elements within the block that can be identified and measured without compromising the specimens should be also noted and can be measured using the 1 or 2-point measurement system but should not be removed from the block. Labeled copies of all photographs should be placed in the bag with the specimen. This is additional to downloading the photographs to the archive computer (see photography section). Articulated or semi-articulated specimens should be extracted in articulation and the sediments around the specimens stabilized to conserve the maximum amount of information derivable from the specimen.

- Bone masses with poorly preserved specimens (fragmented and/or less asphalt-impregnated) are more difficult to measure out individually. Measure out the extent of the mass with the 2-point system rather than the constituent bones. Place a white pin in the top surface along the northern middle portion of the block so that it can be oriented later. Photograph in situ specimens, print and label images and place them in the bag with the specimens.

- As instructed by Lab and collections staff, and depending on their nature and frequency, dermal ossicles and pockets of plant, shell or insect material should either be measured out as a small block with a 2-point measurement (same as above) or placed in pre-labeled bags with locality information for a specific 10cm square within the 1m x 1m grid.

## Geologic Samples

Collect 15 cm by 15 cm soil samples of each sediment type from each grid and level for geologic analysis of composition, weathering, and grain size at a later date. Document each sample in your notebook and measure each one *in situ* as a block using the 2-point measurement system used for fossils and described above. Each sample should have a white pin placed on the upper surface in the northern middle portion of the sample so that later the sample can be oriented. Transcribe all data onto a 3" x 5" card and place in a clear plastic bag with the soil sample. A list of soil samples taken should be kept by the lead excavator for each grid and deposit.

When spits are completed, photograph and map each exposed wall and the floor.

## Floor and Wall mapping

When mapping a wall or floor (Fig. 4, 5 and 6)

- Draw maps on graph paper with a scale of 3 squares = 10 cm.
- Keep the origin point (0, 0) in the southeast corner.
- Mark north arrow.
- Draw in empty spaces and the edge of the box when present.
- Mark asphalt and sediment contacts.
- Use standardized symbols for lithologies and other known sedimentary features. Also
- Indicate where fossils, cobbles, bone, shells and plants masses are located (Fig 4).

**Figure 4: Standard symbols used in mapping each grid's floor and wall**

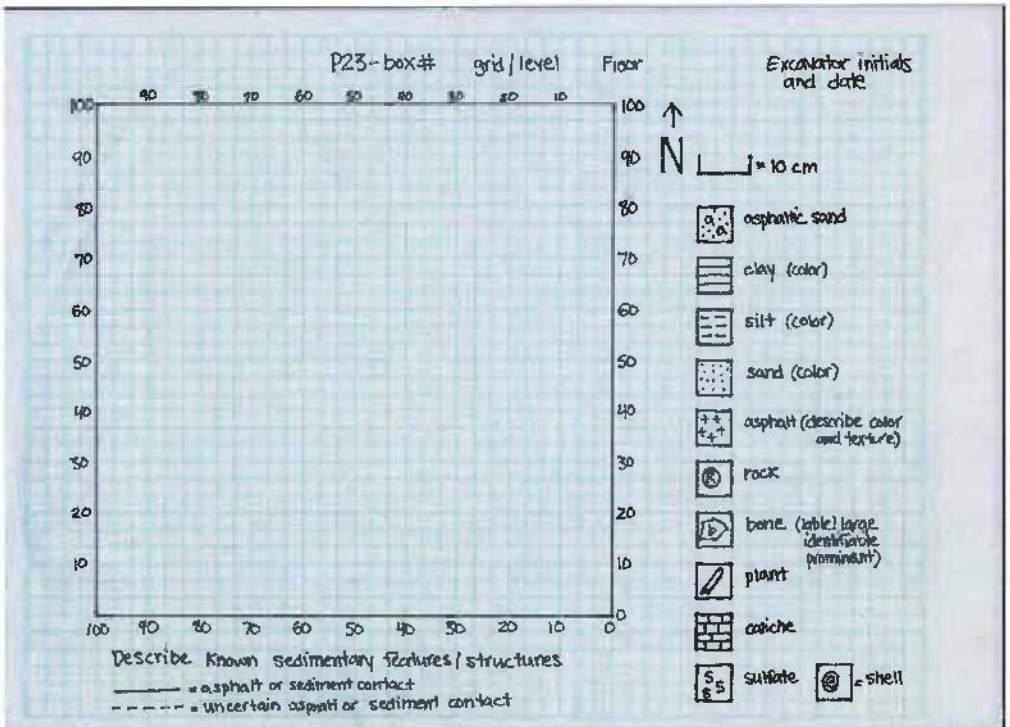



**Figure 5: Sample drawing of the floor of grid C3/L3 of box 14**

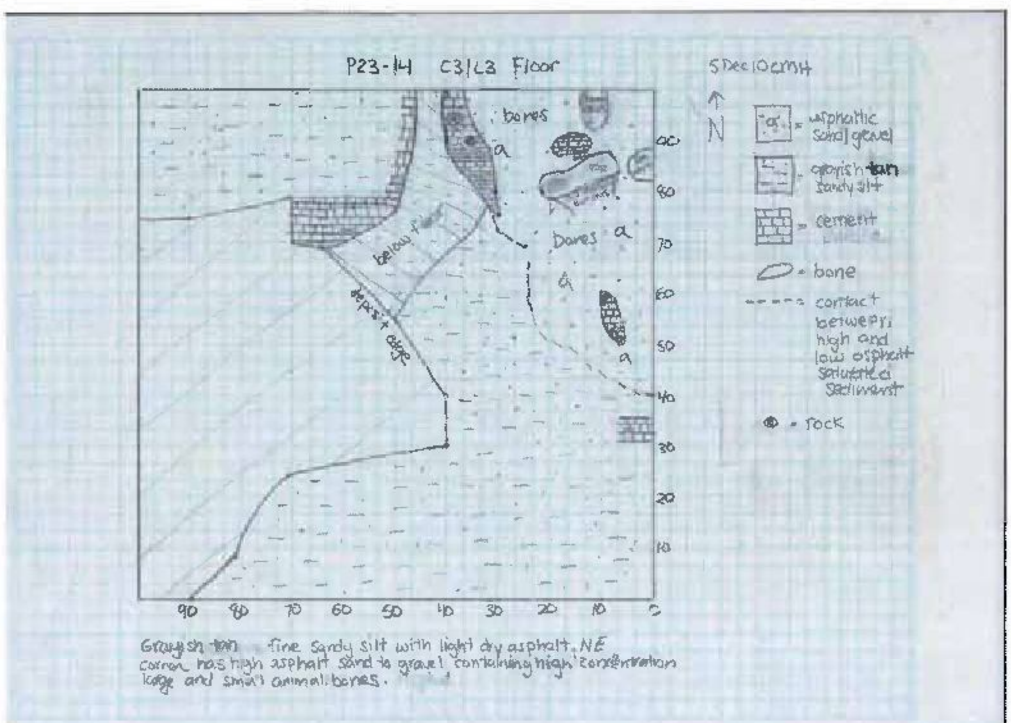
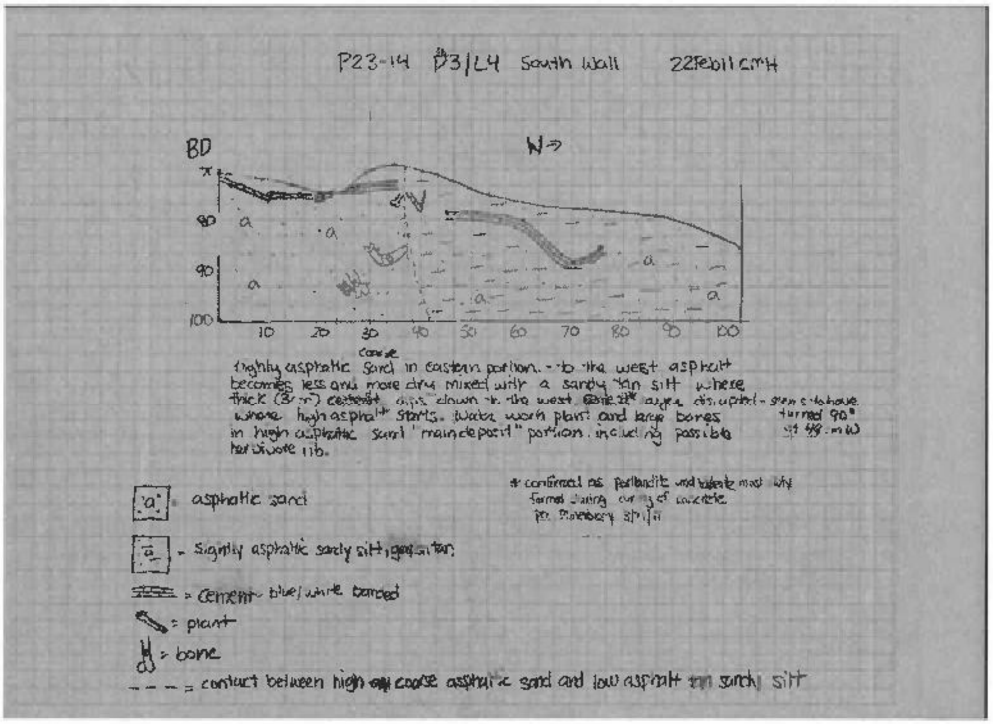


**Figure 6: sample drawing of the south wall of grid D3/L4 of box 14**




## Photography

Photo documentation and the labeling of downloaded images are very important. In the field photo logbook provided, record all the images that you take. This is shared by everyone and has columns for name of photographer, date, box #, grid and level, orientation of image, file number and special notes. Take a photograph whenever it might be useful for lab staff and researchers to see how a specimen was oriented in the ground, broken in a certain way or for any other unusual circumstance. Always photograph the floor and each wall of a grid before starting a new one.

When photographing a specimen:

Write the project name, box #, grid and level #'s, orientation, description of what you are photographing, the date and excavator initials on a 3"x 5" card with a black sharpie and place next to the object you are photographing.

For example:

P23-14 C3/L3

Skull , ventral view ↑

N

Excavator initials and date

Print the photo as soon as possible and place it in the bag with the specimen. This may not be necessary for all the images of *in situ* specimens, so make a judgment call here.

When photographing a floor or wall:

- Write the project name, box #, grid and level #'s, orientation, the date and excavator initials on a 3"x 5" card with a black sharpie.

For example:

P23-14 C3/L3

South Wall ↑

Excavator initials and date N

- Place meter sticks in north and west orientation.
- Take a picture of each exposed wall and floor with the card and meter sticks in frame so as not to cover up any significant features and so the information on the card can be used to tag the photograph in the database.

Download all photographic images to the archive computer and place in the folder "to be sorted" under My Pictures\Project23 under the project 23 login. Rename your files appropriately so that they can be retrieved, tagged in Adobe Bridge and added to the EMu database. This is where the photo logbook will be useful. Each image should be named with the following conventions in order to be searchable in the database:

1. If it is a photo of a grid and a level then name it P23-1 B1 L2 where P23-1 refers to the Box number, B1 refers to the grid and L2 refers to the level. Notice a space between P23-1 and B1 and also between B1 and L2. This is on purpose and helps the database find the files. If there is no level just enter the information that you have.
2. If it is just an image of several grids just name it with the box number e.g. P23-14.

3. If it is a photo of a possible associated skeleton or a specimen in the ground include some more information such as what it might be e.g. P23-1 B1 L2 bird skeleton

## Data entry of field notes

Write field notes in pre-bound notebooks. For each day compile a daily journal that includes notes on the weather, who was working, general work done that day, grids being worked on, etc. as well as geological information on open grids and specimen measurements. On a weekly basis all excavation notes, photographs and grid drawings will be captured electronically.

- Type journal entries into word documents with each day saved as a new file. The naming convention of the file should be "project yearmonthday initials" (e.g. P23 20090201 ABF). Within the word doc file at the top of the page type the initials of the excavator and the date. This serves as a search tool for the database. Save these to the flash drive that is provided. The Collections Manager will import these data into the database.
- Type specimen measurement data into a pre-prepared Excel spreadsheet and save to the flash drive provided. The Collections Manager will import these data into the database.
- The floor and wall drawings and photographs for each grid must be scanned and downloaded onto the archive computer at the Page Museum.

## Matrix processing

There are two different ways that matrix from the excavation is processed. All asphaltic matrix from or adjacent to asphaltic bone concentrations needs to be processed with solvent in a vapor degreaser in order to release small bones and other plant, insect, invertebrate and vertebrate remains from the asphalt. After degreasing, the matrix is dried and dry screened to remove the clay-to-silt fraction. The remaining concentrate is sorted for microfossils under a microscope.

Samples of other (apparently non-fossiliferous) non-asphaltic sediments are screen-washed in water on 20 mesh screens and the concentrates are sorted for microfossils under a microscope. If there is no evidence of microfossils in the sample, the remaining material from that facies of that grid may be discarded (except for the 15 cm archival cube that was collected during excavation of the grid).

# Laboratory Protocols

All material sent to the Lab for cleaning is triaged to resolve appropriate methodology, account for the skill level of available lab workers, and for research and collection priorities. An n-propyl bromide solvent is used to remove asphalt from the bones. Trade names for this solvent include Lenium, GenTech and EcoMax. Elmers white glue is used to repair broken bones and Acryloid (Paraloid) B-72 (Ethyl methacrylate copolymer) is occasionally used to consolidate dry bones.

## Prioritize new specimens

1. For cleaning method
   - Sort and store by locality, grid, depth.
   - Sub-sort by best cleaning method: ultrasonic, soaking, or hand prep.
2. For significance
   - Rareness of taxon
   - Incomplete section of previously excavated specimen
   - New element of known individual skeleton from that locality
   - Unrecognizable to element or taxon.

## Ultrasonic cleaning

Ultrasonic cleaning can be used for the following types of specimens:

- Complete or sturdy bones measured in individually (examples include *Smilodon* or *Canis dirus* carpals, tarsals, phalanges)
- Complete or mostly intact avian bones. The feasibility of processing other fragile bones, including broken small bones, should be assessed by the person who will be re-assembling them.
- Shells, insects, and concentrations of mollusks or insects from within known locality with measurements.

**Steps to be followed**

1. Place each specimen or sample in a baby food-sized jar with all contents of envelope.
2. With pencil, number the envelope and the top of the jar (on masking tape).
3. Prepare six jars as above.
4. Fill with solvent to an equal level in all jars.
5. Place in ultrasonic tank and fill with water up to the level of solvent in jars.
6. Buzz for fifteen minutes.
7. Strain contents of jar through 20 mesh screen on top of pitcher.
8. Rinse with clean solvent.
9. Check specimen or sample for matrix, detail with brush or skewer as needed.
10. Place each specimen or sample on separate paper tray, with flipped out matrix, data, and masking tape number from jar top.
11. Let dry over night, polish, and sort matrix.
12. Solvent that was strained into pitcher can be reused for setting up next batch of six jars if not too dirty.

## Pre-soaking

- Large bone masses: If there is no single identifiable bone, put it in a large jar or a bucket with more solvent than volume of mass. Mass may require a second rinse if solvent becomes too thick with asphalt.
- Unusually hard matrix: Put all of the specimen and loose matrix in jar with data taped to lid.
- Broken *in situ* specimens: If matrix is in internal structure of bone, soak and rinse.

## Hand preparation

- Individual specimens with positional data include vertebrae, ribs, long bones, etc. that are relatively complete.

**Steps to be followed**

1. Rubber stamp, date, and write the signature of preparator on back of data card.
2. Empty all contents of plastic bag or envelope into stainless steel pan.
3. Wet specimen with solvent from squirt bottle.
4. Scrub with tooth brush, dipped in small jar of solvent (n-propyl bromide)
5. DISOLVE MATRIX, DO NOT PUSH OFF WITH BRUSH OR OTHER TOOL.
6. Wood skewers or sticks can be used to loosen or nudge matrix off (If the stick breaks, the matrix is not soft enough yet)
7. When specimens appear clean, rinse thoroughly with solvent and immediately hold in front of vent for quick dry. Matrix still adhering to specimen will be black or darker than bone.
8. DENTAL TOOLS ARE TO BE USED FOR THE REMOVAL OF VISIBLE ROCKS ONLY!
9. When the entire matrix has been removed, place specimen, data card and jarred contents of metal pan matrix on paper tray lined with paper towels to dry.
10. DO NOT GLUE UNTIL ALL MATRIX IS SORTED.

- Multiple pieces of one specimen.
  1. Should be prepared by one person but treated as separate projects.
  2. Finished elements held until all parts are done.
  3. If glued, the part that goes with which data should be recorded in pencil on back of data card.
- Possibly associated elements of one individual
  1. Treat as above but can be cleaned by multiple preparators.
  2. Label for possible association with a known skeleton or a single other element. [more specific].

- Skulls
    1. External surfaces should be freed of larger associated specimens and gross matrix clumps using toothbrushes and solvent.
    2. DO NOT POKE IN EARS, NOSE OR BRAIN CASE.
    3. At the end of session, immerse in solvent in sealable bucket with copy of data on lid.
    4. Soak for two or three days.
    5. Hold skull over bucket and flush with clean solvent to remove loose matrix.
    6. Working in metal tray, nudge with skewers to loosen softened matrix and rinse off.
    7. Add removed matrix back into bucket.
    8. Replace skull in bucket at end of session.
    9. If the tympanic bulla is intact, nudge and rinse ear region over metal pan and process matrix separately for ear ossicles.
    10. When brain case and nasal region are mostly free of matrix, skull will not need to continue to soak and can dry between sessions.
    11. Strain contents of bucket.

## Polishing

- When specimen has dried overnight, go over small sections of solid bone with a dampened **soft cloth**, then go over the same space with a dry cloth. Exposed cancellous tissue should be blotted with a damp rag. Not rubbed!
- If there are small spaces that cannot be reached with a rag use a pipe cleaner or Q-tip. Dip it in solvent and blot off some liquid before applying. IF THE SPECIMEN GETS DARKER OR BEGINS TO LEAK ASPHALT, IT IS TOO WET. Put aside for a day and begin again.

## Processing Matrix from Individual specimens

- Processing sediment that has been soaked in solvent. (most common situation)

1. Pour contents through 20 mesh screen sitting on funnel into carboy.
2. Rinse with clean solvent.
3. With one motion, flip contents onto paper toweling on a paper tray.
4. Make sure everything is out of jar and out of screen.
5. Place tray near vent to dry.
6. When completely dry, sift and put in appropriate sized jar for later sorting.
7. If matrix appears clumpy after sifting, re-soak in solvent.
8. If matrix appears dirty with clay or silt after sifting, soak in hot water with a small amount (1 tsp) of detergent)

- Processing soaked in water sediment.
    1. Pour contents of jar through 20 mesh screen in a basin in the sink.
    2. Agitate the screen in clean warm water.
    3. Flip contents onto newspaper and leave screen on top to thoroughly dry.

## Microfossil sorting

When the matrix from an individual specimen is clean and dry it is ready for microfossil sorting.

Take the entire project (specimen, data and matrix) to a sorting station.

Do not pour out more matrix than you have time to sort. Only 1½ to 2 Tbs. may take several hours.

1. Sifting
    - Always sift matrix before sorting even if it was sifted before putting in a jar.
    - Sift through a designated 20 mesh screen with 2 inch sides.
    - Shake back and forth, (not up and down) over a paper towel.

- Empty contents of screen onto a clean piece of white sorting paper and shape matrix into a pile.
- Discard the fine soil that went through the sifter.

2. Sorting

- Examine matrix, several grains at a time, by moving it across the paper with a fine paintbrush.
- Create a "discard pile" for sediment and oxidized asphalt.
- Move bone, plant, shell and insect fossils into distinct piles on one side of the paper.
- Create a "questions" pile for indeterminate fossils.
- When the entire matrix has been categorized, review fossils and "discard pile".
- Have a staff person double check sorting.
- It may be necessary to examine some specimens under the microscope.

3. Temporary packaging of categories

a. <u>If all of the matrix of a individual project is sorted</u>

- Review bone and separate into three categories:
- 1. Broken pieces of the main bone (put aside for possible gluing);
- 2. Identifiable bones (put into individual capsules or plastic containers);
- 3. Unidentifiable bone fragments (put into one capsule or larger container).
- Review plant material (separate seeds and put into capsule) and put into glass vial.
- Review insect and put into one capsule.
- Review shell and put into one capsule.

b. <u>If only a portion of the matrix is sorted</u>

- Place complete identifiable bones in capsules.
- Place all bone fragments, plant, insect and shell into their own labeled containers.

When a large project is complete, all of the bone fragments must be reviewed and sorted to the above categories. It will be necessary to look at the small bone fragments under the microscope to determine the final number of Identifiable bones.

## Gluing

DO NOT GLUE UNTIL ALL MATRIX REMOVAL, POLISHING AND MATRIX SORTING IS DONE.

Use white glue for reconstructing most bones because it is reversible with warm water.

If a specimen is shattered, first reconstruct it holding the pieces together with masking tape. Do not glue until all of the fragments have been tested in available holes. Determine where all the major fragments go first and then glue from one direction. Have small strips of masking tape cut before the glue is applied. Apply glue with stick or dental pick in small amounts to the broken edges. Tape glued pieces in place and/or balance in sandbox for drying. Allow large pieces to dry overnight.

## Envelopes for finished projects

A copy of the original data must be made for every identifiable bone and one copy each for vial containing plant, insect, shell and unidentifiable bone. A rubber stamp template for "Found in assoc. w/" data is stamped on the face of a #5 ½ coin envelope. An exact copy of the original is then filled in. Note: Do not change the tentative field identification that is part of the original data even if it is wrong. The back of the envelope is stamped with a template for the scientific identification. If an "assoc. w/ bone "or the plant fragment is too large to fit inside an envelope, it should be put in a small plastic bag with an envelope. The envelopes are stapled shut and the entire project is put in one large plastic bag.

The finished bag should include the main bone, fragments of the main bone that could not be glued on, the original data and all the "associated with" specimens.

# Pre-Curation

After the specimens have been cleaned, the microfossils sorted and put into individual capsules and individual envelopes have been made for each specimen with all of the provenance data written on each envelope (see laboratory procedures) they are sent to the curation station. Identification of all of the fossils takes place near the comparative collection in the lab in order to facilitate identification. The principal measured out specimen with its original 3"x 5" field data card is identified first. The card is stamped on the back with a custom stamp with Scientific Name, Element, Identifier, and Notes. The specimen is identified as much as possible but identifications necessarily range from class identification such as Aves to genus and species. The identifier also describes the element according to an established list of bone terminology. Then each of the microfossils associated with that main bone are also identified in the same manner. After all of the microfossils that accompany that main specimen are identified, they are placed in a clear plastic bag with a twist tie and sent to the cataloging station. Below are detailed step-by-step instructions on how to identify specimens.

For each specimen follow the steps below in the order given.

1. Choose a specimen from the 'to be identified' box. If several envelopes are fastened together you must keep them together and complete the work on all of them.
2. Check the bone to see if it is clean and that all broken pieces have been glued if possible. If the bone is not clean then do not proceed with that one and send it back to the lab
3. Identify the bone using the reference collection and write the identification on the back of the envelope or card in pencil. Only use paperclips to join envelopes together.
4. Check to see if the main identified bone is in the original envelope or with the original 3" x 5" card.
5. Send identified specimen to be cataloged

- Always put the comparative bone back in the box it came from!
- if you find a 'found in association with' envelope which is not still with its original envelope, find the original envelope and fasten them together
- put all tools away and empty bags and containers

## Associated groups

If there is more than one specimen in an envelope the principal bone for which the measurements were recorded should remain in the original envelope. The other specimens should be treated as follows;

- all plants in one envelope
- all insects in one envelope
- all shells in one envelope
- each identifiable bone in a separate envelope, along with any of its broken pieces
- all unidentifiable bone in one envelope
- all difficult to identify bones in one envelope

Use envelopes stamped "Found in Association with" and make a complete copy of the information from the original envelope on each one.

## Identifiable and Unidentifiable Specimens

Identifiable bone characteristics:

- presence of an articular surface
- cross-sectional shape
- foramina
- distinctive curves
- relative size combined with other features

Bones are rated in three different grades of how easy they are to identify

- identifiable
- difficult to identify
- unidentifiable

Double check all identifications

## Identification of Specimens

The back of each envelope is marked with a custom stamp (stamp in bold below). Identifications are printed in pencil. An example below

- **Scientific name:** *Smilodon* (use both genus and species if more than one species)
- **Element:** prox. rt. tibia
- **Special Notes:** Pathology
- **Identifier:** ABF

1. Avoid using terms such as "frag" or "portion". Use prox. or dist. if appropriate.
2. You must not abbreviate scientific names but you may use abbreviations for the elements as long as they are the ones listed in this manual.
3. When identifying skulls and mandibles always list the teeth that are present and if they are erupting, fully erupted or worn.
4. The format of the identification is very important. Do not invert the word sequence e.g. prox. rt. rib is correct but rib, rt. prox. is not.
5. For incomplete bones name both the bone e.g. XIII thoracic vert and either the represented part e.g. centrum or the missing portion, e.g., w/o right transverse process. Make sure that the identity of the bone and its qualifier are both listed.
6. Be specific about the identity of any represented epiphysis, e.g., proximal or distal epiphysis of a limb bone, or head epiph of lt femur or ant cent epiph of thoracic vert.

7. Ordinal numbers of ribs, vertebrae, metapodials and digits are written in Roman numerals e.g. rt. II rib or XII thoracic vert

8. Number of phalanges and teeth are written in Arabic numerals e.g. 2nd phalanx or rt. M1. Note that abbreviations for upper molars are written in upper case letters (I, C, P, M) whereas those for lower teeth are written in lower case (i, c, p, m). For clarity of handwritten entries, put a line below the number for upper teeth (e.g. P4/) and a line above the number for lower teeth (e.g. m/1).

9. The side, either left or right comes before a number e.g. rt. II metatarsal

10. There are two special cases:

    - Phalanges that can be precisely named include sloth phalanges, carnivore 'thumb' phalanges and bird carpal phalanges e.g. rt. 1st carpal phalanx, digit I

    - Teeth which can be specifically named e.g. lt. p2

11. Skull fragments: if the facial or cranial region of the skull is mostly intact this can be recorded as 'ant' or 'post' skull. However if there are only a few fragments the individual bones are named e.g. basisphenoid, occipital and rt. temporal or indicate if some parts are missing, e.g. post. skull w/o rt. occipital.

12. Juvenile specimens: it is important to note if an epiphysis is missing as the order of ephiphyseal fusion is used to detect the age of an animal. Also mark "juv." in the special notes section of the identification.

## Abbreviations chart for elements

| | | |
|---|---|---|
| Left: lt. | Posterior: post. | With: w/ |
| Right: rt. | Ventral: vent. | Without: w/o |
| Proximal: prox. | Dorsal: dors. | Juvenile: juv. |
| Distal: dist. | Medial: med. | Pathological: path. |
| Anterior: ant. | Lateral: lat. | Unidentifiable: unid. |

Difficult to identify: diff.

Zygomatic: zygo.

Epiphysis: epiph.

Diaphysis: diaph.

Tuberosity: tub.

Trochanter: troch.

Articular: artic.

Vertebra: vert.

Transverse: trans.

Process: proc.

Centrum: cent.

Prezygapophysis: prezyg.

Postzygapophysis: postzyg.

Incisor: I (upper) or i (lower)

Canine: C (upper) or c (lower)

Premolar: P (upper) or p (lower)

Molar: M (upper) or m (lower)

Deciduous: D

## Dental formulae for Rancho La Brea fauna

Dental formulae are a short hand way of indicating the number and kind of teeth that are present. The upper jaw is indicated first and the teeth are in order: incisor, canine, premolar, molar.

Ruminant artiodactyls

0,0,3,3 / 3,1,3,3

*(Antilocapra, Bison, Capromeryx, Odocoileus)*

Camelids

*Camelops:* 1,1,2,3 / 3,1,1,3

*Hemiauchenia:* 1,1,2,3 / 3,1,1-3,3

Peccaries

*Platygonus:* 3,1,4,3 / 3,1,4,3

Horses

*Equus:* 3,1,3,3 / 3,1,3,3

Tapirs

*Tapirus:* 3,1,4,3 / 3,1,4,3

Dogs and bears

3,1,4,2 / 3,1,4,3

*(Arctodus, Canis dirus, Canis latrans, Urocyon, Ursus)*

Cats

3,1,3,1 / 3,1,2,1

*(Felis atrox: Felis concolor: Lynx)*

Sabertoothed cats

*Smilodon:* 3,1,2,1 / 3,1,1,1

Skunks, weasels, & badgers

3,1,3,1 / 3,1,3,2

- Tympanic bulla
- Vomer

**Auditory ossicles**

- Malleus
- Incus
- Stapes

**Mandible**

- Angular process
- Articular condyle
- Coronoid
- Symphysis

**Hyoid**

- Basihyal
- Ceratohyal
- Epihyal
- Stylohyal
- Thyrohyal

**Teeth**

- Permanent upper and lower. Upper denoted by upper case abbreviation and lower by lower case abbreviation.
    - Incisor – I (upper) or i (lower)
    - Canine – C (upper) or c (lower
    - Premolar – P (upper) or p (lower)
    - Molar – M (upper) or m (lower)
- Deciduous upper and lower. Upper denoted by upper case abbreviation and lower by lower case abbreviation.
    - Incisor – DI (upper) or di (lower)
    - Canine – DC (upper or dc (lower)
    - Premolar –DP (upper) or dp (lower)

**Vertebra (e)**

- Atlas
- Axis
- Caudal
- Centrum
- Cervical
- Lumbar
- Neural spine
- Odontoid process
- Postzygapophysis
- Prezygapohysis
- Sacral
- Sacrum
- Thoracic
- Transverse process
- Wing

**Ribs**

- Capitulum
- Shaft
- Tuberculum

**Sternum**

- Manubrium
- Sternebra
- Xiphisrernum

**Scapula**

- Acromium process
- Coracoid process
- Glenoid fossa
- Metacromion
- Spine
- Vertebral border

**Humerus**

- Deltoid tuberosity
- Entepicondylar foramen
- Greater tuberosity
- Head
- Lateral condyle
- Lateral epicondyle
- Lesser tuberosity
- Medial condyle
- Medial epicondyle

**Radius**

- Styloid process
- Radial tuberosity

**Ulna**

- Coronoid process
- Olecranon
- Semilunar notch
- Styloid process
- Radial notch

**Carpals**

- Cuneiform
- Trapezium
- Lunar
- Magnum
- Trapezoid
- Central
- Pisiform
- Unciform
- Radial sesamoid
- Scapholunar
- Scaphoid

**Metacarpal**

- Plantar tubercle

**Sesamoids**

- Proximal sesamoid
- Distal sesamoid

**Phalanges**

- 1st, 2nd, 3rd, 4th, 5th
- Carpal
- Tarsal

**Inominate**

- Acetabulum
- Iliac crest
- Ilium

- Ischial tuberosity
- Ischium
- Pubic symphysis
- Pubis

**Fabella**

- Lateral
- Medial

**Femur**

- Greater trochanter
- Head
- Lateral condyle
- Lateral epicondyle
- Lesser trochanter
- Medial condyle
- Medial epicondyle
- Neck
- Patellar track
- Third trochanter

**Patella**

**Tibia**

- Lateral condyle
- Medial condyle
- Medial malleolus
- Tibial tuberosity

**Fibula**

- Head
- Lateral malleolus
- Distal fibula (herbivore)

**Tarsals**

- Astragalus
- Calcaneum
- Cuboid
- Ectocuneiform
- Entocuneiform
- Mesocuneiform
- Navicular
- Sustentaculum
- Naviculocuboid

- Mesoectocuneiform

**Metatarsal**

- Plantar tubercle

**Non-articulating bones**

- Baculum (male)
- Dermal ossicle (sloth)
- Sclerotic ossicles (birds and lizards)
- Falciform (sloth)
- Tracheal ring (birds)
- Dermal scale (lizard)

**Variations for juveniles**

- Diaphysis – shaft of juvenile long bone
- Epiphysis – the unfused articular surfaces of juvenile bone

**Numbers**

- Ribs – roman numerals
- Metapodials – roman numerals
- Digits – roman numerals
- Phalanges – Arabic numerals—1st, 2nd, 3rd, 4th, 5th, terminal

## Curation

In order to curate specimens into the collections of the George C. Page Museum, all of the above-mentioned steps for excavation, preparation, and identification must be followed. The field number, orientation measurements, and pertinent field notes and photographs are all integral parts of the specimen information and must be readily available. Each specimen will receive an individual catalog number that is first recorded in an archival catalog book and then entered into the electronic database EMu, which is stored on the Natural History Museum's server. Once cataloged, each specimen is stored taxonomically in the collections. Specimens are housed in metal or wooden drawers within standard metal Lane cabinets. On average each drawer holds about seventy five specimens and each cabinet contains nine drawers.

Based on a typical deposit for Project 23, a 1m X 1m x 25cm grid yields approximately 1000 macro-vertebrate specimens per one (1) cubic meter. Additionally each cubic meter can have up to 2000 micro-vertebrate fossils. A typical conical shaped deposit can be up to 30 cubic meters.

## Appendix A

Table 1. Anatomical codes used for orienting specimens in the 2- and 3-point measurement system.

| | |
|---|---|
| A -- Anterior | Px -- Proximal |
| P -- Posterior | Dt -- Distal |
| M -- Medial | Lt -- Left |
| L -- Lateral | Rt -- Right |
| D -- Dorsal | R -- Root |
| V -- Ventral | C -- Crown |

Table 2. Anatomical codes of osteologic points used for orienting specimens in the 3-point measurement system.

## MAMMALS

**Skull:**
- AP - Anterior Premaxillae
- OC - Occipital Condyles
- POP- Postorbital Process (Rt or Lt)

**Mandible:**
- A - Anterior
- CP - Coronoid Process
- P - Posterior

**Vertebra:**
- AC - Anterior Centrum
- ANS- Anterior Neural Spine
- NS - Neural Spine
- PC - Posterior Centrum
- TP - Transverse Process (Rt and Lt)

**Rib:**
- Dt - Distal
- GC - Greatest Curve
- Px - Proximal
- Tub- Tuberculum

**Scapula:**
- AP - Acromion Process
- CP - Coracoid Process
- D - Dorsal
- PA - Posterior Angle
- V - Ventral

**Humerus:**
- Dt - Distal
- LEP- Lateral Epicondyle
- MEP- Medial Epicondyle
- Px - Proximal

**Radius:**
- Dt - Distal
- Px - Proximal
- RT - Radial Tuberosity

**Ulna:**
- CP - Coronoid Process
- Dt - Distal
- Px - Proximal

**Innominate:**
- IC - Iliac Crest
- IS - Ischial Tuberosity
- PU - Anterior Pubic Symphysis

**Femur:**
- Dt - Distal
- FC - Fovea Capitis
- Px - Proximal

**Tibia:**
- Dt - Distal
- Px - Proximal
- TT - Tibial Tuberosity

**Fibula:**
- Dt - Distal
- LM - Lateral Malleolus
- Px - Proximal

**Calcaneus:**
- Dt - Distal
- Px - Proximal
- S - Sustentaculum

**Metapodial:**
- Dt - Distal
- PT - Plantar Tubercle
- Px - Proximal

## BIRDS

**Skull:**
Same as Mammals

**Mandible:**
Same as Mammals

**Vertebra:**
- NS - Neural Spine
- TP - Transverse Process (Rt and Lt)

**Sternum:**
- A - Anterior
- CA - Carinal Apex
- P - Posterior

# ATTACHMENT 3

# Attachment 3—Wilshire/Fairfax Station Construction. Paleontological Resources Extraction

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WESTSIDE SUBWAY EXTENSION PROJECT

# Wilshire/Fairfax Station Construction. Paleontological Resources Extraction.

Metro

December 2011

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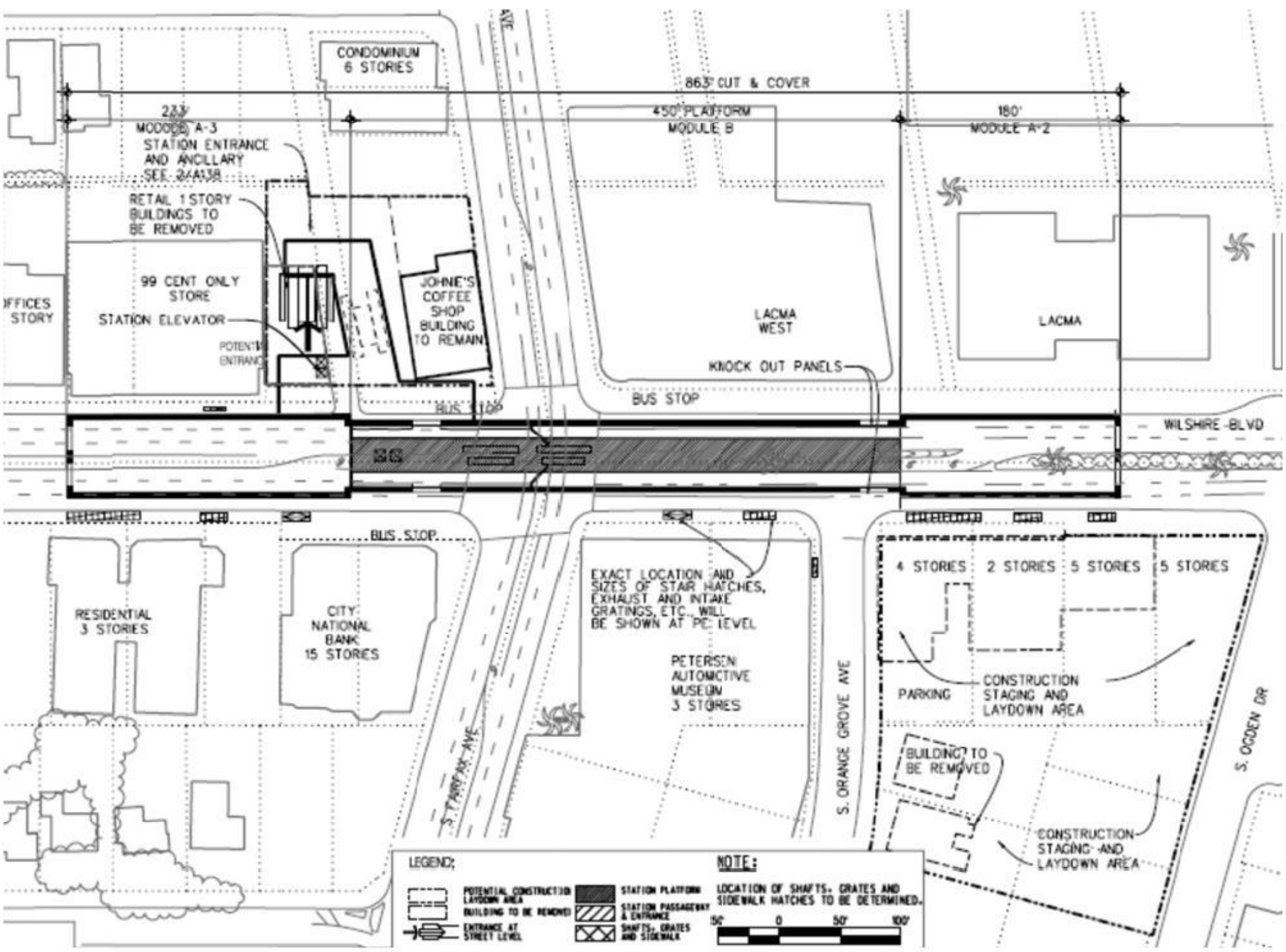
## Appendix

# 1.0 BACKGROUND

The Wilshire/Fairfax station box excavation will be approximately 860-ft long, 70-ft wide, and 60 to 70-ft below street level. The station extends beneath the intersection of Wilshire Boulevard and Fairfax Avenue - see Figure 1-1. The station entrance is planned to be located near the northwest corner of Wilshire and Fairfax between the 99 Cent Only Store and Johnie's Coffee Shop. Two alternative entrances under consideration; the south side of Wilshire between South Orange Grove Avenue and South Ogden Drive and; within the LACMA building at the north east corner of Fairfax Avenue and Wilshire Boulevard (May Company). A construction staging and materials laydown area is planned for the south side of Wilshire between South Orange Grove Avenue and South Ogden drive. Side access shafts will be located at the construction staging and materials laydown area and at the location selected for the station portal. The side access shafts will be excavated to the full depth of the station. The station box will be excavated by the cut and cover method and most probably use a temporary shoring system to support the excavation and decking system during construction, though a permanent shoring system that would be integrated into the permanent station structure could also be used. The side access shafts will be excavated by the open cut method and would most probably use the same type of shoring system that is used on the station box.

**Figure 1-1: Wilshire/Fairfax Station Box**



# 2.0 GEOLOGIC CONDITIONS

The geologic conditions in this region consist of soft alluvium deposits of sands, silty sand, clayey sand, gravely sand, silty clay, clayey silt, shell fragments, soil saturated with crude oil, and asphaltic (tar) sands. Several borings were taken within the station area; see Figure 2-1 through Figure 2-4. Core G-118 (Figure 2-1) was taken east of the station box between La Brea and Fairfax, the sample at 82-ft below ground surface (bgs) consists of silty clay/clayey silt with traces of crude oil. The portion of ring sample G-123 shown in Figure 2-2 is located just east of Fairfax at 60-ft bgs and consists of predominantly fine grained soil with channels of medium grained sand saturated with crude oil. Heavy tar was reported in G-123 from 38 – 110-ft bgs. Core sample G-124 (Figure 2-3 and Figure 2-4) was obtained just west of Fairfax by the Standard Penetration Test (SPT). The sample pictured was taken from 80-ft bgs and consists of medium to coarse grained sand saturated with tar. Heavy tar was reported in G-124 from 45 – 105-ft bgs. The consistency of tar in this region ranges from dry and hard to wet and oozing. This reach is also known to contain pockets of pressurized gases and dissolved gases in groundwater. The groundwater conditions are measured to have a water table depth of 74-ft bgs, and zones of perched water between 10 – 50-ft bgs. Since the station box invert depth will be located between 60 – 70-ft bgs, perched water can be anticipated during excavation.

**Figure 2-1: Core Sample G-118**

**Figure 2-2: Core Sample G-123**

**Figure 2-3: Core Sample G-124 (1 of 2)**

**Figure 2-4: Core Sample G-124 (2 of 2)**

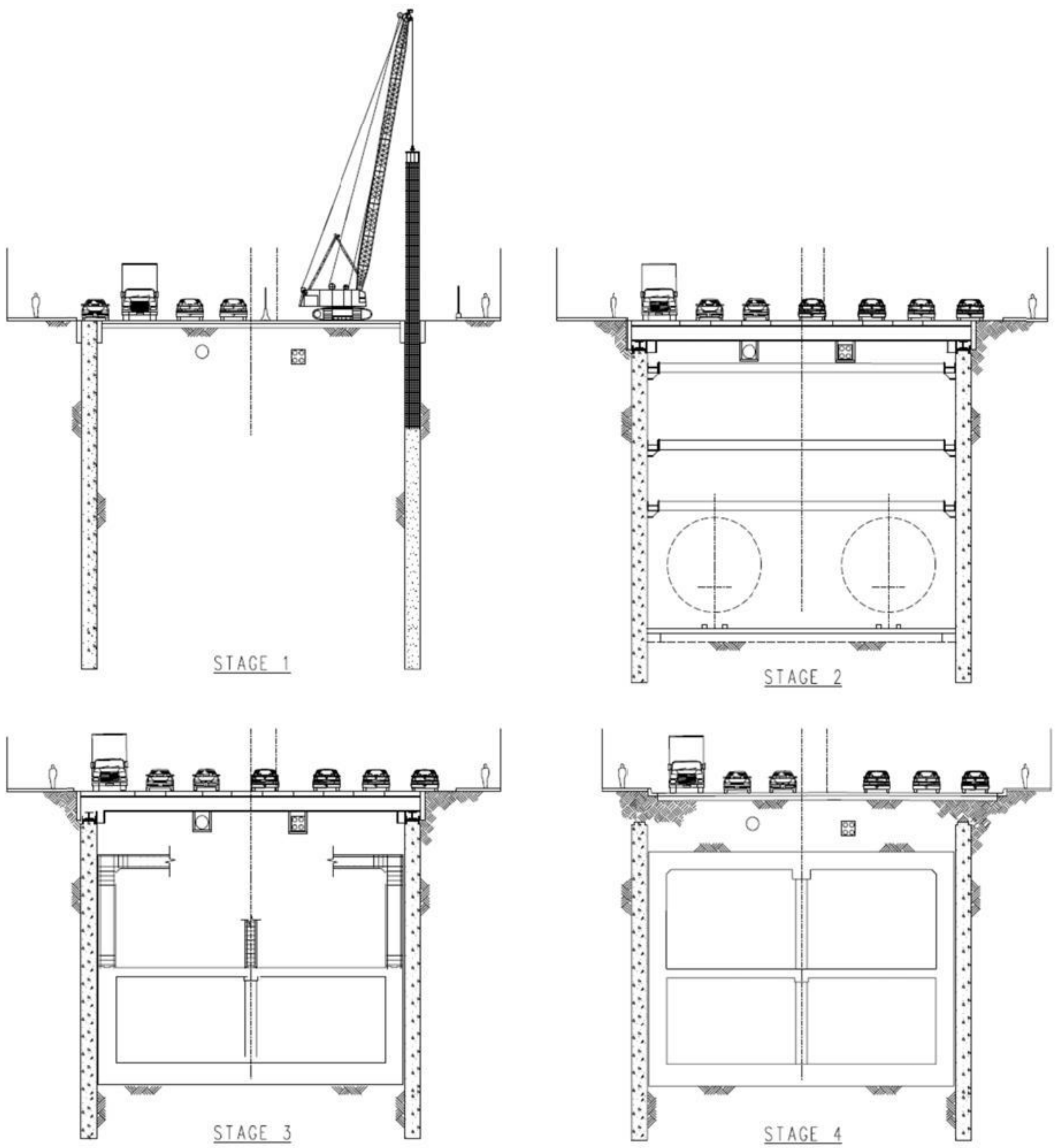
## 2.1 Gassy Ground Conditions

The gases present in the soils of this region are methane ($CH_4$) and hydrogen sulfide ($H_2S$). They are likely to occur in pressurized pockets as well as in a dissolved state in groundwater. These gases can seep into tunnels and other excavations through soil and also through discontinuities (fractures, faults, etc.) in bedrock. $CH_4$ and $H_2S$ are considered hazardous gases due to their explosive properties. $H_2S$ is also highly toxic. Being heavier than air, it tends to accumulate at the bottom of poorly ventilated spaces. Although very pungent at first, it quickly deadens the sense of smell, so potential victims may be unaware of its presence. $CH_4$ is extremely flammable and may form explosive mixtures with air. It is odorless and lighter than air, and it dissipates quickly once at the surface causing no threat of explosion. However, in 1985 an explosion occurred at the Ross Dress-for-Less in the Fairfax area which resulted in injuries requiring hospital treatment of twenty-three people. The explosion took place in a poorly ventilated ancillary room of the building where $CH_4$ gas had accumulated. There was no gas detection equipment at this location.

# 3.0 EXCAVATION SUPPORT TECHNIQUES

Cut and cover excavation is the preferred technique to excavate the station box structure, although cut and cover still leads to lengthy occupation of streets with noise disturbances and interrupted access (see Figure 3-1). Traffic interruptions can be mitigated by performing most excavation below a temporary decking system constructed at an early stage (See Figure 3-2 through Figure 3-6).

**Figure 3-1: Open Cut Excavation**



Shoring the excavation walls and providing structural support beneath the decking system can be accomplished through a variety of excavation support techniques. The following sections describe several excavation support methods, including: soldier pile and lagging, slurry walls, tangent piles, secant piles, and deep soil mix walls.

**Figure 3-2: Initial Excavation at Soto Station**


**Figure 3-3: Precast Concrete Decking**


**Figure 3-4: Installation of Decking (1 of 2)**

**Figure 3-5: Installation of Decking (2 of 2)**

Figure 3-6: Roadway Operations Restored on Temporary Decking System

## 3.1 Soldier Piles and Lagging

Soldier pile and lagging walls are a type of shoring system typically constructed along the perimeter of excavation areas to hold back the soil around the excavation. This support system consists of installing soldier piles (vertical structural steel members) at regular intervals and placing lagging in between the piles to form the retaining structure. Pre-augering is necessary for installation of the soldier piles. Pre-augering involves drilling holes for each pile from the street surface to eliminate the need for pile driving equipment and thereby reduces project noise and vibration levels that would otherwise occur while pile driving. Pre-augering also provides better accuracy of location than pile driving. The lagging, which spans and retains the soil between the piles, is typically timber or shotcrete (sprayed-on concrete) and is installed in a continuous downward operation taking place concurrently with excavation. The installation of soldier piles and lagging is a relatively clean process. The majority of construction materials, such as, drilled earth spoils, concrete, backfill, and H-piles are easy to contain within the construction site. The soldier piles and deck beams are installed first with excavation and lagging installation taking place from beneath the street decking. A soldier piles and lagging earth retention system is shown in Figure 3-7 through Figure 3-9. The equipment required for installation of the soldier piles includes drill rigs, concrete trucks, cranes, and dump trucks.

Soldier piles and lagging are generally used where groundwater inflow is not a consideration, or where grouting, or lowering of the groundwater level (dewatering) can be used to mitigate water leakage between piles. Based on findings from core samples, the geologic conditions in this area consist of soils containing deposits of oil and tar. Where these deposits occur along the excavation perimeter, oil or tar may tend to seep between the joints in the lagging. This is not considered to be a hazard to workers, although some cleanup may be necessary. Alternatives to soldier pile and lagging walls being considered for this station include tangent pile or secant pile walls, slurry walls, and deep soil mix walls (see next sections below).

Figure 3-7: Pre-augering for Soldier Pile


Figure 3-8: Cut and Cover with Soldier Pile and Lagging

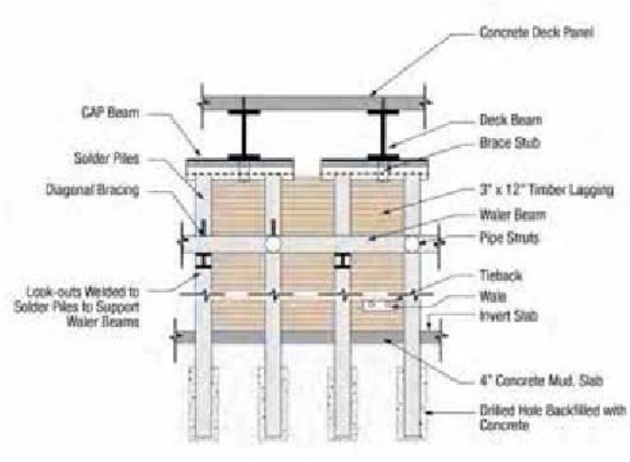


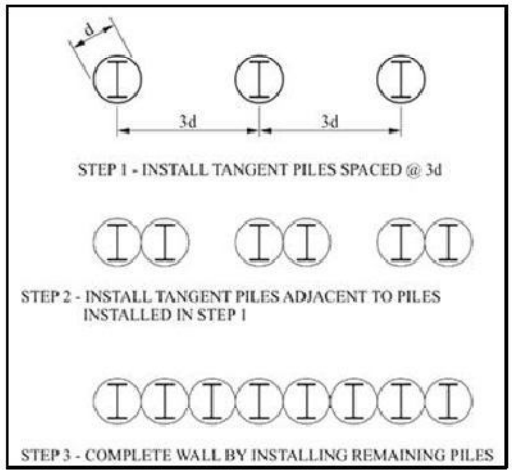

Figure 3-9: Soldier Pile and Lagging

## 3.2 Tangent Pile or Secant Pile Walls

Tangent pile walls consist of contiguous cast-in-drilled-hole (CIDH) reinforced concrete piles – see Figure 3-10. The contiguous wall generally provides a better groundwater seal than the soldier pile and lagging system, but some grouting or dewatering could still be needed to control leakage between piles.

A secant pile wall system is similar to the tangent pile wall but the piles have some overlap, facilitating better water tightness and rigidity - see Figure 3-11. This method consists of boring and concreting the primary piles at centers slightly less than twice the pile diameter. Secondary piles are then bored in between the primary piles, prior to the concrete achieving much of its strength.

Figure 3-10: Tangent Pile Installation




In terms of relative cleanliness, tangent pile and secant pile walls are comparable to one another and both are more difficult to contain than soldier piles and lagging due to the greater amount of pumped concrete and the expected larger diameter of drilled holes. The completed secant pile wall for the Barnsdall Shaft in Hollywood for the Metro Red Line project is shown on Figure 3-12. Secant and Tangent pile shoring systems are slower to construct that soldier pile and lagging and therefore have the disadvantage of requiring longer lane closures on Wilshire while they are being constructed. Furthermore, because of the close spacing of tangent piles, utilities crossing the wall often require relocation whereas a soldier pile system can often be built around the existing utilities. The equipment required for installation of the tangent pile or secant pile walls includes drill rigs, concrete trucks, cranes, and dump trucks.

Figure 3-11: Secant Pile Installation

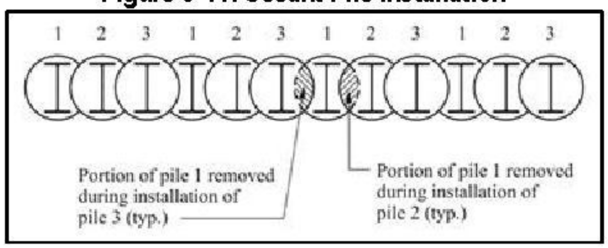



Figure 3-12: Secant Pile Wall at Barnsdall Shaft on Metro Red Line

## 3.3 Diaphragm/Slurry Walls

Diaphragm walls (commonly known as slurry walls) are structural elements used for retention systems and permanent foundation walls. Use of slurry wall construction can provide a nearly watertight excavation, eliminating the need to dewater. Slurry walls are constructed using deep trenches or panels which are kept open by filling them with a thick bentonite slurry mixture. After the slurry filled trench is excavated to the required depth, structural elements (typically a steel reinforcement cage - see Figure 3-13) are lowered into the trench and concrete is pumped from the bottom of the trench, displacing the slurry. Figure 3-14 and Figure 3-15 illustrate slurry wall excavation equipment.

Tremie concrete is placed in one continuous operation through one or more pipes that extend to the bottom of the trench. The concrete placement pipes are extracted as the concrete fills the trench. Once all the concrete is placed and cured, the result is a structural concrete panel. Grout pipes can be placed within slurry wall panels to be used later in the event that leakage through wall sections, particularly at panel joints, is observed. The slurry that is displaced by the concrete is saved and reused for subsequent panel excavations.

**Figure 3-13: Steel Reinforcement Cage for Slurry Wall**

Slurry wall construction advances in discontinuous sections such that no two adjacent panels are constructed simultaneously. Stop-end steel members are placed vertically at each end of the primary panel to form joints and guides for adjacent secondary panels. In some cases, these members are withdrawn as the concrete sets. Secondary panels are constructed between the primary panels to create a continuous wall. Panels are usually to full depth and 8 – 20-ft long and vary from 2 – 5-ft wide.

**Figure 3-14: Slurry Wall Construction Equipment**

**Figure 3-15: Clamshell Digger for Slurry Wall Construction**

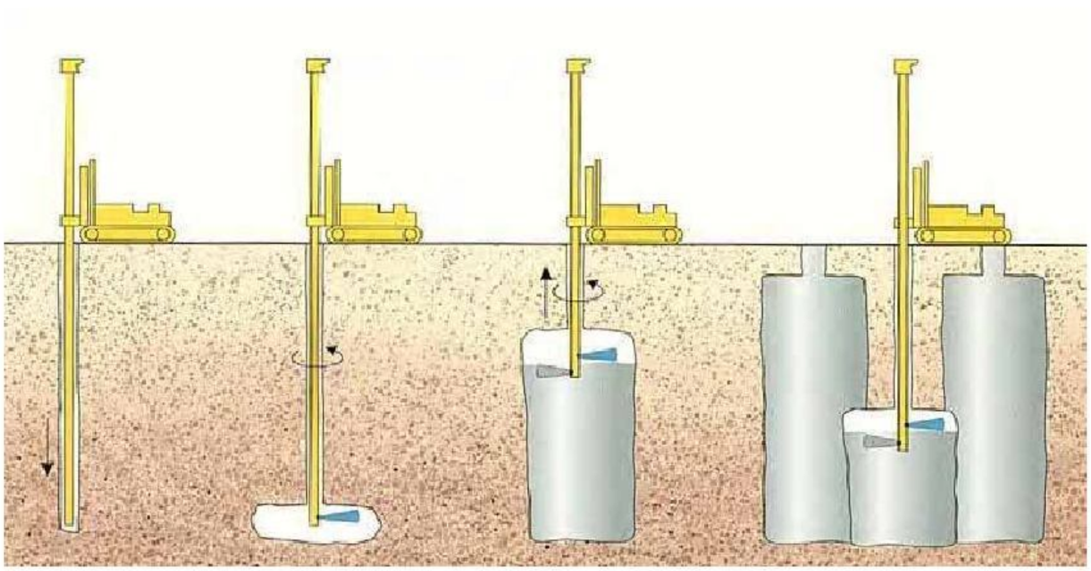
Similar to other shoring systems, slurry wall construction would occur in stages, working on one side of the street at a time. These walls have been constructed in virtually all soil types to provide a watertight support system in addition to greater wall stiffness to control ground movement. Because slurry walls are thicker and more rigid than many other shoring methods, the walls may in some cases be used as the permanent structural wall, although this application is not anticipated for this project. Where slurry walls are used, the thickness of the permanent structural walls can sometimes be reduced, i.e. when compared to wall thicknesses used with a conventional soldier pile and lagging system after removal of internal bracing.

Slurry wall construction materials are the most difficult to contain within the construction site of all the shoring types being considered due to the inherent messy nature of bentonite slurry combined with the operational characteristics of the clamshell digger which will likely be used to excavate large volumes of soil from the wall trench. Slurry walls are generally not adaptable to utility crossings and all utilities crossed by the wall would require temporary or permanent relocation. The equipment required for installation of the slurry walls includes clamshell or rotary head excavators, concrete trucks, slurry mixing equipment, cranes, slurry treatment plant, and dump trucks. The bentonite slurry would require disposal after a number of re-use cycles. Slurry walls are also slow to construct and will be very disruptive to traffic on Wilshire Boulevard.

## 3.4 Deep Soil Mix Walls

Deep soil mix walls are another type of temporary or permanent shoring system for deep excavation. Mechanical soil mixing is performed using single or multiple shafts of augers and mixing paddles. See Figure 3-16. The auger is rotated into the ground and slurry is pumped through the hollow shaft feeding out at the tip of the auger as the auger advances. Mixing paddles blend the slurry and soil along the shaft above the auger to form a soilcrete mixture with high shear strength, low compressibility, and low permeability. Spoils come to the surface comprised of cement slurry and soil with similar consistency to what remains in the ground. Steel beams are typically inserted in the fresh mix to provide structural reinforcement. A continuous soil mix wall is constructed by overlapping adjacent soil mix elements. Similar to secant pile walls, soil mix elements are constructed in alternating sequence; primary elements are formed first and secondary elements follow once the first have gained sufficient strength.

**Figure 3-16: Deep Soil Mix Construction**



Deep soil mix wall construction materials are also difficult to contain. Most of the construction process is performed by a single piece of equipment which mixes cement and soil in situ. Cement and soil mixture can be expected to escape beyond the confines of the drilling operation creating problems for traffic and pedestrians. The equipment required for installation of deep soil mix walls includes multi-shaft drill rigs, concrete trucks, cranes, and dump trucks.

## 3.5 Comparison of Excavation Support Techniques

Due to the speed of construction, and the ability to work around utilities, soldier piles and lagging is preferred unless site conditions dictate the use of other methods. See Table 3-1 for a comparison of excavation support methods. Soldier piles and lagging is the predominant shoring system used in the Los Angeles area and has been used successfully by Metro on construction of both Red and Gold Line stations. Experience at the LACMA parking garage excavation suggests that soil off-gasses immediately after being exposed but with a short period of time, the off gassing slows to levels acceptable for work. This suggest that the relatively impervious seal achieved by slurry walls, secant piles, and deep soil mix walls may only provide very short term benefits and that gas entering the station box excavation through a soldier pile and lagging system could be controlled with a well designed ventilation system.

Since it is anticipated that gassy soils will be encountered regardless of shoring system type, various methods of providing a safe and hazard free workplace will be implemented in all situations. No matter which type of temporary shoring system is selected; other measures such as, partially open decking, ventilation, gas detection, and Personal Protective Equipment (PPE), will be in use to protect workers from gases that may enter the excavation site.

**Table 3-1: Comparison of Excavation Support Types**

| Shoring Method | Permeability | Installation Duration | Containment Impacts | Noise / Vibration Impacts | Traffic Impacts | Utility Impacts | Business Impacts |
|---|---|---|---|---|---|---|---|
| Soldier Pile & Lagging | High | concurrent w. excavation | Low | Moderate | Moderate | Moderate | Moderate |
| Slurry Wall | Low | 3 Months | High | Moderate | High | High | High |
| Secant Pile | Low | 3 Months | Moderate | Moderate | High | High | High |
| Tangent Pile | Moderate | 3 Months | Moderate | Moderate | High | High | High |
| Deep Soil Mix | Low | 3 Months | Moderate | Moderate | High | High | High |

## 3.6 Construction Staging

For all types of shoring, the contractor would first occupy one side of the street to install one line of excavation support piles or wall panels. The installation will require extended closures of 2 – 3 traffic lanes on the side of the street where the equipment would be staged. After installation of piles or walls on both sides of the street at the station excavations, piles or walls would then be installed across the street at the station ends. This operation would also require lane closures, and is often done during night-time or weekend periods. The contractor would then proceed with installation of deck beams, installation of the deck panels and excavation and bracing. Deck panels (decking) allow continued traffic and pedestrian circulation since they will typically be installed flush with the existing street or sidewalk levels though raised decking, which requires less excavation during installation is being discussed with the traffic authority. Raised decking does have particular advantages at Wilshire / Fairfax Station as less excavation during the weekend closures while installing the decking makes it less likely that fossils will be encountered during the decking operation.

Deck installation will require successive full road closures on weekends with traffic detours. The decking would be installed in stages, commensurate with the amount of decking that can be installed during a weekend closure. Typical decking installation rates range from 50 -100 ft / weekend for an installation crew. Multiple crews will be used wherever possible to reduce the number of full road closures

## 3.7 General Approach to Handling Utilities

Prior to beginning construction of shoring and decking, it will be necessary to relocate, modify or protect in place all utilities and underground structures that would conflict with excavations. The contractor will verify locations through potholing methods and where feasible, the utility will be relocated so as to stay out of station or other surface structure excavation. Where the utility cannot be relocated outside the excavation footprint, it will be exposed and hung from the supporting structure (deck beams) for the roadway decking over the cut-and-cover structure. See Figure 3-17 and Figure 3-18.

**Figure 3-17: Utilities Hung from Deck Beams**

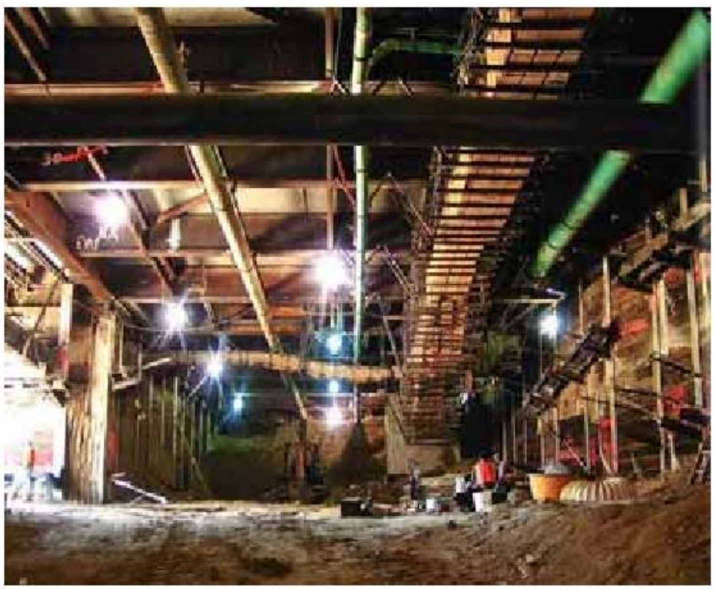
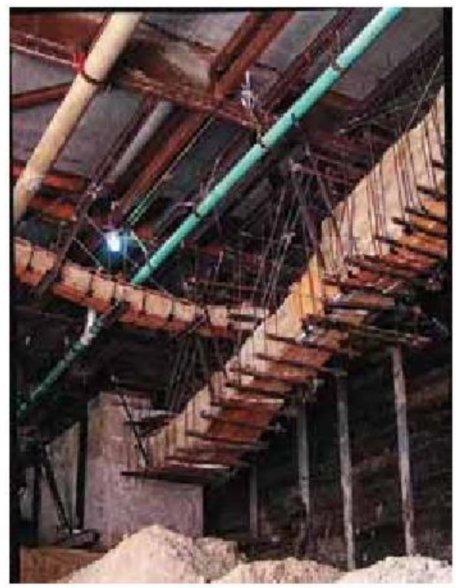


**Figure 3-18: Utilities Hung from Deck Beams (Close Up)**



Shallow utilities, such as maintenance holes or pull boxes, which would interfere with excavation work, will require relocation. The utilities alignments will be modified and moved away from the proposed facilities. Utility relocation takes place ahead of station and other underground structure excavation. During this time, it will be necessary to close traffic lanes.

It is possible that in some instances, block-long sections of streets would be closed temporarily for utility relocation and related construction operations. Pedestrian access (sidewalks) would remain open and vehicular traffic would be re-routed. Temporary night sidewalk closures may be necessary in some locations for the delivery of oversized materials. Special facilities, such as handrails, fences, and walkways will be provided for the safety of pedestrians.

Minor cross streets and alleyways may also be temporarily closed but access to adjacent properties will be maintained. Major cross streets would require partial closure, half of the street at a time, while relocating utilities.

**Figure 3-19: Backfilling Utilities in Final Location beneath Road Surface**

Utilities, such as high-pressure water mains and gas lines, which could represent a potential hazard during cut-and-cover and open-cut station construction and that are not to be permanently relocated away from the work site, would be removed from the cut-and-cover or open-cut area temporarily to prevent accidental damage to the utilities, to construction personnel and to the adjoining community. These utilities would be relocated temporarily by the contractor at the early stages of the operations and reset in essentially their original locations during the final backfilling above the constructed station. See Figure 3-19

# 4.0 PALEONTOLOGICAL ISSUES

The Wilshire/Fairfax Station is situated within the vicinity of the Hancock Park Rancho La Brea Tar Pits. The San Pedro Sand layer exists beneath the older and younger alluvium deposits near the surface in this region. This formation has a high likelihood for producing significant paleontological resources. The existing La Brea Tar Pits immediately adjoining the Wilshire/Fairfax Station site is the largest collection of fossils of extinct mammals in the entire world. Because of the high likelihood of fossil discovery while excavating the Wilshire/Fairfax station box, station construction at Wilshire/Fairfax will be given the maximum time available within the overall project schedule, so that excavation can proceed slowly and carefully and fossils located and removed without schedule pressures.

Before fossil recovery can begin, utility relocation and shoring for the station excavation using one or more of the shoring methods outlined above must occur. Utility relocations, by their nature (narrow trenches beneath paved streets) will make recovery of fossils during this phase of the work unlikely. Then, any fossils that lie within the footprint of the shoring will necessarily be destroyed when the shoring is constructed, as there is no way to remove them in advance of the shoring. However, shoring will at worst occupy less than 10% of the footprint of the station excavation, leaving 90% of the footprint unaffected and suitable for fossil recovery.

The plan for fossil removal has been based on the methods used by the Page Museum for the removal of fossils from the nearby LACMA parking garage excavation, referred to from here-on by the Page Museum name, Project 23. The ground will be excavated in shallow lifts, with museum staff on land to inspect the excavated surfaces as earth is removed and to mark the locations of fossils when discovered. It is assumed that the fossils will occur in a manner similar to that at Project 23, i.e. concentrated in vertical tar "pipes" which, once located, can be boxed in place and then removed from the site for further analysis. As with Project 23, fossils can also be found away from the tar pipes so all excavated surfaces must be inspected, and the contractor's team must be alerted to the possibility of finding fossils anywhere with the excavation. The Project 23 site was an open excavation, not constrained by a deck at ground level. This made boxing and removal of the fossil boxes a good deal more straight-forward than will be the case at Wilshire/Fairfax. Figure 4-1 shows fossils in a pit at the Page Museum, and Figure 4-2 a boxed "pipe" containing fossils being prepared at the Project 23 site. Figure 4-3 and Figure 4-4 show examples of fossils recovered from Project 23 after processing.

**Figure 4-1: Tar Deposit Containing Fossils**

**Figure 4-2: Fossil Box Construction at Project 23**

Figure 4-3: Smilodon (Sabre Tooth Cat) Pelvic Bone

Figure 4-4: Smilodon Skull in Fossil Box

## 4.1 Minimize Excavation Done Before Decking Installation

Although the Project 23 experience suggests that fossils will mainly be 10 ft or more below street level, fossils must be anticipated anywhere within undisturbed ground. Using the cut and cover excavation technique, deck beams which support the deck panels are installed in the road bed after the piles or shoring walls are complete. The top of the deck beams sit just below the roadway surface so that the decking is flush with the roadway. The deck beams are approximately 6-ft tall and joined together with cross bracing so a minimum of 7-ft of excavation is required for their installation. On Red line and Gold Line stations, contractors have normally excavated 10 ft deep when installing the deck beams to provide clear space beneath the beams for better access when commencing to dig out from beneath the decking and to expose utilities immediately below the deck beams.

Because the street decking requires a full street closure to install, only limited times are available in which to close the street. Full street closures, especially along Wilshire Boulevard will be limited to approximately 52 hours duration on week-ends, and this will not provide time to carefully remove soil in layers to expose fossils nor to box and remove any fossils found in this initial excavation. Therefore, opportunities for fossil recovery from the initial excavation for the street decking will be limited. It therefore requires a construction approach to try and reduce the depth of the initial excavation. Two strategies are being pursued in this regard. One approach is to use raised decking so that the bottoms of the deck beams can be raised up by the same height that the station decking is installed above street level. Metro is in discussions with traffic authorities regarding the acceptability of using raised decking at Fairfax. See Appendix A for details of raised decking. The other approach is to use shallower deck beams, either for a flush deck system or in conjunction with a raised decking approach. Shallower beams will almost certainly require installing the deck beams at closer centers, probably 7 ft centers instead of the usual 14 ft centers but the shallow beams will reduce the likelihood of finding fossils during decking.

It should be noted that many utilities in the street are much deeper than the bottom of the deck beams, and any fossils would have been destroyed during the construction of such utilities. Utilities already have disturbed a significant percentage of the station excavation footprint, and this will increase with the relocations required prior to the installation of the shoring and decking. Nevertheless, there will remain areas of undisturbed soil within the 10 ft immediately below street level and fossils therefore could be found in these locations. These areas can be mapped in advance so that they can be excavated carefully.

## 4.2 Excavation of the topmost layers beneath the street decking

Once the street decking has been installed, excavation beneath the decking will commence. The side access shaft(s) from the contractor's laydown area (see Figure 4-5) and from the station portal site will be excavated in shallow lifts, using methods similar to those of Project 23. Any fossils found will be removed. Once the side access shafts are deep enough to allow equipment to commence digging beneath the street decking, equipment will be lowered into then shaft to commence digging. One scenario will be for the contractor to dig the initial lift by scraping down the face, using low headroom equipment such as a Gradall (see Figure 4-6) or other equipment acceptable to Metro and to the Page Museum. The working face would be inclined at probably a 2:1 slope and would be accessible for inspection (see Figure 4-7). The excavation would proceed in this manner until the first lift was completely removed. The height of the first lift will be determined by the head room needed by the equipment needed for the subsequent lifts, but probably of the order of 12-14 ft. depending on the equipment selected, subsequent lifts could continue to be inclined or horizontal. Fossils and tar pipes containing fossils would be removed under the supervision of Page Museum staff, probably using the boxing techniques developed for Project 23. Because the Fairfax Station will be decked, handling large boxes beneath the decking will be very difficult. Boxes of not more than 500 cubic ft (approximately 30 tons) are proposed as an upper limit, and smaller boxes for the first lift below the decking may be necessary so that low headroom equipment will be able to carry the boxes back to the side access shaft. Actual box sizes can be determined in the field by the contractor and paleontologists. Figure 4-7 and Figure 4-8 show the proposed excavation sequence.

**Figure 4-5: Open Cut Excavation of Side Access Shaft**

**Figure 4-6: Gradall Excavator - East Side Access Project NYC**

**Figure 4-7: Cross Section Showing Excavation Procedure of Shallow Lifts at 2:1 (Approx) Slope Beginning from the Side Access Shaft**

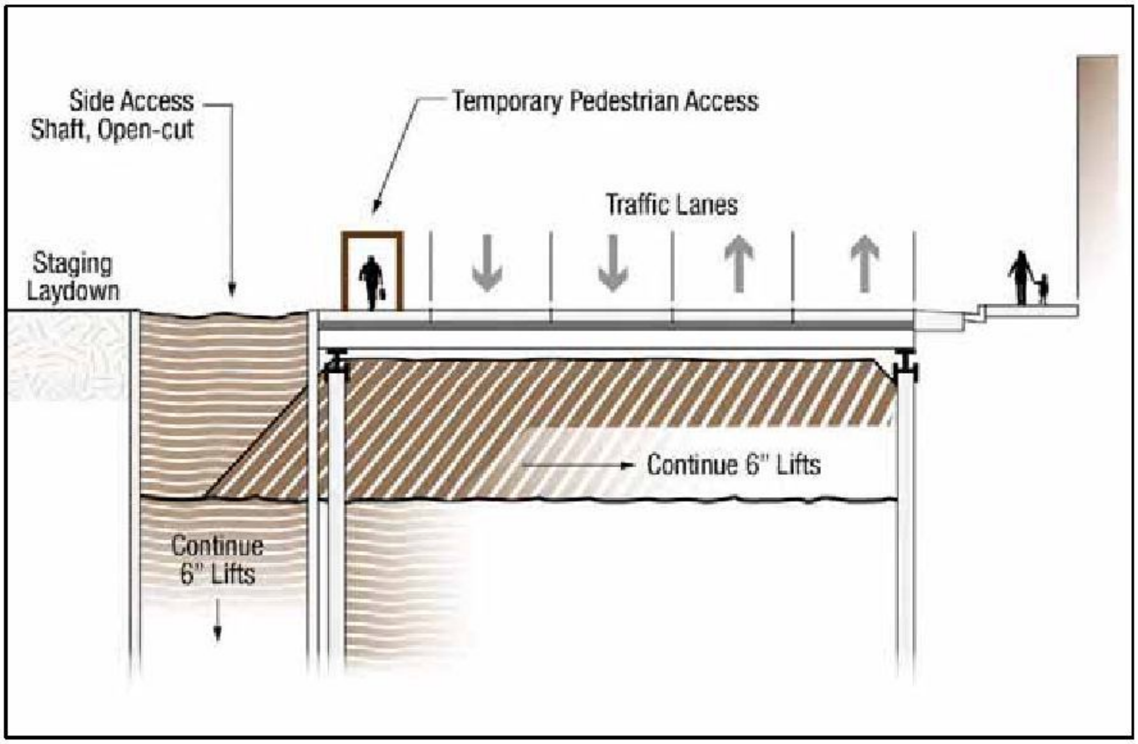
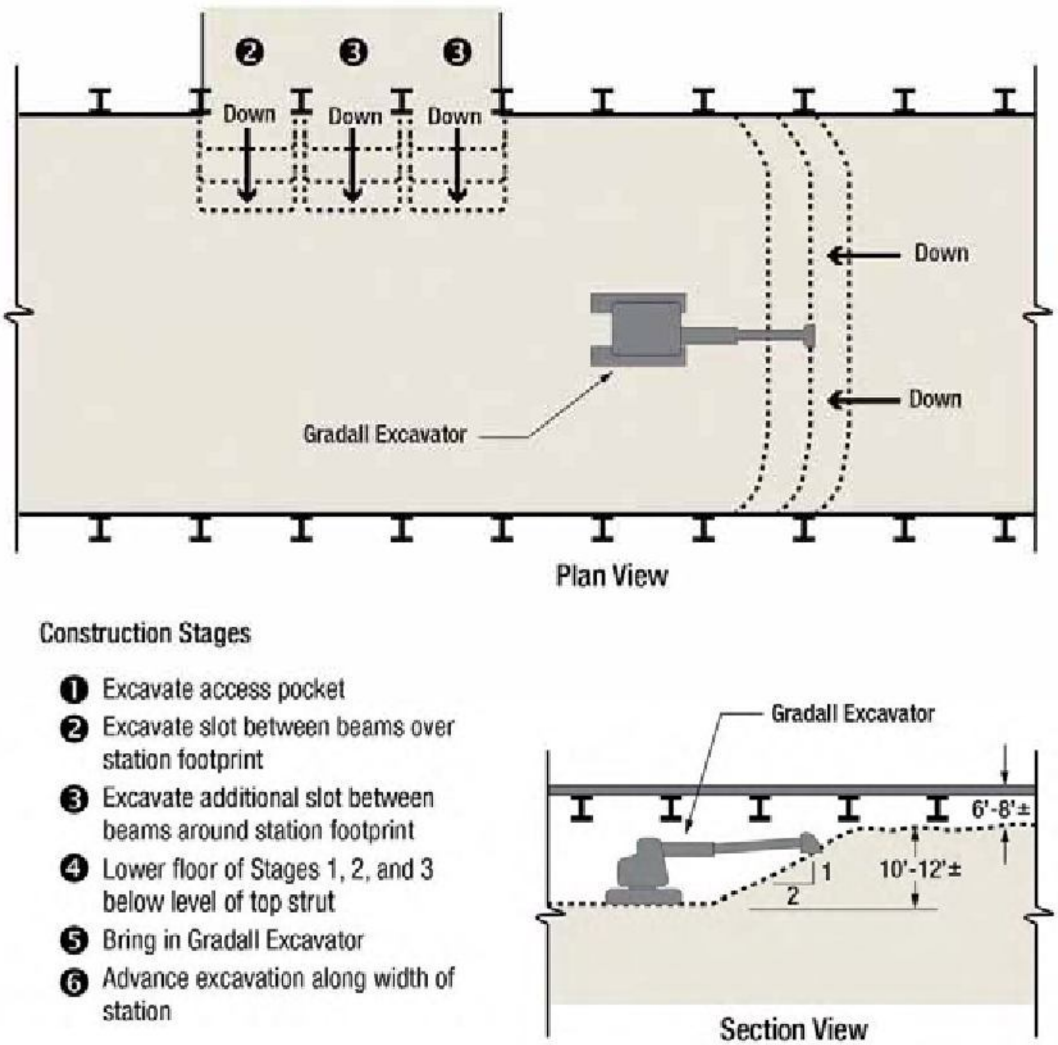


**Figure 4-8: Plan Showing Excavation Procedure of Shallow Lifts with Low-Profile Gradall Excavator**



## 4.3 Excavate in Layers

The station box and side access shafts will be excavated in shallow lifts to carefully expose and locate fossils. The Page Museum is suggesting 6" lifts based on experience at the Los Angeles County Museum of Art (LACMA) parking garage. As with Project 23, fossils can also be found away from the tar pipes so all excavated surfaces must be inspected, and the contractor's team must be alerted to the possibility of finding fossils anywhere with the excavation.

Compact track loaders and compact excavators (see Figure 4-9 and Figure 4-10) are likely necessary for initial soil removal directly beneath the deck beams due to their low vertical clearance, and relatively small bucket size capable of excavating precise lifts. Continuous tracks improve vehicle traction on soft and sticky terrain and reduce the amount of pressure exerted on the soil below. A pressurized although this may not be an option due to tight clearances and proper ventilation will still be needed regardless. If soil conditions permit, a rubber tire vehicle like skid steer loaders or equipment fitted with floatation tires may be used instead of compact track loaders. Gradalls operate a bucket at the end of a telescopic arm in a linear motion. The linear shoveling motion enhances depth control improving the ability to cut in precise shallow lifts. These will be considered considered as well. Track loaders, wheeled dozers and hydraulic excavators would be employed to remove the bulk of the soils in order to maintain efficiency in excavating (see Figure 4-11 through Figure 4-13. Excavation with these tools will require careful observation to identify the location of tar deposits. When tar deposits are located, smaller equipment should step in to avoid damaging fossil resources with heavier machines.

**Figure 4-9: Compact Track Loader**

**Figure 4-10: Compact Excavator – 6.75'-Tall/12'-Long/6.5'-Wide**

It is possible that the discovery and removal of fossils could lead to schedule delays and the station box structure would not be completed in time to precede the TBM breakthrough. As long as station box excavation has not breached a reasonable depth above where the top of the tunnel liner will be so that it would compromise the operation of the TBM, then the TBM drive should continue through the station box location and station excavation would work its way down and eventually break through the tunnel liner.

Figure 4-11: Tracked Loader Removing Muck from Beneath Struts

Figure 4-12: Hydraulic Excavator between Struts

Figure 4-13: Track Loader beneath Struts

It may be possible to use an imaging technique to locate fossils ahead of excavating operations thus allowing the pace of excavation to accelerate beyond the recommended 6" lift limit. If the imaging technique produces a reliable indication, the boxing of fossils can be pre-planned. Some techniques of scanning for objects below the surface that should be considered are Ground Penetrating Radar (GPR), HAARP Detection using ELF and VLF radio waves, electrical resistivity imaging, and geophysical diffraction tomography.

If an Early Work Authorization is obtained, construction can begin on an exploratory shaft to test the effectiveness of the anticipated geophysical methods. The shaft could be located within the limits of a side access shaft and would ideally reach full station depth in order to learn as much as possible from this process. The length and width of the shaft should be a minimum size to allow a variety of the equipment under consideration to perform excavation operations during the exploration process. Construction methods will be tested to determine the best techniques and tools for station box excavation. Shoring types will be tested to determine the effectiveness of the planned shoring in the soils present in the area. Gas levels will be measured to gauge the specifics of the ventilation scheme.

## 4.4 Fossil Box Size

As layers of soil are removed, tar-laden sand deposits containing fossils are likely to be uncovered. When this happens, work is halted within proximity of the fossil to allow the paleontologists on site to assess the discovery and begin preparations for boxing and removal of the deposit. The technique of boxing and removing fossil deposits to an off-site facility for additional paleontological work is an efficient process that was first implemented at the La Brea Tar Pits in 1915 and more recently during the construction of Project 23. A photo of the 1915 boxing method is contained on Page 8 of Rancho La Brea, Death Trap and Treasure Trove, Edited by John M. Harris, June 2001.

**Figure 4-14: Fossil Boxes at Project 23**

The box construction technique used on Project 23 is similar to that which is used for boxing palm trees for transport. See Figure 4-14. First, the paleontologist defines the location of the fossil deposit. Next, trenches are dug around the sides and excavation continues by removing sterile soil from around the fossil zone with heavy equipment leaving an island where the deposit sits. The bottom of the box is most challenging. After the box is supported by blocks and shims at each of the four corners, workers must crawl beneath the box and dig by hand while inserting the timber boards which make up the base of the box (Figure 4-15). An alternative approach to creating the bottom of the box which would improve worker safety and expedite the excavation process would require an auger to drill holes in the island beneath the fossil deposit. Timbers would be inserted through the auger holes, thus beginning to form the base of the box. The auger would then remove the balance of soil between the timbers allowing completion of the box and freeing the deposit from the soil below. See Figure 4-16. During the excavation of Project 23, sixteen tar deposits were discovered. From the sixteen deposits, twenty-three boxes were recovered, thus giving the parking garage project its name. The boxes range in size from 5x5x5-ft (weighing 3 tons) to 12x15x10-ft (weighing 56 tons).

**Figure 4-15: Fossil Relocation Process. (From Page Museum Whiteboard)**

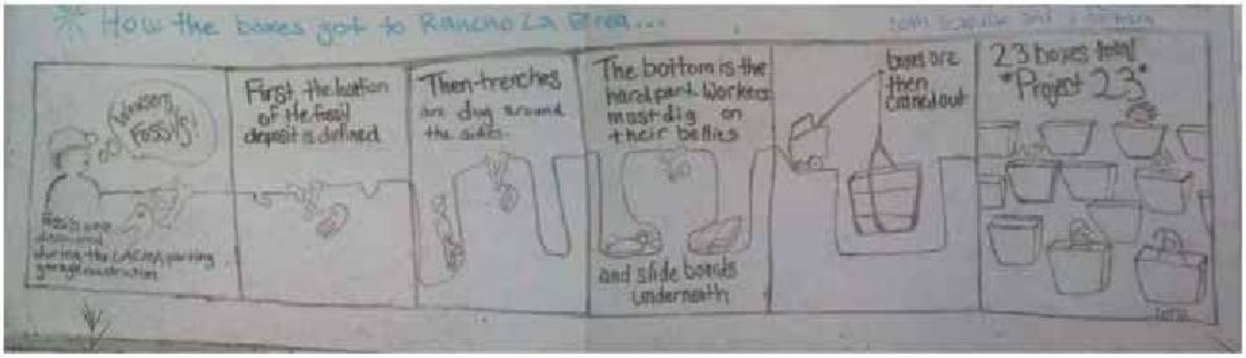
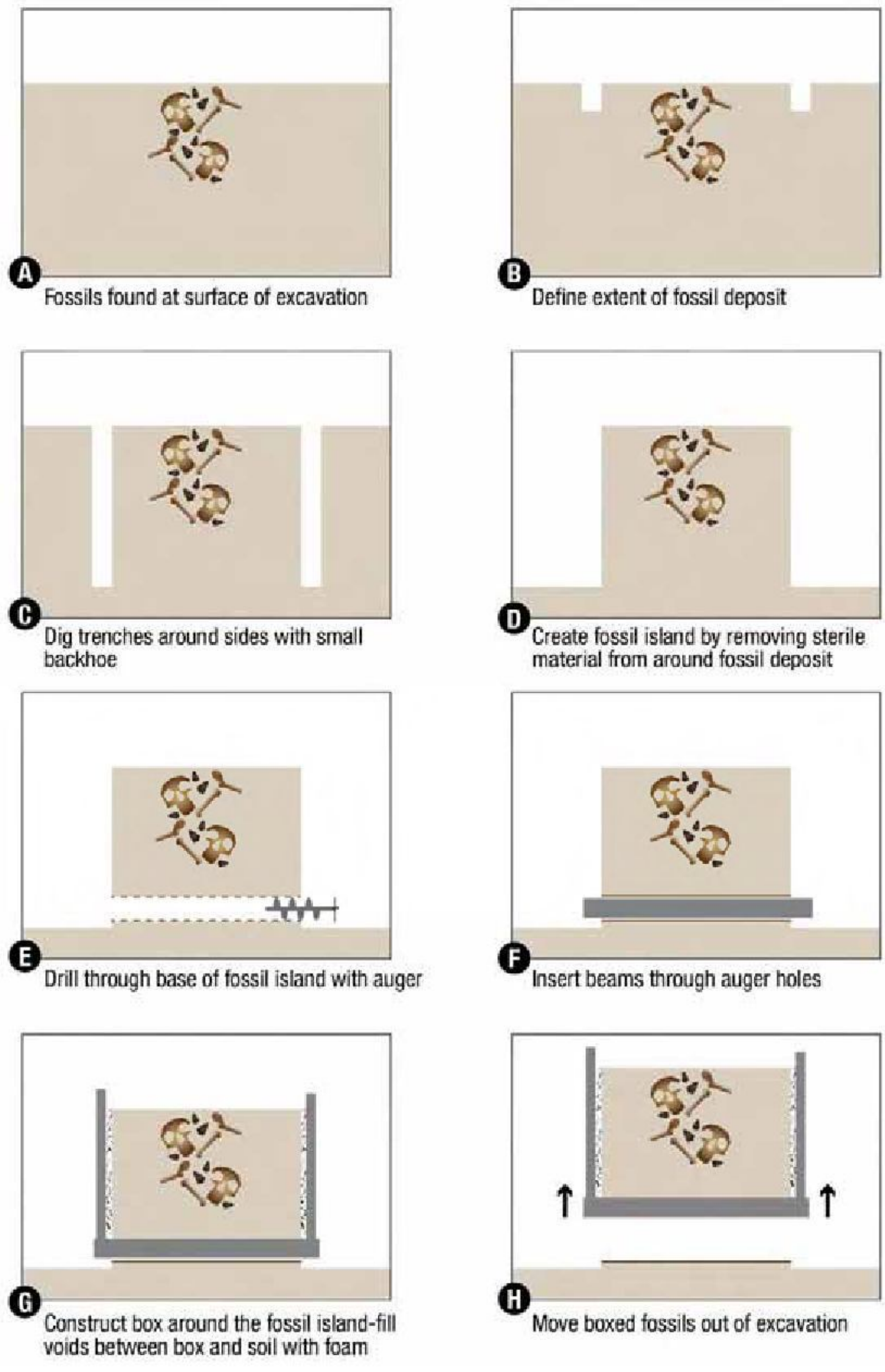


**Figure 4-16: Proposed Alternative Boxing Technique Using Auger for Floor Construction**



Depending on the size and weight of each box, fossils located beneath deck panels may be lifted in place by crane through temporary openings in the decking. However, this may prove to be impossible if street closure is not possible or the crane cannot be positioned on the street decking in a way to perform the lift. It is proposed to limit the size of fossil boxes to about 30 tons, i.e. 500 cubic feet which will make boxes easier to lift or to move around below the decking with low headroom equipment or with a system of skids and temporary tracks constructed within the station box. Once positioned adjacent to the side access shaft, fossil boxes can be lifted by mobile cranes positioned on “terra firma”. The crane would lift the box out through the access shaft and load it on a truck which will transport the tar and fossils either to the Page Museum site where paleontologists can continue their work or to the contractor’s laydown area at South Orange Grove/ Ogden for storage and processing. Offsite processing is preferred as there is less potential for damage by heavy equipment that will be operating at the South Orange Grove/Ogden laydown area.

## 4.5 Construction Issues in Tar-Laden Soils

The asphaltic sands have unique properties and the engineering characteristics are not as well documented as compared to other soils. However, contrary to common expectations, it is proven that these sands possess shear strength. Design parameters for excavation support systems in asphaltic sands will need to consider some additional pressure due to the makeup of these soils. There are numerous cases of successful experience in construction of deep basements and underground parking structures in the Wilshire/Fairfax area soils, such as construction of underground structures at LACMA (see Figure 4-17). Similar design elements, construction techniques and operating methods and procedures can be applied to the planned excavations.

**Figure 4-17: Aerial View of Project 23 Excavation with Dark Tar Seeps**

## 4.6 Potential Impacts to Construction Methods from Anticipated Tar-Laden Soils

When excavating in tar-laden soil, efforts will be undertaken to avoid excessive disturbance. Excavation methods will be closely controlled to minimize over-excavation or vibrations. When grade is achieved within these soils, a mud slab could be applied to minimize disturbance. In some cases, a layer of gravel may be placed over the asphaltic sands to increase traction and reduce the amount of soil compaction caused by construction traffic. The contractor can also apply various other materials on top of the tar such as cement, lime, or other additives to prevent it from fouling the tracked equipment. Wide tracked machinery can be used to reduce the pressure exerted on the soils below. Timber mats can make a sturdy foundation to drive equipment on. Rubber tire vehicles are considerably lighter than their tracked counterparts and could be operated with floatation tires specifically designed to minimize the amount of soil compaction caused by heavy equipment. Because the tar is rather sticky or tacky in some areas, it is anticipated that the equipment's tracks, axles, or buckets could become fouled and would require occasional cleaning. Steam cleaners would handle the task well, by heating the tar to a less viscous consistency.

## 4.7 Handling Gas Intrusions during Construction Operations

Previous projects in the Methane Risk Zone have been successfully and safely excavated. Multiple underground parking garages have been constructed in this area. For example, LACMA built a two-level subterranean parking structure in the Methane Risk Zone, previously referred to as Project 23. During the excavation, H2S (above safe working levels) was encountered on several occasions. Workers donned PPE to protect against exposure during these events (se Figure 4-18). Further investigation of operating underground structures will be undertaken during future design phases to assess effectiveness of barrier systems and detection equipment used.

**Figure 4-18: Fossil Boxes with Worker Donning Oxygen Respirator at Project 23**

Since the majority of gas is expected to enter the excavation through the excavation surface, the release of gases may be constricted by applying a ground cover to all areas except the area where current excavation operations are taking place. An impervious membrane of Visqueen plastic sheeting or geotextile fabric may serve this purpose.

In areas of potential H2S exposure, there are a number of techniques that can be used to lower the risk of H2S release or exposure. Because station excavations are less confined than tunnels, gas exposure issues are anticipated to be less significant. Although pre-treatment of the ground water prior to excavation, with additives such as hydrogen peroxide or copper-zinc, is an option, it is not expected to be required. If released, H2S will not naturally dissipate because it is heavier than air, hence it would build up around the bottom of the excavation. The first line of defense is dewatering since H2S occurs in a dissolved state in ground water. Dewatering will remove any contaminated water from the excavation area. At the surface, a sealed tank would capture the water and treat the air for H2S off-gassing before discharging it to the surrounding environment. Additionally, a ventilation system will be used to introduce fresh air in the workspace. Fans will be used to circulate the air while a gas detection system monitors levels of hazardous gas. A suction system fitted with scrubbers may be required to collect H2S from the bottom of the excavation and treat the air before discharging clean air at the street surface.

CH4 is a hazard in confined spaces. As such, it is essential that workers be sufficiently protected, and thus detection and monitoring equipment would be required. Fans similar to those used to dilute H2S concentrations would also dilute CH4 concentrations in the station box. Once above-ground, CH4 dissipates rapidly in the atmosphere and would not be a health hazard.

## 4.8 Ventilation Schemes

Ventilation is required to combat harmful or dangerous gasses when present in underground construction. Cal OSHA classifies subterranean work areas as “gassy”, “potentially gassy”, “non-gassy”, or “extra hazardous”. Excavation equipment in “gassy” spaces must be manufactured to resist accidental sparks and either be sealed or of explosion proof design.

Since CH4 and H2S gases are expected to be encountered during the excavation of Wilshire/Fairfax station, adequate ventilation and continuous air quality monitoring will be in use throughout construction. In addition to maintaining acceptable levels of CH4 and H2S in the air supply, the ventilation system must maintain a certain level airflow for workers present in the work space (see Figure 4-19) . The size of the system is dependent on the number of persons and the size of diesel equipment underground. The air supply shall not be less than 200 CFM (cubic feet per minute) per person underground, plus 100 CFM per diesel horse brake power.

Use of perforated deck panels, either perforated steel or concrete integrated with steel could be used in place of concrete only deck panels to allow the free flow of air between the excavation area and the surface, especially if full decking is required across the entire station box.

**Figure 4-19: Underground Ventilation Ducts**

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

The project is committed to recover fossils and to work closely with the Page Museum to minimize the loss of fossils due to the construction of a station at Wilshire/Fairfax.

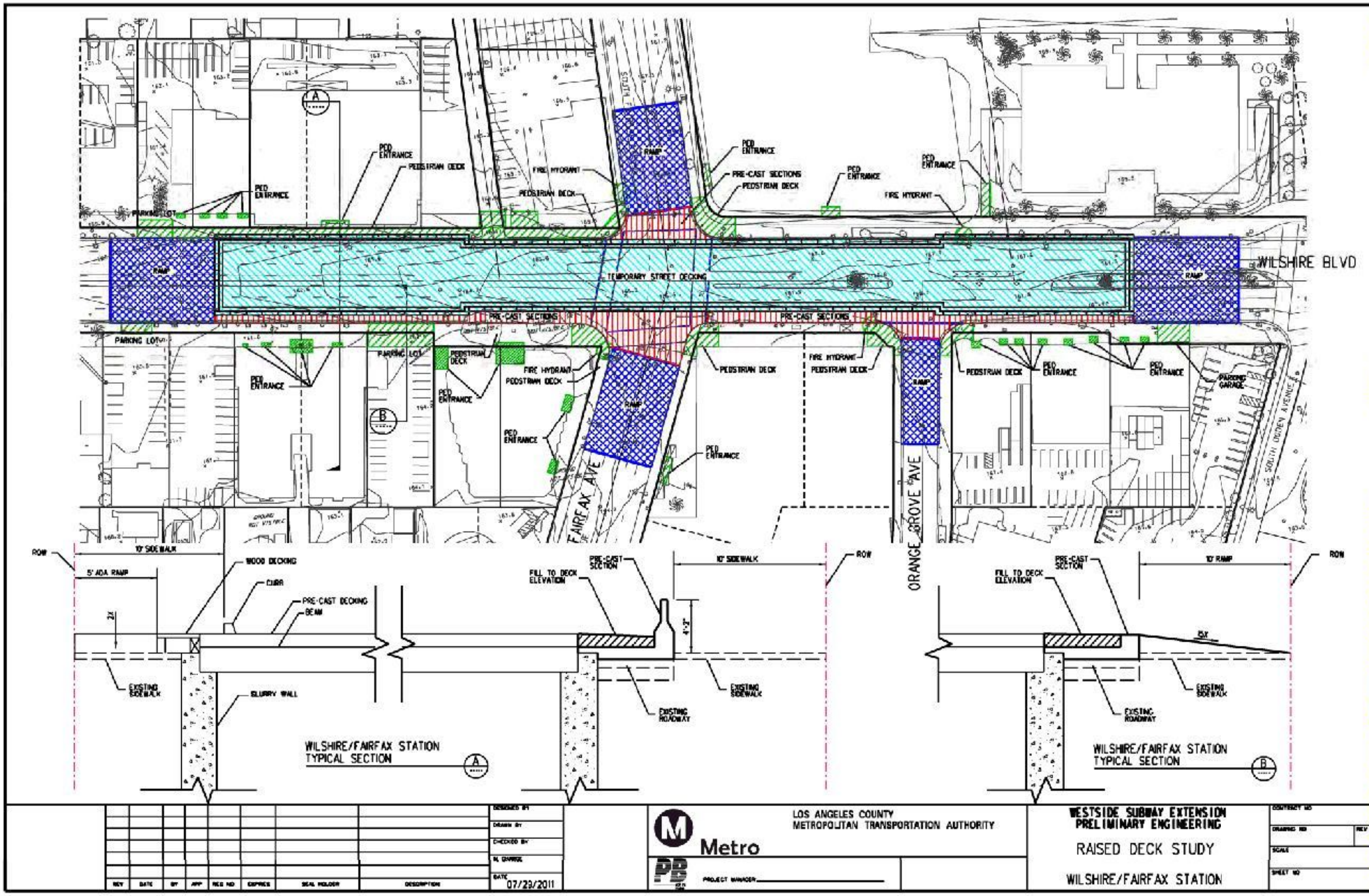
The project plans to use the same recovery methods that have been proven at Project 23, and with the cooperation of Page Museum staff, will seek to customize and improve on these methods to tailor them for the site conditions at Wilshire/Fairfax.

Further studies are on-going to find ways to raise the height of the beams used for street decking, which in turn, will leave more soil beneath the beams for controlled excavation and fossil recovery.

The fastest and lowest cost shoring method is preferred. This means that a soldier pile and lagging system will be employed provided that continuing geotechnical investigation do not find ground conditions that preclude this system. Soldier pile and lagging shoring has the added advantage of disturbing less of the station excavation footprint than other methods, minimizing the loss of fossils in this phase.

Gases will be controlled by installing adequate ventilation within the excavation, and by designing the street decking system with gaps for natural ventilation and elimination of pockets where gases could accumulate.

# APPENDIX A EXAMPLE OF RAISED DECKING




WESTSIDE SUBWAY EXTENSION PROJECT

# ATTACHMENT 4

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PALEONTOLOGY - ARCHAEOLOGY - HISTORY

# PALEONTOLOGICAL RESOURCES MONITORING AND MITIGATION PLAN FOR THE LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY

# PURPLE LINE EXTENSION PROJECT,

## LOS ANGELES, LOS ANGELES COUNTY, CALIFORNIA

**Submitted to:**

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Los Angeles, CA

**Author:**
Sherri Gust, M.S., Qualified Principal Paleontologist

May 2013; revised February 2015

***Project Number:*** 2068-003
***USGS 7.5’ Quadrangles:*** Beverly Hills 1995, Hollywood 1966 (PR 1981), Los Angeles 1996 (PR 1981, MR 1994)
***Area:*** nine linear miles with seven stations
***Key Words:*** Fernando Formation, San Pedro Formation, Quaternary older alluvium, Rancho La Brea, Pleistocene fossils, Pliocene fossils, mitigation plan, La Brea Zone

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State Certifications DBE, WBE, SBE, UDBE

# ABSTRACT

This Plan includes an overview of the Project, regional paleontological setting, significance criteria, and methods to be employed for monitoring, fossil recovery and evaluation, laboratory work, reporting and curation of paleontological resources encountered during the construction activities associated with the Purple Line Extension (PLE) Project proposed by the Los Angeles County Metropolitan Transportation Authority (Metro) and Federal Transit Administration (FTA).

Specific significance criteria and examples of application for fossils discovered are delineated. Generally fossils must be recovered to allow evaluation. When combined with observations on extent and integrity of the resource, this will allow rapid implementation of treatment measures and a concomitant minimization of work delays. All work within the La Brea Zone (2 mile radius around Page Museum at depths up to 55 feet below the surface) will have oversight from Page Museum staff.

The Purple Line (Westside Subway) Extension Project is located in western Los Angeles County and includes portions of the Cities of Los Angeles and Beverly Hills, as well as an unincorporated portion of Los Angeles County in the vicinity of the Greater Los Angeles Healthcare System-West Los Angeles Medical Center. The Project Alignment would extend heavy rail transit, in subway, from the existing Metro Purple Line Wilshire/Western Station to the Westwood/VA Hospital South Station, a distance of approximately nine miles. The separated right-of-way is all in a tunnel, with the top of the tunnel at least 30 to 70 feet below the ground surface. The extension would include a total of seven new stations.

More than a dozen fossil localities are known in non-asphaltic Quaternary older alluvium adjacent to the Project Alignment and have produced fossils including mammoth, mastodon, camel, horse, bison, deer, American lion and rodents. In the Project Alignment vicinity, the San Pedro Formation has produced horse, coyote, turtle, fish, shark, and numerous invertebrate fossils. While this formation is entirely marine, terrestrial animals such as fossil horse and coyote were washed into the ocean in streams or rivers. The Fernando Formation has produced invertebrate fossil in the Project Alignment but no vertebrate paleontological resources. Elsewhere in the Los Angeles Basin the formation has produced vertebrate fossils.

The late Pleistocene fossils of the La Brea tar pits are internationally known. Over 4 million specimens including mammals, birds, fish, plants and insects have been documented. The La Brea deposits are known within a two mile radius around the George C. Page Museum of La Brea Discoveries, an area known as the La Brea Zone.

Based on locations and depths of prior fossil discoveries, all excavations for stations and associated facilities and the drop/retrieval shafts for the tunneling machine require full time paleontological monitoring of native sediments. At Fairfax Station only, work from the bottom of imported fill to the top of the marine sediments will be performed using six inch lifts. Once marine sediments are encountered, regular excavation lifts will be utilized. Unanticipated discoveries along the Project Alignment may be encountered during trenching below existing streets or during other ground-disturbing activities. For unanticipated discoveries crews will stop work in the vicinity of the discovery so that the resource may be evaluated for significance. Evaluation and/or recovery operations will be completed as quickly as feasibly possible in order to minimize construction delays.

# TABLE OF CONTENTS

# 1. INTRODUCTION

## 1.1 Purpose of Document

This Plan includes an overview of the Project, regional paleontological setting, significance criteria, and methods to be employed for monitoring, fossil recovery and evaluation, laboratory work, reporting and curation of paleontological resources encountered during the construction activities associated with the Purple Line Extension (PLE) Project proposed by the Los Angeles County Metropolitan Transportation Authority (Metro) and Federal Transit Administration (FTA).

## 1.2 Project Description and Location

The Purple Line (Westside Subway) Extension Project is located in western Los Angeles County and includes portions of the Cities of Los Angeles and Beverly Hills, as well as an unincorporated portion of Los Angeles County in the vicinity of the Greater Los Angeles Healthcare System-West Los Angeles Medical Center (Figure 1). The Project Alignment would extend heavy rail transit, in subway, from the existing Metro Purple Line Wilshire/Western Station to the Westwood/VA Hospital South Station, a distance of approximately nine miles. The separated right-of-way is all in a tunnel, with the top of the tunnel at least 30 to 70 feet below the ground surface. The extension would include a total of seven new stations.

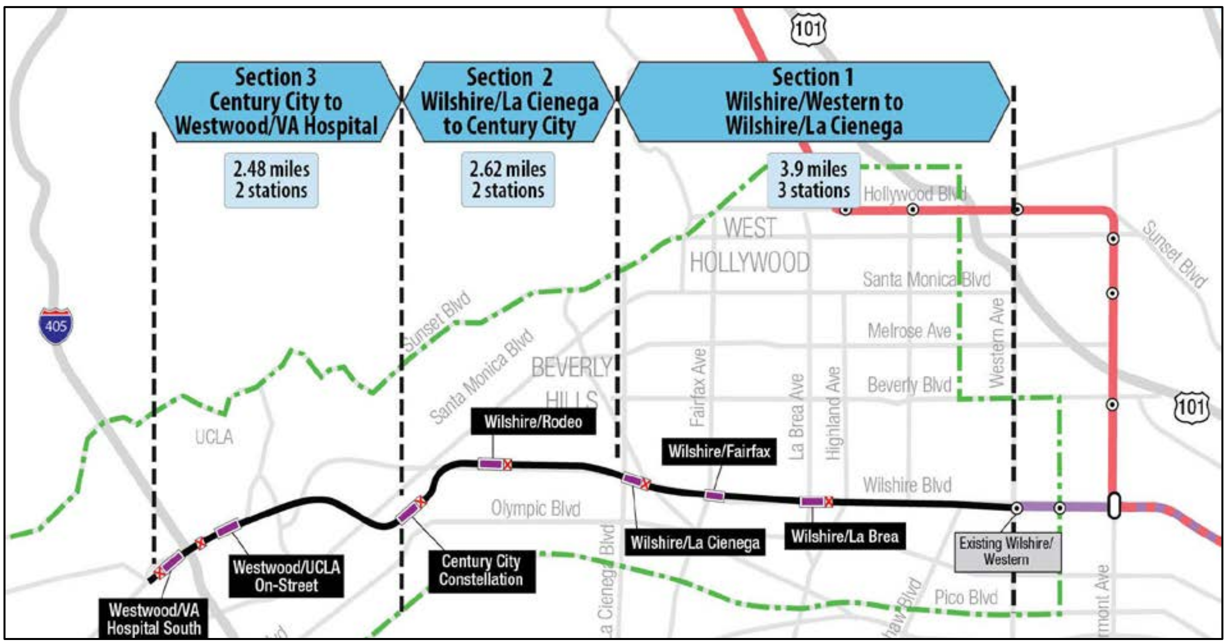


**Figure 1. Project Sections and Components**

## 1.3 PLE Mitigation Requirements

The Federal Transit Administration (FTA) is acting as the Federal lead agency for this Project. Metro is the cooperating State lead agency. A Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the undertaking was approved in March 2012 (Metro 2012). The instructions contained in this document, (together with the already completed Paleontology Exploratory Shaft), if implemented, will ensure compliance with Metro's legally binding obligation to enact the Paleontology Mitigation Measures contained in the Final Environmental Impact Statement/Environmental Report.

Metro retained the services of a qualified Principal Paleontologist in 2012 (Appendix A). This document is the Paleontological Resources Monitoring and Mitigation Plan (PRMMP) required. Metro is currently implementing the PRMMP during preconstruction utility relocations and will do so for construction once that phase of work begins. This PRMMP includes specifications for processing, stabilizing, identifying, and cataloging any fossils recovered on the PLE. It also includes provisions for curation of scientifically significant fossils.

Upon conclusion of construction excavations on the Project, the Principal Paleontologist will prepare a report detailing the paleontological resources recovered, their significance, and interpretation. Yearly progress reports will be prepared since the Project has a long time frame. Repositories for the Project will be the George C. Page Museum for fossils from the La Brea Zone, the Natural History Museum of Los Angeles County for fossils outside the La Brea Zone and the University of California Museum of Paleontology for plant fossils.

# 2. PALEONTOLOGICAL SETTING

The paleontological context prepared for the present study is based on information from the *Cultural Resources Technical Report* (URS 2010), the Final EIS/EIR (Metro 2012:Section 4.14) in addition to data from Fraser and Sues (2013), Gust (2012), Harris and Jefferson (1985), Parsons Brinckerhoff (2012), Powell and Stevens (2000), Quinn et al (2001) and tarpits.org.

## 2.1 GEOLOGY

### 2.1.1 Artificial Fill

Discontinous deposits of artificial fill are present in some locations up to 13 feet deep. These sediments were generally imported from other locations for past construction purposes. It generally consists of silty sand, silt, clay and gravel of varying colors.

### 2.1.2 Quaternary younger alluvium and fan deposits

These sediments are Holocene in age (less than 11,000 years old) and were deposited by streams flowing over the Project area. The sediments are typically yellow sand, silt and clay up to five feet deep.

### 2.1.3 Quaternary older alluvium and fan deposits

These sediments are late Pleistocene in age (50 to 11 thousand years old) and were also deposited by streams flowing over the Project area. The sediments are layered yellow silt sand, clay, silty clay and silt with some gravel. Quaternary older alluvium was encountered from about two to about 40 feet deep.

### 2.1.4 San Pedro Formation

The marine San Pedro Formation (one million to 50 thousand years old) is generally below the alluvium. The sediments consist of mostly greenish gray and bluish gray fine-grained sand, medium to course-grained sand, and some layers of silt. The San Pedro Formation was found as shallow as 12 feet below the surface and as deep as 100 feet.

### 2.1.5 Fernando Formation

The marine Fernando Formation (five to one million years old) underlies the San Pedro Formation and mostly consists of massive buff siltstone with some claystone layers. The Fernando Formation was identified as shallow as 65 feet below the surface.

## 2.2 PALEONTOLOGY

Work under this plan is divided between most Project sediments, regardless of geological formation and depth, and those within the La Brea Zone which are entirely Quaternary older alluvium saturated with asphalt and extend no more than 55 feet below the surface. Most such deposits discovered in the past have been less than 35 feet deep; however, the staff of the Page Museum specifically requested that a maximum depth of 55 feet be included in this document to account for the fact that natural ground surface slopes toward the ocean (John Harris, Chief Curation of Earth Sciences, personal communication, 2013). The La Brea Zone has a radius of two miles around the George C. Page Museum of La Brea Discoveries.

### 2.2.1 Deposits outside the La Brea Zone

More than a dozen fossil localities are known in non-asphaltic Quaternary older alluvium adjacent to the Project Alignment and have produced fossils including mammoth, mastodon, camel, horse, bison, deer, American lion and rodents. In the PLE vicinity, underlying sediments may be non-asphalt or asphaltic. The San Pedro Formation has produced horse, coyote, turtle, fish, shark, and numerous invertebrate fossils. While this formation is entirely marine, terrestrial animals such as fossil horse and coyote were washed into the ocean in streams or rivers. The Fernando Formation has produced invertebrate fossils in the Project Alignment but no vertebrate paleontological resources. Elsewhere in the Los Angeles Basin the formation has produced vertebrate fossils.

### 2.2.2 Deposits within the La Brea Zone

The late Pleistocene fossils of the La Brea tar pits are internationally known (Fraser and Sues 2013, Harris and Jefferson 1985). Over four million specimens including mammals, birds, fish, plants and insects have been documented.

Prehistorically, local Native Americans collected and utilized the asphaltum at La Brea for both waterproofing and glue. The alignment of Wilshire Boulevard was the original indian trail to the tar pits. After El Pueblo de la Nuestra Señora la Reina de los Angeles was founded in 1781, the residents of the town used the asphaltum to waterproof their roofs and as fuel. Fossils were probably discovered and collected in both prehistoric and early historic times. By the late nineteenth century, La Brea was owned by the Hancock family. They gave a saber cat canine tooth to a visiting professor named William Denton who published the first description of the fossils from La Brea.

Between 1907 and 1913 there was a flurry of fossil collecting at La Brea by The University of California at Berkeley, the Southern California Academy of Sciences, and Los Angeles High School. The scientific importance of these collections was instrumental in the Hancock family’s decision to donate the land to the County as a scientific park. The fledgling Los Angeles County Museum conducted excavations from 1913 to 1915 and again in 1929 of more than 100 separate localities. The focus was on collecting large animals and they successfully collected about one million fossils.

In 1969, the Museum reopened excavations at La Brea at Pit 91. This pit was discovered and partially excavated in the early 20$^{th}$ century but deliberately backfilled and preserved for future excavation. Pit 91 was excavated with vastly improved technical methods and focused on recovering small and microscopic specimens in addition to taphonomic information such as how the fossils were oriented. These new excavations doubled the number of species known; particularly of small mammals, fish, lizards, frogs, snails, plants, and insects.

In 1975, when the foundations for the Page Museum were being excavated, fossils were discovered there also. The fossils were divided into blocks and jacketed (covered with burlap soaked in plaster to make a strong, protective casing) for later excavation in the laboratory. These jackets yielded the first articulated skeletons of individual animals known from La Brea. One of the articulated animals was a saber cat and it was discovered that past assumptions regarding the order and placement of bones of the forepaw of sabercats had been incorrect.

In 2006, new La Brea Zone deposits were discovered at Wilshire and Ogden during excavations for a parking garage. These included 23 new localities in asphaltic matrix as well as some non-asphaltic deposits with fossils. Among the new discoveries from the portions of this material excavated to date is recovery of the most complete individual skeleton of a mammoth known at La Brea.

### 2.3 Paleontologically Sensitive Areas

Based on locations and depths of prior fossil discoveries, all excavations in native sediments (non-fill) for stations and associated facilities and the drop/retrieval shafts for the tunneling machine require full time paleontological monitoring. Construction of the Project Alignment is expected to encounter La Brea Zone fossils at the Wilshire/Fairfax Station and possibly at Wilshire/La Brea Station. All stations have potential to encounter non-asphaltic or asphaltic fossils from the marine formations. No monitoring is required for any other Project components. The tunneling for the subway is exempt from monitoring due to logistics of the machinery which drills and then immediately exudes the tunnel wall materials. Unanticipated discoveries along the Project Alignment may be encountered during trenching below existing streets or during other ground-disturbing activities.

## 3. SIGNIFICANCE CRITERIA

### 3.1 Definition of Significance for Paleontological Resources

Only qualified, trained paleontologists with specific expertise in the type of fossils being evaluated can determine the scientific significance of paleontological resources. Fossils are considered to be significant if one or more of the following criteria apply:

1. The fossils provide information on the evolutionary relationships and developmental trends among organisms, living or extinct;
2. The fossils provide data useful in determining the age(s) of the rock unit or sedimentary stratum, including data important in determining the depositional history of the region and the timing of geologic events therein;
3. The fossils provide data regarding the development of biological communities or interaction between paleobotanical and paleozoological biotas;
4. The fossils demonstrate unusual or spectacular circumstances in the history of life;
5. The fossils are in short supply and/or in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and are not found in other geographic locations.

As so defined, significant paleontological resources are determined to be fossils or assemblages of fossils that are unique, unusual, rare, uncommon, or diagnostically important. Significant fossils can include remains of large to very small aquatic and terrestrial vertebrates or remains of plants and animals previously not represented in certain portions of the stratigraphy. Assemblages of fossils that might aid stratigraphic correlation, particularly those offering data for the interpretation of tectonic events, geomorphologic evolution, and paleoclimatology are also critically important (Scott and Springer 2003).

## 4. RESOURCE ASSESSMENT METHODS

This section details the statutory requirements and standard professional methods used to evaluate paleontological resource significance. The methods discussed include those used to conduct fieldwork, recover fossils, document localities, prepare specimens, identify specimens, analyze specimens and formally evaluate significance of fossils identified during the course of the Project.

The potential to impact fossils varies with depth of impacts, previous disturbance and presence of non-fossiliferous sediments. Unidentifiable fossils will generally not meet significance criteria and should not be collected unless the quantity and preservation is sufficient for dating purposes (criterion 2 above). For identifiable fossils, significance will need to be assessed subsequent to recovery but generally single fossils are isolated finds that will not meet significance criteria unless they represent previously unknown species in the area or they provide a useful radiocarbon date that assists with local sedimentary sequencing (criteria 2 and 5 above). This is because single fossils, such as a left bison tibia, do not have sufficient data potential to evaluate evolutionary relationships, development of biological communities, interaction between paleobotanical and paleozoological biotas, or unusual or spectacular circumstances in the history of life (criteria 1, 3 and 4 above). Associations of whole or partial skeletons of different animals are likely to meet multiple significance criteria. Deposits which are determined to be part of the Rancho La Brea deposits will meet criterion 4 at a minimum.

# 5. WORKER PALEONTOLOGICAL AWARENESS TRAINING

All Project management supervisory and earth-moving personnel, including construction workers, inspectors and supervisors, will receive Paleontological Resources Awareness Training prior to commencement of any ground-disturbing activity. The training program was developed by the author of this document to ensure consistency. The training will include instruction on: (1) the possibility of unearthing fossils; (2) the types of fossils and deposits that may be unearthed and how to recognize them; (3) the importance of, and legal basis for, the protection of significant resources; and (4) the requirement that they immediately halt work within 50 feet of discovery of fossils.

All attendees will sign to verify that they understand the Project mitigation requirements and will be issued hard-hat stickers. Personnel will be required to affix the stickers prior to signing. New personnel commencing work on the project must receive the training prior to start of work.

Paleontological Resources Awareness Training will be provided in at least two setting – classroom and field tailboard. The training presentation will take about 15 minutes and 10 minutes will be allowed for questions. A current contact list will be provided to each attendee. The worker education will include visuals of fossils that might be found in the project vicinity. Presentations for management personnel may be conducted as presentations utilizing computer software. Presentations for field construction crews (generally less than 10 people) may be conducted in the field as tailboard flipbook presentations.

# 6. TREATMENT OF FOSSILS OUTSIDE THE LA BREA ZONE

## 6.1 SCOPE OF WORK

This section of the work plan was developed to guide and facilitate the identification and treatment of paleontological resources located in non-asphaltic Quaternary older alluvium and non-asphaltic or asphaltic underlying sediments during the Project in an effort to reduce adverse effects on significant resources. Since the La Brea Zone is a maximum of 55 feet deep, this applies to sediments that underlie the Quaternary sediments even at Wilshire/Fairfax Station.

## 6.2 PALEONTOLOGICAL PERSONNEL

The qualified Principal Paleontologist retained by Metro, Sherri Gust, has a graduate degree, more than ten years of experience as a Principal Paleontologist, demonstrated expertise in vertebrate paleontology, and has been specifically approved by the Museum. The Principal Paleontologist will be responsible for ensuring that all subordinate personnel are appropriately qualified.

Personal protective equipment (PPE) may be required for safe working conditions. All will receive a comprehensive safety manual and Project-specific safety training. Attendance at job site safety meetings is required of all paleontological field personnel. Paleontological field personnel will wear clothing appropriate to the jobsite and are required to wear hard hats, safety vests, hard-toed boots and hearing protection in active construction zones.

## 6.3 MONITORING

### 6.3.1 Full-time Monitoring

All excavations for stations and associated facilities and the drop/retrieval shafts for the tunneling machine require full time paleontological monitoring below any fill. All stations and the drop/retrieval shaft locations may encounter paleontological resources in non-asphaltic sediments outside the La Brea Zone (both horizontally and vertically). No excavation is permitted at any of these locations without presence of a paleontological monitor.

### 6.3.2 On-Call Monitoring

No monitoring is required for any other Project components other than those stated above. The tunneling for the subway is exempt from monitoring due to logistics of the machinery which drills and then immediately exudes the tunnel wall materials. Unanticipated discoveries may be encountered during trenching below existing streets or during other ground-disturbing activities. The crew should immediately halt work in that specific location and notify the Principal Paleontologist. Work may resume immediately a minimum of 50 feet from the find.

### 6.3.3 Construction Phase Schedule

Metro will provide the Principal Paleontologist with an initial schedule of subsurface ground-disturbing activities to be conducted within the Project limits in writing at least 15 working days prior to beginning of construction and update the schedules as needed. The Contractor will make arrangements for the Paleontological Monitoring Team to be at the work site in accordance with these requirements.

### 6.3.4 Monitor's Authority to Temporarily Halt Project Activities

Paleontological monitors may temporarily divert equipment to inspect fossil finds and reveal the extent of deposits. The excavation contractor will cooperate with the monitor and assist with sediment removal around fossil deposits at the request of the monitor and with approval of Metro. Metro will be responsible for final decisions regarding the issuance and duration of any formal Suspend Work orders.

### 6.3.5 Monitoring Methods and Documentation

The paleontological monitor will maintain close communication with the on-site resident engineer and earthmoving personnel in order to maintain a safe working environment and to be fully appraised of the upcoming areas of impact and any schedule changes.

The paleontological monitor is responsible to complete daily documentation of monitoring presence and daily documentation of monitoring activities including the location of monitoring activities throughout the day and the type, observations of sediment type and distribution, observations regarding fossils, collection of fossils and other information. The paleontological monitor is responsible to photograph activities, sediments and paleontological resources for documentation purposes and to fill out a Photograph Record Sheet daily. All paperwork and photographs will be submitted to the Principal Paleontologist weekly. All documentation will be filed and maintained by the Principal Paleontologist.

#### 6.3.6 Reporting

A weekly email summary will be submitted to Metro. If fossils are observed, the Contractor and Metro will be immediately notified. Additional documentation will also be incorporated if fossils are recovered. These records and the field notes will be used to prepare a monthly letter report. The monthly reports will summarize the monitoring activities of the previous period, discoveries made, and other information as appropriate. Monthly reports will be submitted to the Metro.

Upon conclusion of the Project, a final report will be prepared. The final report will include the inclusive dates of monitoring, personnel utilized including qualifications, summarize the monitoring effort and coverage using text and maps, documentation of paleontological localities discovered, paleontological resources identified, interpretation of fossils, evaluation of the adequacy of this paleontological resources management plan and suggestions for improving paleontological resource monitoring procedures and include all specialists' reports as appendices. The report will be submitted to Metro and the repository.

### 6.4 Fossil Discovery and Recovery

Fossils observed will be treated differently depending on type and circumstance. Generally, discovery of identifiable invertebrate (shells, crustaceans, etc.) fossils requires a scientifically significant sample be collected for identification and analysis and that the locality be documented (see below). Similar procedures are followed for microvertebrates such as rodents. Current professional standards call for testing of 200 lb. samples (four-five full five gallon buckets) from each locality followed by processing of up to 6000 lbs. of matrix if significant fossils are recovered by testing. Documentation of localities is required.

Larger fossils observed must be evaluated to determine their condition. Generally the monitor will be able to quickly determine if the fossils are sufficiently well-preserved to meet preliminary significance criteria. If necessary, the monitor will cordon off the immediate area around the fossil to permit a safe work zone to recover the fossil and notify the construction foreman. The monitor will also immediately notify the field supervisor if assistance is needed and sufficient personnel to perform the work will be fielded. Documentation of localities is required.

Discovery of a bone bed or other type of fossil sites containing multiple large fossils may require a formal Stop Work order. The monitor will cordon off the area until evaluation occurs. The Principal Paleontologist will consult with the Metro Cultural Resources Coordinator regarding the amount of time necessary. This type of discovery requires a detailed field map, a sedimentary structure analysis, one or more stratigraphic columns and data for taphonomic analysis.

Depending on the formations being impacted additional samples collected may include specimens for dating analyses or materials for microfossil, botanical or pollen analyses. All fossils and sediment samples are accompanied by a field tag with Project and locality information including a unique field number.

#### 6.4.1 Fossil Locality Documentation

Every fossil locality requires a standard set of data be taken. This includes one or more coordinate readings using a resource grade high resolution GPS device such as a Trimble GeoXH or better. Currrently, the combination of Trimble GeoXH and most recent updates to the post-processing software permit an average accuracy of four". All field members of the Paleontological Team will be trained in the use of the resource grade GPS prior to start of the Project. The Paleontological Team will coordinate with the prime construction contractor to obtain accurate elevation readings. Lithology, paleoenvironmental information and a true north reading are also required. Additional information collected may include one or more stratigraphic columns, sedimentary structure analysis, taphonomic analysis and photographs of the fossil *in situ*. Depending on the formations being impacted additional samples collected may include specimens for dating analyses or materials for microfossil, botanical or pollen analyses.

If recovered fossils are within the limits of radiocarbon dating, samples will be submitted to Beta-Analytic to obtain dates. If fossils are demonstrably older, radiocarbon may not be feasible and alternative dating methods will be utilized if possible such as optical luminescence dating.

### 6.4.2 Fossil Preparation

Many fossils require only cleaning and stabilization through the use of hardeners. Others require lab excavation of plaster jackets with gradual cleaning and hardening. Sometimes larger fossils require a "cradle", usually a form-fitted plaster lined with acid-free cloth to provide support and prevent breakage during storage or transport. Fossils found in bedrock formations may require more tedious preparation using mechanical devices such as zip scribes.

Processing of matrix samples for microvertebrates varies depending on the nature of the sediments and may be washed using water, may require chemical agents to break apart the rock or may require floatation using heavy liquids. Sediment to be screenwashed will be transported to the lab for mechanical screen washing.

### 6.4.3 Fossil Identification

All fossils will be identified by experts. All identifications will be as specific as possible and include element, portion, side, sex, age, taphonomy and notes. Cataloging, including identification information, is entered into a computer database. Each specimen is maintained with a tag specifying the provenience and identification information.

### 6.4.4 Fossil Analyses

Analyses conducted depend to a great extent on the number of fossils recovered and their condition. Guild analysis (relative number of carnivores, herbivores and omnivores of various body weights in an ecosystem), demographic analysis (age and sex structure of populations), habitat analysis (certain types of animals indicate grasslands as opposed to deserts for example), paleoecology (use of botanical and/or pollen analysis to reconstruct the paleoenvironment) and comparative analysis (comparison to other faunas of the same time period regionally) are the most typical. Geological context analyses include stratigraphy of the fossil deposit, dating (to narrow the time range of the fossils), taphonomy (history of alteration of the fossils by scavengers, water transport, etc.) and other ancillary studies.

### 6.4.5 Fossil Curation and Discard Protocol

Fossils meeting significance criteria will be curated in perpetuity at an accredited repository along with all Project data and a copy of the final report. Fossils are only to be removed from a collection at the discretion of the Principal Paleontologist. Typically specimens are discarded to educational uses because the fossil was not identifiable to at least family level, was not found *in situ* or was part of a large collection of the same species from the same locality and individual specimens in poor condition are discarded.

### 6.4.6 Fossil Repository

The Natural History Museum of Los Angeles County will be the repository for all significant fossils from outside the La Brea Zone. Plant fossils will be curated at the University of California Museum of Paleontology. FTA/Metro will make available Project funds to pay for curating the collection.

# 7. TREATMENT OF FOSSILS WITHIN THE LA BREA ZONE

## 7.1 Scope of Work

This section of the work plan was developed to meet the requirements of the 2011 Memorandum of Understanding (MOU) between the Metropolitan Transportation Authority of Los Angeles County (Metro) and the Natural History Museum of Los Angeles County (Museum) (see Attachment B) and subsequent communication (see Attachment C). Implementation of the paleontological resources mitigation plan will guide and facilitate the identification and treatment of paleontological resources located during the Project in an effort to reduce adverse effects on significant resources.

Geotechnical work for the Project did not reveal asphaltic deposits at Wilshire/La Brea and on that basis this section applies to Wilshire/Fairfax station from the bottom of fill to the top of the marine sediments only. These are typically Quaternary older alluvium saturated with asphalt and contain terrestrial and freshwater species only. The George C. Page Museum of La Brea Discoveries will provide oversight to ensure that data standards are met and will be the repository for any fossils recovered.

## 7.2 Paleontological Personnel

The qualified Principal Paleontologist retained by Metro, Sherri Gust, has a graduate degree, more than ten years of experience as a Principal Paleontologist, demonstrated expertise in vertebrate paleontology, demonstrated expertise in the paleontology of Rancho La Brea and has been specifically approved by the Museum. The Principal Paleontologist will be responsible for ensuring that all subordinate personnel are appropriately qualified.

In addition to preparing this mitigation plan the Principal Paleontologist will coordinate with the Museum for all activities, supervise monitoring of all subsurface ground disturbance, recovery of the fossil deposits, ensure data collection in accord with MOU, provide progress reports and ensure that construction delays are minimized while preserving significant fossils. When requested by the Museum, the Principal Paleontologist will ensure appropriate identification and maintain necessary space for storage and laboratory work on recovered deposits at a secure laboratory facility.

Due to environmental hazards including subsurface methane and hydrogen sulfide, all paleontological field personnel including selected Museum staff must participate in all special training offered by Metro for safety. Personal protective equipment (PPE) may be required for safe working conditions. All will receive a comprehensive safety manual and Project-specific safety training. Attendance at job site safety meetings is required of all paleontological field personnel. Paleontological field personnel will wear clothing appropriate to the jobsite and are required to wear hard hats, safety vests, hard-toed boots and hearing protection in active construction zones.

## 7.3 Monitoring

### 7.3.1 Full-time Monitoring

All excavations for stations and associated facilities and the drop/retrieval shafts for the tunneling machine require full time paleontological monitoring below any fill. All stations and the drop/retrieval shaft locations may encounter paleontological resources. No excavation in native sediments (this excludes fill) is permitted without presence of a paleontological monitor.

### 7.3.2 On-Call Monitoring

No monitoring is required for any other Project components other than those stated above. However, unanticipated discoveries along the Project Alignment may be encountered during trenching below existing streets or during other ground-disturbing activities. The crew should immediately halt work in that specific location and notify the Principal Paleontologist. Work may resume immediately a minimum of 50 feet from the find.

### 7.3.3 Construction Phase Schedule

Metro will provide the Principal Paleontologist and Museum with an initial schedule of subsurface ground-disturbing activities to be conducted within the Project limits in writing at least 15 working days prior to beginning of construction and update the schedules as needed. The Contractor will make arrangements for the Paleontological Monitoring Team to be at the work site in accordance with these requirements.

### 7.3.4 Monitor's Authority to Temporarily Halt Project Activities

Paleontological monitors may temporarily divert equipment to inspect fossil finds and reveal the extent of deposits. The excavation contractor will cooperate with the monitor and assist with sediment removal around fossil deposits at the request of the monitor and with approval of Metro. Metro will be responsible for final decisions regarding the issuance and duration of any formal Suspend Work orders.

### 7.3.5 Monitoring Methods and Documentation

The paleontological monitor will maintain close communication with the on-site resident engineer and earthmoving personnel in order to maintain a safe working environment and to be fully appraised of the upcoming areas of impact and any schedule changes.

Fill does not require monitoring but all excavations in native sediments require full time paleontological monitoring. Due to the special circumstances of asphaltic deposits (Attachment B), all grading for Fairfax Station from the bottom of the fill to the top of the marine sediments will proceed in shallow removals of six inch lifts. This requirement does not apply to Western, La Brea or La Cienega drop shaft/station excavations as no asphaltic matrix was observed in any geotechnical boring at these locations. The paleontological monitor will need to be in direct proximity to the excavations to be able to observe fossils uncovered by grading. As noted above, the monitor has the authority to temporarily halt excavations if fossils are observed.

The paleontological monitor is responsible to complete daily documentation of monitoring presence and daily documentation of monitoring activities including the location of monitoring activities throughout the day and the type, observations of sediment type and distribution, observations regarding fossils, collection of fossils and other information. The paleontological monitor is responsible to photograph activities, sediments and paleontological resources for documentation purposes and to fill out a Photograph Record Sheet daily. All paperwork and photographs will be submitted to the Principal Paleontologist weekly. All documentation will be filed and maintained by the Principal Paleontologist.

### 7.3.6 Reporting

A weekly email summary will be submitted to Metro and forwarded to the Museum by Metro. If fossils are observed, the Museum, Contractor and Metro will be immediately notified. Additional documentation will also be incorporated if fossils are recovered. These records and the field notes will be used to prepare a monthly letter report. The monthly reports will summarize the monitoring activities of the previous period, discoveries made, Museum involvement and other information as appropriate. Monthly reports will be submitted to the Metro.

Upon conclusion of the Project, a final report will be prepared. The final report will include the inclusive dates of monitoring, personnel utilized including qualifications, summarize the monitoring effort and coverage using text and maps, documentation of paleontological localities discovered, paleontological resources identified, interpretation of fossils, evaluation of the adequacy of this paleontological resources management plan and suggestions for improving paleontological resource monitoring procedures and include all specialists' reports as appendices. The report will be submitted to Metro and the Museum.

## 7.4 La Brea Zone Fossil Discovery and Recovery

If La Brea Zone fossils are discovered, Metro and the Museum will be immediately notified. The Principal Paleontologist in consultation with the Museum will determine the best method of collecting any fossil or deposit. All work will be expedited to minimize construction delays. The extent of the fossil deposit will require controlled excavation by the paleontological monitor and assistance from additional paleontological personnel will be provided as needed. The contractor may be requested to assist the paleontological team with sediment removal. All fossil localities will be extensively recorded using a Trimble GeoXH high resolution GPS unit to ensure precise locational data. If satellite reception by the GPS unit is not adequate, localities will be mapped using triangulation of multiple metric tape measures.

Asphaltic fossil deposits may be conical or tabular and range from five to 20 ft. across. If a conical deposit is found and the extent has been determined the sediment surrounding it will be carefully removed by the paleontological team with possible assistance from the contractor so that the deposit is fully exposed except for a pedestal of dirt under the deposit. The deposit is reinforced with wooden planks surrounded by metal bands and covered with nylon or plastic tarping to preserve the integrity of the deposit. A custom tree box can then be constructed around each deposit. The space between the tarping and box must be filled in with foam or preferably fill/gravel of a distinctly different color than the native sediments to prevent deformation of the deposit during transit while making the packing material easily differentiable. More metal bands are added around the outside of the completed tree box. Subsequently, the sediment beneath the tree box is removed by tunneling so that the box floor can be constructed. The field number of the locality and the locality data will be placed on the exterior of the box, in addition to the field notes, using permanent ink or paint. A crane is used to place the tree box on a flatbed truck for transit. Boxes will be moved to the Page Museum or a secure laboratory of the Principal Paleontologist depending on space required. [Attachment B]

Non-asphaltic fossil deposits can consist of single bones or whole skeletons. These fossils must be stabilized using conventional paleontological methods such as hardeners and plaster jackets in order to be removed. These fossils can generally be moved onto truck by hand. [Attachment B]

### 7.4.1 La Brea Zone Locality Documentation

Every fossil locality requires a standard set of data be recorded. A field number is assigned to each locality and sometimes to multiple specimens. Field number convention to be utilized consists of the numerical year, the numerical month, the date, followed by the monitor's initials, and possibly a specimen number (for example, 20120427 SMG.1). Multiple precise location readings with resource grade GPS (Trimble GeoXH), creation of an accurate field map, accurate elevation measurements, depth below surface, lithology including Munsell Soil Color Chart evaluation, and true north reading are necessary. Additional information collected may include one or more stratigraphic columns, sedimentary structure analysis, taphonomic analysis and photographs of the fossil *in situ*. Tree boxed deposits and plaster jackets must have the permanent markings indicating top and bottom of deposit, north arrow and field number as well as reference corners (coordinated with GPS readings).

### 7.4.2 La Brea Zone Treatment Decisions

The MOU provides that recovered fossils will be evaluated by the Museum for a determination about who will prepare and identify the fossils. The Museum will be involved in oversight of any fossils prepared by the Principal Paleontologist's team.

Metro and the Museum will determine when fossils are prepared. This may be immediately after recovery or may await full Project construction. Generally, immediate preparation is preferred to prevent drying out of the sediments and subsequent problems with the integrity and scientific value of the deposits due to slumping and other deformations. Decisions about further analysis will depend on the nature of the deposit recovered and the potential of the fossils to provide information new to science.

### 7.4.3 La Brea Zone Asphaltic Fossil Preparation

A detailed protocol has been prepared and is included by reference (Attachment B). Under the direction of the Museum the fossils will be prepared either by the Museum or by the Principal Paleontologist overseen by Museum personnel in accordance with the protocol and the MOU.

# 8. REFERENCES CITED

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# ATTACHMENT A: QUALIFICATIONS

cogstone
PALEONTOLOGY - ARCHAEOLOGY - HISTORY

**SHERRI GUST**
Project Manager & Principal Paleontologist

### EDUCATION

1994 M. S., Anatomy (Evolutionary Morphology), University of Southern California, Los Angeles
1979 B. S., Anthropology (Physical), University of California, Davis

### SUMMARY QUALIFICATIONS

Gust has more than 34 years of experience in California, acknowledged credentials for meeting national standards, and is a certified/qualified principal paleontologist in all California cities and counties that maintain lists. She holds California and Nevada statewide BLM paleontology permits. Gust is an Associate of the Natural History Museum of Los Angeles County in the Vertebrate Paleontology and Rancho La Brea Sections. She is a Member of the Society of Vertebrate Paleontology and the Society of Economic Paleontologists and Mineralogists. She has special expertise in the identification and analysis of fossil bone.

### SELECTED PROJECTS

**Aroleda Drive Freeway Project.** Paleontological Monitoring for 5 mile segment of State Route 99 south of Merced. Some 128 localities and 1667 fossils recovered in five months of excavation for detention basins. Project Manager and Principal Paleontologist. 2012. Subconsultant to URS.

**Plainsburg Interchange Project.** Paleontological Mitigation Plan with updated assessment for 5.5 mile new road segment and interchange on State Route 99 between Chowchilla and Merced. Project Manager and Principal Paleontologist. 2012. Subconsultant to URS.

**Westside Subway Exploratory Shaft Project.** Paleontological Mitigation Plan for deep exploration prior to excavation of new subway station near the La Brea tar pits. Project Manager and Principal Paleontologist. 2012. Subconsultant to PB.

**Santa Clara County Express Lanes Project.** Paleontological Evaluation Report and Mitigation Plan for 34 miles of State Route 85 in San Jose and Mountain View. Project Manager and Principal Paleontologist. 2012. Subconsultant to URS.

**Topock Groundwater Remediation Project.** Paleontological Resources Management Plan with updated evaluation for 794 acre project at energy facility on California-Arizona border. Project Manager and Principal Paleontologist. 2012. Subconsultant to Parus Consulting.

**Geospatial Paleontology Database.** Managed paleontological research and GIS database development for 15 counties in central and eastern California. Delivered detailed information about potential fossil yield, geological units, prior fossils and other information at cursor click. Project Manager and Principal Paleontologist. 2011-2012. Subconsultant to URS.

**Eldorado-Ivanpah Transmission Line.** Paleontological survey and Paleontological Resources Management Plan for 71 miles of electrical lines and associated telecommunications from Eldorado, NV to Ivanpah, CA across both BLM and private lands. Project Manager and Principal Paleontologist. 2010. Prime contractor.

**Mojave Water Agency Ground Water Replenishment Project.** Cultural and Paleontological Resources Management Plan was prepared, including an updated assessment, and submitted to SHPO. Cultural resources awareness training provided to all construction personnel and both archaeological and paleontological monitoring performed. Principal Archaeologist and Paleontologist and Project Manager. 2010-2012. Subconsultant to RBF.

# Attachment B: Page Museum MOU and attachments

MEMORANDUM OF UNDERSTANDING

**THIS MEMORANDUM OF UNDERSTANDING** ("MOU") is entered into as of this 2nd day of November 2011 by and between the Los Angeles County Metropolitan Transportation Authority ("MTA") and the Los Angeles County Museum of Natural History, including the Page Museum at the La Brea Tar Pits ("Museum") (collectively, "the Parties"), for the preservation of paleontological and archaeological resources associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station.

## BACKGROUND

**WHEREAS**, the MTA has the responsibility under Federal and State law to recover and preserve for future scientific and educational use paleontological, archaeological, and historical resources that may be impacted by the Westside Subway Extension Project and associated records; and

**WHEREAS**, the Museum has established expertise in recovery, management, curation and research of paleontological resources and is willing to permanently curate paleontological and asphalt-related archaeological resources recovered from the Westside Subway Extension Project in asphaltic deposits associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station and recognizes the benefits which will accrue to it, the public and scientific interests by housing and maintaining the Paleontological Resources and Records Collection for study and other educational purposes; and

**WHEREAS**, the Parties hereto recognize the mutual benefits to be derived by having paleontological and archaeological resources suitably housed and maintained by Museum;

**NOW, THEREFORE**, in consideration of the terms, conditions, covenants and performances herein contained, and other consideration the receipt and sufficiency of which is hereby acknowledged, and with the intent to be legally bound hereby, the Parties agree to incorporate the above recitals into this MOU and further contract, promise and agree as follows:

1. **MTA shall:**

a. Retain a qualified principal paleontologist (minimum of graduate degree, ten years of experience as a principal paleontologist and having demonstrated expertise in vertebrate paleontology) approved by the Museum to plan, implement and supervise paleontological monitoring, preservation, fossil recovery, fossil preparation, fossil documentation and reporting of significant paleontological resources within the areas of disturbance for the Wilshire/Fairfax Station or other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station. The principal paleontologist will be responsible to ensure that all subordinate personnel are appropriately qualified.

b. Require the principal paleontologist to prepare a mitigation plan, subject to approval by the MTA and Museum, to address monitoring, preservation and, recovery of any paleontological resources. The mitigation plan shall be consistent with best practices guidelines for both field and laboratory work on project paleontological resources to meet state and federal laws and guidelines and Museum standards (Attachments 1 and 2).

c. Require the principal paleontologist to monitor all ground-disturbing activities where sub-surface soils are exposed. The areas to be examined will be determined based on project plans and in consultation with construction staff and the qualified paleontologist during pre-construction meetings and as needed throughout the construction process.

d. Ensure that if subsurface paleontological resources are identified by the principal paleontologist during construction, all construction activities in the area of identified paleontological resources will be temporarily halted so that the resources may be documented and recovered. All resources shall be documented on appropriate forms approved by the Museum and these will be placed on file in the Museum.

e. Ensure that any paleontological resources, including asphaltic deposits containing fossils and/or archaeological objects, will be recovered in accordance with best practices outlined by the Museum (Attachment 1).

f. Require that the principal paleontologist have designated and secure space sufficient to store and, if necessary, analyze and process boxed or individual fossil deposits for preparation [but see section 2.c].

g. Require that the principal paleontologist record all data and, if necessary, perform excavation of boxed deposits or individual fossils, prepare fossils and store fossils prior to curation in accordance with best practices outlined by the Museum (Attachment 2).

h. Require that the principal paleontologist provide periodic progress reports including copies of all field notes to the MTA and Museum in addition to a comprehensive final report meeting all state and federal standards. The original copies of the field notes will be archived in the Page Museum at the time that the fossils are transferred to its jurisdiction.

i. Provide funding for required fossil recovery, cleaning, preservation, curation and storage and any other fossil-related Museum activities specified in Paragraph 2 based on a cost per amount recovered to be agreed upon by the MTA and Museum in a subsequent detailed Agreement to be signed between the MTA and Museum during further Project Design. Such agreement will be based in part on the Museum's cost for processing and storage of its Project 23 materials, taking into account the possible variation in the density of fossils and in the matrix in which the fossils are found. Such agreement should include contribution to cost of permanent storage premises in the event that significant quantities of fossils are recovered. Such agreement shall prevent unreasonable payment if few fossils are found, but assure payment for vital effort.

j. Allow the Museum to be involved, in an oversight capacity, for all field and laboratory work to ensure that Museum standards are being maintained.

k. Require that paleontological resources be removed expeditiously to allow Project completion according to schedule, but in compliance with Museum standards as recently demonstrated in the construction of the new LACMA Underground Garage and corresponding Project 23 Paleontological Project.

l. Retain responsibility for compliance with all legal and regulatory provisions related to monitoring, reporting, consultation, and repatriation of Native American remains and related material, including under NAGPRA and California law.

m. Assign an MTA Representative to make any further revisions or adjustments to this document necessary in the course of the project, in cooperation with the Museum.

n. Designate the Museum as the sole source for the scientific description of fossils and artifacts recovered from the Westside Subway Extension Project in asphaltic deposits associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station. Publicity concerning the discovery of such fossils and artifacts shall be jointly undertaken by MTA and the Natural History Museum of Los Angeles County.

2. **Museum shall:**

a. Make available Museum personnel to provide oversight for the qualified principal paleontologist's preparation of a mitigation plan, subject to approval by the Agency, to address monitoring, preservation and, recovery of paleontological resources. The mitigation plan shall be consistent with best practices guidelines for both field and laboratory work on project paleontological resources to meet state and federal laws and guidelines and Museum standards (Attachments 1 and 2).

b. Make available Museum personnel to provide oversight of all field and laboratory work on paleontological resources for the duration of the project to ensure that Museum standards are being maintained.

c. Provide an option, dependent upon the volume and number of fossils recovered, that the Museum will directly house boxed fossil deposits and internally perform excavation and preparation of those deposits for compensation comparable to that offered to the principal paleontologist for similar services.

d. Provide for the professional care and management of the curated paleontological resources associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station.

e. Ensure that personnel assigned responsibilities related to the Westside Subway Extension Project are qualified museum professionals whose expertise is appropriate to the nature and content of the paleontological resources recovered.

f. Provide and maintain a repository facility having requisite equipment, space and adequate safeguards for the physical security and controlled environment for the paleontological resources (but see 1.i).

g. Perform those conservation treatments necessary to ensure the physical stability and integrity of the paleontological resources prepared by the principal paleontologist.

h. Curate the paleontological resources to ensure adequate scientific documentation of the circumstances of their recovery.

i. Credit the MTA when the Collection or portions thereof are exhibited, photographed or otherwise reproduced and studied in accordance with the terms and conditions of Museum policy with the statement: "In Cooperation with the Federal Transit Administration and Los Angeles County Metropolitan Transportation Authority". The Museum agrees to provide the Agency with copies of any resulting publications.

3. **Paleontological Advisory Board**

The Parties agree to mutually appoint a three person Paleontological Advisory Board comprised of appropriately qualified paleontologists to help guide this effort as previously agreed by the Parties in their Paleontological MOU for this site in 1983.

4. **Amendment**

This MOU may be revised by issuance of a written amendment signed and dated by both parties.

5. **Donation of Paleontological and asphalt-related Archaeological Resources**

Agency agrees to donate title to all paleontological and asphalt-related archaeological resources to the Museum.

**IN WITNESS WHEREOF**, the Parties hereto have executed this MOU.

Dr. Jane Pisano
President and Director
Los Angeles County Museum of Natural History

10/25/11
Date

Arthur T. Leahy
Chief Executive Officer
Los Angeles County Metropolitan Transportation Authority

11-02-11
Date

**ATTACHMENTS**

Attachment 1. Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

Attachment 2. Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

Attachment 3. Wilshire/Fairfax Station Construction Methodology

# Paleontological methods for mitigation of fossils in the vicinity of Hancock Park.



**Images courtesy of ArchaeoPaleo Resource Management, Inc.**

**2011**

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# Introduction

Rancho La Brea is the world's richest Ice Age fossil locality, yielding well over 3 million fossils and representing more than 600 species of animals and plants that lived in the Los Angeles Basin between 11,000 and 50,000 years ago. The asphaltic fossil deposits generally occur in randomly distributed inverted cone-shaped masses between 10 to 35 feet in depth. The sizes of the accumulations vary considerably from less than 5 cubic feet to more than 20 cubic feet. Flat tabular deposits such as that recovered during the construction of the Page Museum are rare. Ideally, the fossil accumulations should be carefully excavated as they are discovered. The fall back position is to remove the deposit intact, preserving it for excavation at a later date. This methodology, developed during the mitigation of the LACMA underground parking structure, preserves stratigraphic integrity, permits less hurried excavation under more optimum conditions, maximizes fossil and information retrieval, and enhances opportunities for major discoveries and new scientific contributions. All data pertaining to the location and condition of newly discovered fossil deposits must be recorded and photographed as outlined later in this document.

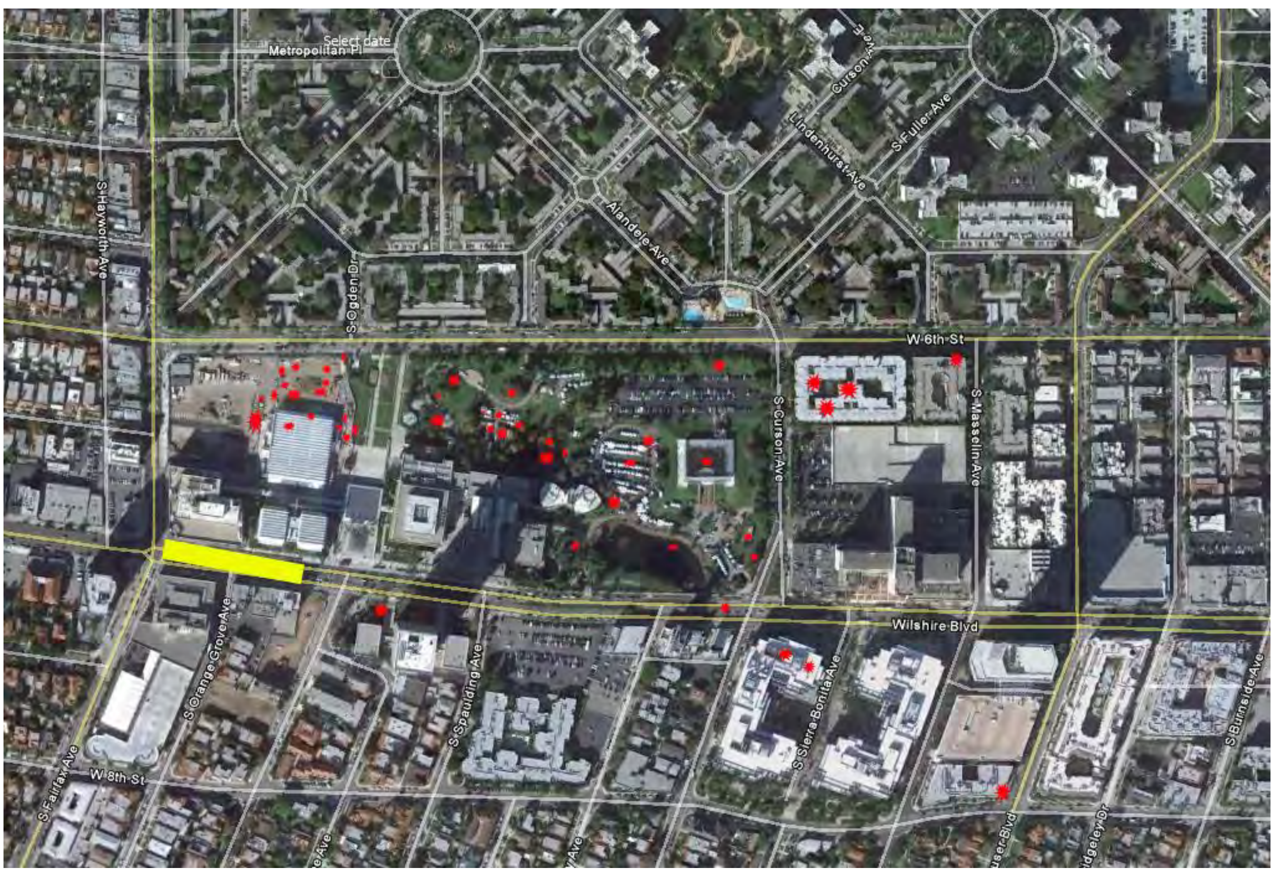



**Fig 1: Map of Hancock Park** and vicinity with known asphalt preserved fossil localities (red stars) and the approximate location of the proposed MTA subway station (yellow rectangle)

## Fig 2: Monitoring

All excavation activity must be carefully monitored. In areas of asphaltic sediment or other areas where fossils have been discovered, sediment should be removed in 4-6” levels while paleontologists monitor closely. The monitors are empowered to halt the process as soon as fossils are located.

**Fig 3: Fossils are discovered**

After a fossil deposit has been located the surrounding area must be roped off so that paleontologists can determine the extent of the deposit or if it is an isolated fossil. In the case of an accumulation deposit this may range from 5 feet to 20 or more feet across. Construction work in the immediate vicinity of the fossil deposit must be halted temporarily but may proceed normally elsewhere in the construction site. Asphalt saturated conical shaped deposits and isolated fossil mitigation are described separately below.

## Taking Field notes

Whether an accumulation of fossils are discovered or an isolated fossil is found, detailed field notes must be taken. The precise locality of each fossil deposit must be recorded with a resource-grade GPS device, its extent clearly described, mapped, and photographed on site using conventional field data collection methods, and its context including represented lithologies and depositional environments must be described. Types of geologic information to be collected should include: the nature of bounding contacts (erosional, sharp, gradational), thickness, geometry, grain size, shape, and sorting, color (fresh and weathered, use a color chart), sedimentary structures (physical and biogenic), cement type, pedogenic features (rooting, nodules, slickensides, etc.), halos, mineral crusts, microstructures around bio-clasts, and other fossils. Types of taphonomic information to be collected should include: taxonomic

representation, skeletal articulation and association, scale and geometry of assemblage, density, and orientation of bones. Bone modification information to be collected should include: weathering, polishing, abrasion, scratch/tooth marks, root traces, borings, fragmentation/breakage, and distortion. Each isolated fossil and each individual fossil deposit must be given an individual field number. This number should be written in permanent ink on individual fossils and clearly marked in permanent marker or paint on the box containing a deposit.

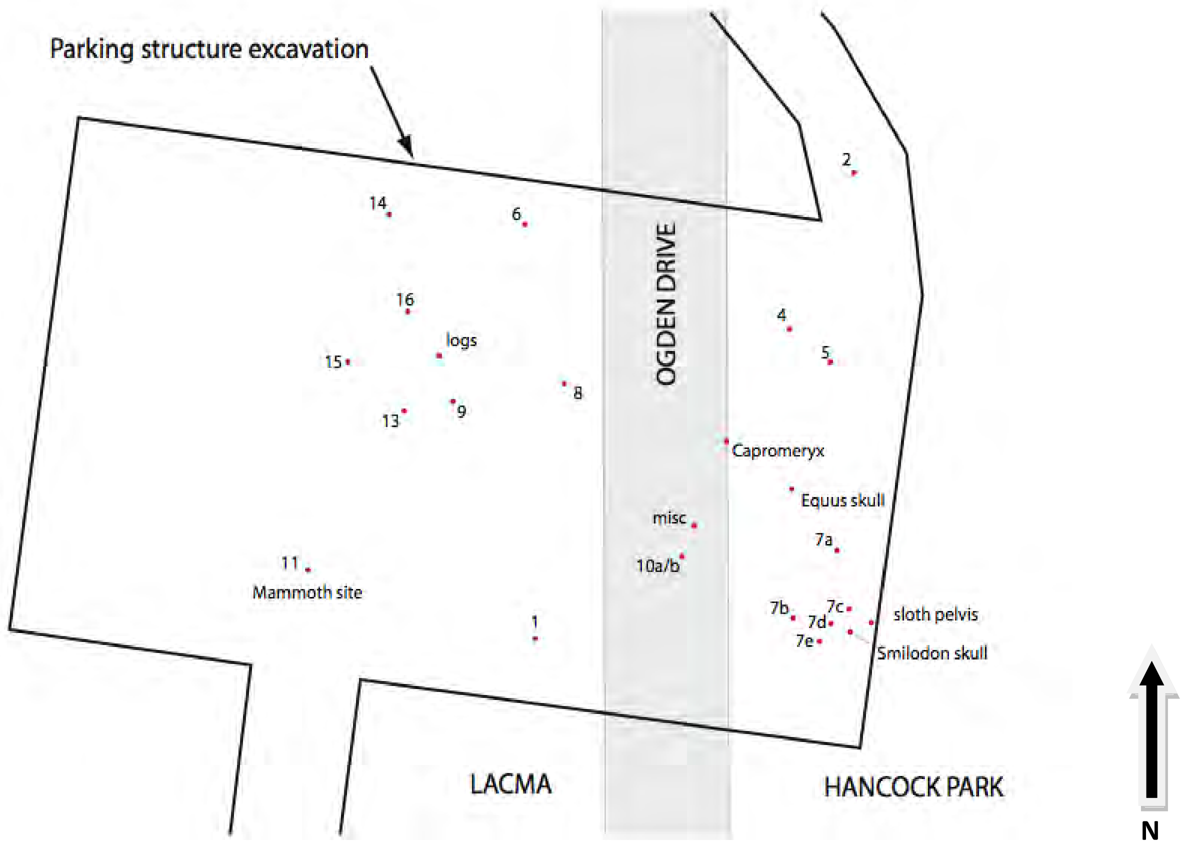
## Asphalt saturated conical shaped deposits

### Fig 4: Pedestal a deposit

Once the extent of the fossil accumulation has been determined, the sediment surrounding the fossiliferous deposit is carefully removed, isolating the accumulation on a pedestal. It may be necessary for monitors to wear a SCBA, as in this image, because of the high concentrations of hydrogen sulfide.

**Fig 5: View of east end of LACMA construction site**

It is possible that there will be a number of fossil deposits within the construction site. Work may continue at non-fossiliferous locations while the deposits are being salvaged.




## Fig 6: Map of fossil localities from LACMA parking garage

These were mostly asphaltic fossiliferous masses but included some occurrences of isolated bones, trees, and other fossils.


**Fig 7: Fossil accumulation pedestals before tree box**

After the deposit has been isolated it will be surrounded by metal bands to conserve its integrity before the box is built and a brightly colored strong plastic or a tarp to keep the deposit dirt separated from the 'fill' dirt.

## Fig 8: Building a tree box around a fossil deposit

A custom sized box is then built around each deposit by a ‘tree boxing’ company. Valley Crest was used on the LACMA project. Any space between the plastic-wrapped deposit and the edge of the box must be filled with polyurethane foam, distinctly different sediment or gravel to preserve the integrity of the deposit and to prevent its deformation during subsequent transportation and storage. It is important that the ‘fill’ sediment be easily recognizable from the matrix during later excavation of the deposit.

**Fig 9: Secure the tree box with metal bands**

After the sides of the box are nailed into place, metal bands are added to secure and strengthen the sides of the box.

## Fig 10: Tunnel under the tree box

After the sides of the box are secured and banded, the sediment beneath the box is removed by tunneling so that the box floor can be constructed. The field number and locality data must be clearly written on the outside of the box in permanent marker or paint. The orientation of the box and the depth below datum of the top and bottom of the deposit must also be clearly and permanently marked on the box, as well as added to the field notes for that deposit.



**Figs 11, 12 & 13: Relocating the tree boxes by crane and truck**

A crane is used to lift the completed boxes, load them onto a flat bed truck, and to relocate them to the place where their excavation will take place.

## Isolated fossils

In addition to conical and flat tabular asphaltic accumulations, construction activities may encounter isolated fossils in non-asphaltic or asphaltic sediments such as the trees, mammoth skeleton, and bison and horse skulls that were discovered during the recent construction of the LACMA's underground parking structure. Similar procedures pertain. The area must be roped off in order for the monitors to determine the extent of the fossil occurrence, which may then be removed using conventional paleontological field techniques.  Large or fragile bones must be pedestaled (with sediments immediately surrounding the fossil) and covered in a plaster and burlap jacket. The type of plaster used determines the time it takes to dry. Once the plaster is dry, it is flipped over and the other side is covered with plaster and burlap and left to dry completely. In the meantime paleontologists need to determine the extent of other isolated fossils in the area looking in particular for other elements of the skeleton of the jacketed specimen or sediments in which microfossils such as rodent, bird and reptile remains may occur.

It is crucial; that all isolated fossil occurrences be given a field number, their location recorded with a resource-grade GPS device, and these data entered into the field notes together with a map and description of the fossil, its orientation and its locality including description of the lithology in which the fossil was preserved. Standard guides such as Munsell Soil Color Charts should be used. The field number should be clearly and permanently affixed to the fossil and written on its container or jacket as appropriate. Maps must have a legend and scale to the show the orientation and depths of each fossil as well as a datum point. In addition to the field number, plaster jackets should also be marked "field side up" on the appropriate surface.

## Fig 14: Excavating isolated fossils

Paleontologists need to excavate around large bones with hand tools before covering them with a protective plaster jacket for later removal and transport.

**Fig 15: Mammoth discovered**

This image show the mammoth locality in the context of the construction site during the LACMA underground parking garage.

# Techniques for excavation, preparation and curation of fossils from the Project 23 salvage at Rancho La Brea.

A MANUAL FOR THE RESEARCH AND COLLECTIONS STAFF OF THE GEORGE C. PAGE MUSEUM



2011

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# Introduction

This document was compiled mid project to record and codify best practices for excavation, preparation and curation of specimens from Project 23 and other Rancho La Brea localities that are housed in the George C. Page Museum. Some of the techniques are similar to Pit 91 excavations that were reported by Shaw (1982) and others that are unique to Project 23 because of the nature of the salvage. This provides guidelines for possible future salvage efforts. Documents discussing the nature of the mitigation are available elsewhere.

# Excavation Techniques for Project 23

Excavation of Project 23 deposits began in August, 2008. The measuring techniques used to determine and record data for *in situ* specimens follow those of Shaw (1982) for Pit 91 with some modifications described here (for instance, the imperial measurement system was used prior to Project 23). New excavation procedures have also been devised as a result of the removal of the deposits from their original location due to construction.

In Project 23, a custom-sized wooden box was built around each isolated plastic-wrapped deposit by a ‘tree boxing’ company (Valley Crest was used for this particular project). Any space between the deposit and the edge of the box was filled with either polyurethane foam or sediment to preserve the integrity of the deposit and to prevent its deformation during subsequent transportation and storage.

Because the deposits are no longer *in situ*, all excavation grids are oriented with respect to the deposits’ original north orientation. Where feasible, box walls may be removed in part or in their entirety to allow excavation from the side of the deposit rather than from the top. Each “tree box” from Project 23 is treated differently depending on the type of deposit, size of the box and integrity of the sediments in the box. Refer to paleo mitigation protocol and ArchaeoPaleo report documents for descriptions on how the ‘tree boxes’ were constructed.

## Preparing a tree box for excavation

First read all the field notes pertinent to that particular deposit. In a field notebook or deposit logbook document the nature of the “box” size, construction, fill, plastic, etc. If the box is taller than 5 feet, erect scaffolding for excavators to safely access the box. Depending on the size of

the tree box it may be necessary to construct a safety railing extending upward from the sides of the box. After the top of the box is safe to access, remove the metal bands that are strapped across the top of box. Use specific snips if recommended by the tree boxing company. Remove supportive fill dirt, foam and plastic to reveal deposit surface, taking care to maintain an appropriate area for excavators to work safely.

Depending on box stability and size, board walls or portions of board walls may be removed to enable excavation from the side of the deposit. Smaller boxes containing deposits with cohesive sediments may allow the removal of all sidewalls. For larger boxes, removal of one wall or a small "window" cut into a sidewall may be feasible.

Before any asphaltic sediment is removed, set up a gas monitor close to where work will be conducted. The Solaris Multigas Detector is an economical, 4-gas instrument providing simultaneous detection of CO, O2, H2S and combustible gas and costs ~$600 from Safety Tek Industries.

## Grid layout

Determine the deposit's north side from field data and data written on the box.

Establish a datum point near the top of the box and record it based on field data. The datum point should not be removed during excavation.

Lay out grids into 1m x 1m squares with origin in the SE corner of the box using an alphanumeric system (N/S = A-Z; W/E = 1, 2, 3). Gridlines can be marked with string, spray paint or chalk and need to be refurbished and maintained periodically. A map of the box showing the grid lines and a north arrow should be drawn for reference.

## Excavation and Documentation

After grids are established, clean surface to remove fill dirt, to determine sediment type and to locate fossils if exposed. Note nature and location of fossils (bones, shells, plant remains, etc.)

Excavate grids in 25 cm spits (i.e. Level 1=0cm-25cm, L2=25cm-50cm, etc). If multiple grids are worked on at the same time, ensure that this doesn't compromise the mapping of each spit wall and floor. If a deposit has been exposed from the side, the spits in any one grid may be excavated sequentially from the top to the base of the deposit.

Depending on degree of consolidation, use small hand tools (hammers, chisels, and screwdrivers as required) on non-fossiliferous areas. Pneumatic or electric hammers can be used on areas with hard matrix where there are no fossils. Use dental picks and small screwdrivers to expose and extract fossils. Hard asphaltic matrix can be softened with clamp lamps or loosened with a small amount of solvent. Measure exposed fossils *in situ* (see below) within each grid and record their data in field notes before extracting them.

Note: Clamp lamps should be placed at least 8" away from the specimens and always monitored. Never leave lamps unattended. If the sediments start to smoke immediately turn off the lamp. 150 watt incandescent unfrosted bulbs should be used.

Save all of the surrounding sediments but separate them based on sediment type into 5 gallon metal buckets with lids. The pre-designated sediment types are A= asphaltic sand, B=brown silts and C=clay. Mark each bucket with box #, grid and level data as well as the sediment type (A, B or C). Note the number of buckets of each sediment type from each grid on an inventory list kept by the lead excavator. This is important because it determines how each bucket is processed later (see matrix processing section).

Keep daily documentation in field notes of who is excavating, a list of the grid or grids being excavated and describe the type of matrix being removed, what is being found within each grid, and any challenges encountered with the excavation. Geologic and paleobiological data should be recorded in field notes for later use to constrain and further refine taphonomic, paleoenvironmental, and paleobiological interpretations. A description of each lithology (soil type) should include color (fresh and weathered), lithologic composition, grain size, sorting and shape, sedimentary structures, induration, type of cement, fossil content, and pedogenic features (rooting, nodules, slickensides, etc.). As excavation proceeds note unit thickness, nature of the bounding contacts (erosional, sharp, gradational), and inferred depositional setting. Note nature and location of fossils (bones, shells, plant remains, etc.). Any visible modifications to the bones (weathering, polish, abrasion, scratch/tooth marks, root traces, borings, pitwear, breakage, distortion) and gross orientation should be recorded. Features of the matrix surrounding the bones, such as alteration halos, mineral crusts, micro-structures, fine root traces (small burrows or borings), and localized invertebrate bioturbation should be noted. The degree and nature of articulated, semi-articulated, associated, and dissociated skeletal elements should be described. Notes should also be taken on the general geometry of the fossil deposit (vertical pipe, tabular, etc.) drawings and/or photographs should be taken when appropriate.

## Measurement system

The most common types of macrofossils recovered from asphaltic deposits are isolated bones. The following measurement system has been devised for capturing data for individual bones.

See the Special Cases section for the treatment of associated skeletons, dermal ossicles, plant masses, etc.

*In situ* measurements are taken from specific anatomical points on each bone (see Table 1 and 2 Appendix A) to define its spatial orientation with reference to its depth below an established datum point (BD), its distance north (N) of the southern grid line and its distance west (W) of the east grid line using the metric system (see Fig 1. of Shaw (1982) but note this uses the imperial measurement system). Recording this data at the time of excavation will facilitate studies of stream current energy and direction, deposition, and taphonomy.

All identifiable bones from 1 cm to 2 cm in size should be measured *in situ* as a 1-point measurement before being excavated. Each Standard Measurement (BD, N, W) is taken to the center point of the longest dimension (Fig. 3)

Bones larger than 2cm in minimum length or diameter should be measured as either a 2-point or a 3-point measurement. The 3-point measurement is used on all bones in which three predetermined identifiable anatomical points are visible. The 2-point measurement is used if the bone lacks three distinct reference points and records the orientation of the long axis of the specimen (proximal-distal, anterior-posterior, medial-lateral, etc.). Detailed instructions for measuring out specimens are provided by Shaw (1982), which also lists the elements that generally fall into each of these categories.

All the data pertinent to the specimen should be recorded in the field notebook and should also accompany the specimen until its preparation and curation have been completed. One method of doing this is to duplicate the field notebook entries onto a 3” x 5” card using carbon paper (Fig 1, 2 and 3 below). This card then accompanies the specimen throughout its preparation, curation, and final cataloging. Only when the data have been recorded in the catalog are they separated.

In addition to measurements on individual bones, the dip of all limb bones and skulls should be recorded with a Brunton compass. Recording these data at the time of excavation will assist with interpretation of stream current energy and direction, and taphonomy which may include possible vertical movement in a vent, trampling, etc.

The soil type surrounding each measured bone should also be noted on the 3” x 5” card by a letter using a pre-designated lettering system. The pre-designated sediment types are A= asphaltic sand, B=brown silts and C=clay.

After a bone has been measured *in situ*, it is placed in an appropriate sized clear plastic bag. The 3” x 5” data card is placed in its own small clear plastic bag for safety and then placed in the bag with the bone.

**Fig 1: Example of excavation data for a 3-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

| P23-14 | B3/L4 | | |
|---|---|---|---|
| | GT | Px | Dt |
| BD = | 58cm | 53cm | 64cm |
| N = | 31cm | 35cm | 31cm |
| W = | 13cm | 10cm | 90cm |

*Canis dirus* femur

Soil type= A
Dip=30°SW
Excavator initials and date

**P23-14 = Project 23-Box 14**
**B3/L4 = grid B3/level 75cm-100cm**

**GT = Greater Trochanter is 58cm below datum, 31cm from the south grid axis and 13cm for the east axis**
**Px = Proximal end is 53cm below datum, 35cm from the south grid axis and 10cm from the east axis**
**Dt = Distal end is 64cm below datum, 31cm from the south axis and 90cm from the east axis**

**Soil type A= asphaltic sand**

**Fig 2: Excavation data for a 2-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

| P23-1 | B1/L2 | |
|---|---|---|
| | Px | Dt |
| BD = | 53cm | 64cm |
| N = | 35cm | 31cm |
| W = | 10cm | 90cm |

Canid juv. radius

Soil type= B
Dip=1°SW
Excavator initials and date

**P23-1 = Project 23-Box 1**
**B1/L2 = grid B1/level 25cm-50cm**

**Px = Proximal end is 53cm below datum, 35cm from the south grid axis and 10cm from the east axis**
**Dt = Distal end is 64cm below datum, 31cm from the south axis and 90cm from the east axis**

**Soil type B= brown silt**

**Fig 3: Excavation data for a 1-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-5B D3/L7

BD = 20 cm
N = 10cm
W = 15cm

Rodent tooth

Soil type=C
Excavator initials and date

**P23-5B = Project 23-Box 5B**
**D3/L7 = grid D3/level 150cm-175cm**

**20cm below datum**
**10cm from south gridline**
**15cm from east gridline**

**Soil type=clay**

Specimens smaller than 1 cm, fragments, or unidentifiable smaller bones are placed into "bulk matrix bags" together with field data cards (P23-deposit # and grid/level information, excavator initials and date). Because they are known to contain fossils, the bulk matrix bags will be processed before the rest of the matrix samples. Keep associated fragments together in capsules or envelopes within the bag. Be sure to always place delicate bones into snap cap vials first and then into a clear plastic bag with their data. If a fossil is not in place, identify it and label it "not *in situ*"

## Special cases

Each special case requires consultation by lab and collections staff to assess the best way of documenting each potentially unique occurrence.

- An articulated or associated skeleton should be extensively photographed. If, after consultation with Lab and collection staff this is removed as a small block, be sure to place a white pin in the top surface along the northern middle portion of the block so that it can be oriented later. Draw and annotate a diagram of the block and the elements that are visible on each surface before it is removed. Measure out the block as a 2-point measurement. Elements within the block that can be identified and measured without compromising the specimens should be also noted and can be measured using the 1 or 2-point measurement system but should not be removed from the block. Labeled copies of all photographs should be placed in the bag with the specimen. This is additional to downloading the photographs to the archive computer (see photography section). Articulated or semi-articulated specimens should be extracted in articulation and the sediments around the specimens stabilized to conserve the maximum amount of information derivable from the specimen.

- Bone masses with poorly preserved specimens (fragmented and/or less asphalt-impregnated) are more difficult to measure out individually. Measure out the extent of the mass with the 2-point system rather than the constituent bones. Place a white pin in the top surface along the northern middle portion of the block so that it can be oriented later. Photograph in situ specimens, print and label images and place them in the bag with the specimens.

- As instructed by Lab and collections staff, and depending on their nature and frequency, dermal ossicles and pockets of plant, shell or insect material should either be measured out as a small block with a 2-point measurement (same as above) or placed in pre-labeled bags with locality information for a specific 10cm square within the 1m x 1m grid.

## Geologic Samples

Collect 15 cm by 15 cm soil samples of each sediment type from each grid and level for geologic analysis of composition, weathering, and grain size at a later date. Document each sample in your notebook and measure each one *in situ* as a block using the 2-point measurement system used for fossils and described above. Each sample should have a white pin placed on the upper surface in the northern middle portion of the sample so that later the sample can be oriented. Transcribe all data onto a 3" x 5" card and place in a clear plastic bag with the soil sample. A list of soil samples taken should be kept by the lead excavator for each grid and deposit.

When spits are completed, photograph and map each exposed wall and the floor.

## Floor and Wall mapping

When mapping a wall or floor (Fig. 4, 5 and 6)

- Draw maps on graph paper with a scale of 3 squares = 10 cm.
- Keep the origin point (0, 0) in the southeast corner.
- Mark north arrow.
- Draw in empty spaces and the edge of the box when present.
- Mark asphalt and sediment contacts.
- Use standardized symbols for lithologies and other known sedimentary features. Also
- Indicate where fossils, cobbles, bone, shells and plants masses are located (Fig 4).

**Figure 4: Standard symbols used in mapping each grid's floor and wall**

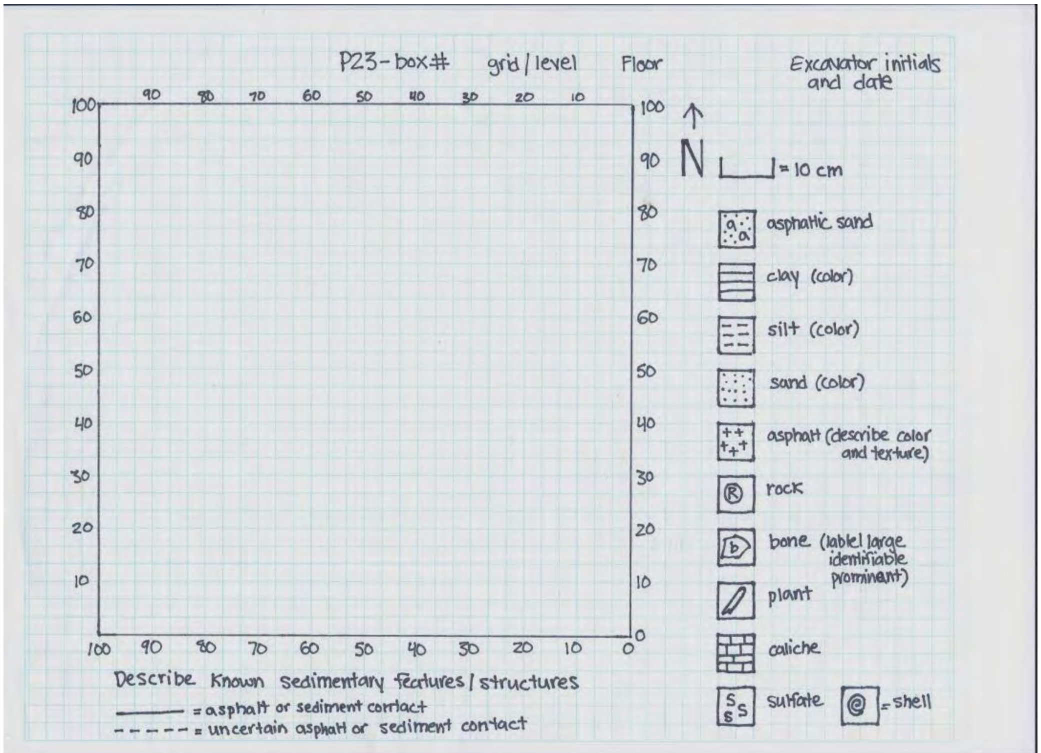



**Figure 5: Sample drawing of the floor of grid C3/L3 of box 14**

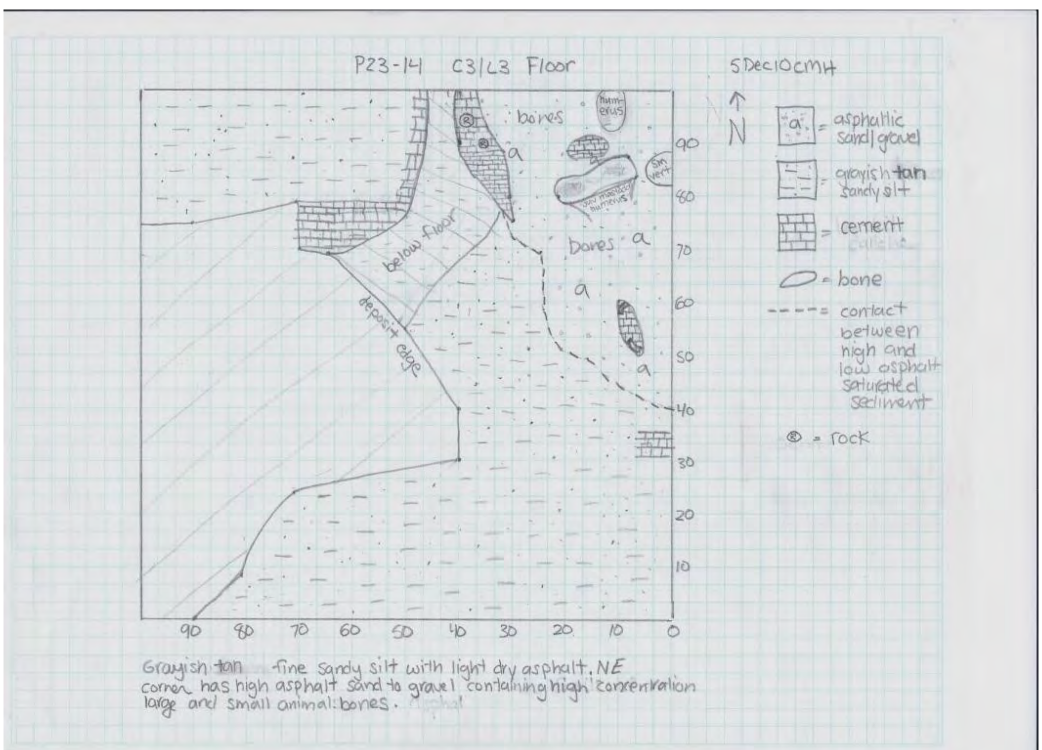
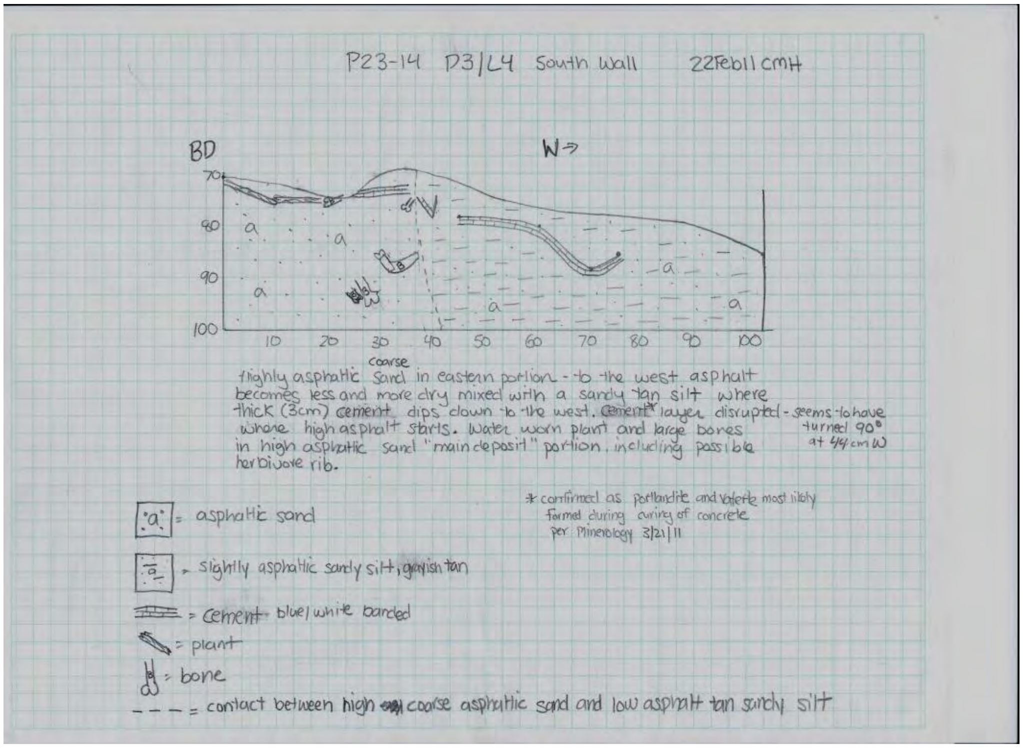


**Figure 6: sample drawing of the south wall of grid D3/L4 of box 14**




## Photography

Photo documentation and the labeling of downloaded images are very important. In the field photo logbook provided, record all the images that you take. This is shared by everyone and has columns for name of photographer, date, box #, grid and level, orientation of image, file number and special notes. Take a photograph whenever it might be useful for lab staff and researchers to see how a specimen was oriented in the ground, broken in a certain way or for any other unusual circumstance. Always photograph the floor and each wall of a grid before starting a new one.

<u>When photographing a specimen:</u>

Write the project name, box #, grid and level #'s, orientation, description of what you are photographing, the date and excavator initials on a 3"x 5" card with a black sharpie and place next to the object you are photographing.

For example:

| |
|---|
| P23-14 C3/L3<br><br>Skull , ventral view ↑<br><br>N<br><br>Excavator initials and date |

Print the photo as soon as possible and place it in the bag with the specimen. This may not be necessary for all the images of *in situ* specimens, so make a judgment call here.

<u>When photographing a floor or wall:</u>

- Write the project name, box #, grid and level #'s, orientation, the date and excavator initials on a 3"x 5" card with a black sharpie.

For example:

| |
|---|
| P23-14 C3/L3<br><br>South Wall ↑<br><br>Excavator initials and date N |

- Place meter sticks in north and west orientation.
- Take a picture of each exposed wall and floor with the card and meter sticks in frame so as not to cover up any significant features and so the information on the card can be used to tag the photograph in the database.

Download all photographic images to the archive computer and place in the folder "to be sorted" under My Pictures\Project23 under the project 23 login. Rename your files appropriately so that they can be retrieved, tagged in Adobe Bridge and added to the EMu database. This is where the photo logbook will be useful. Each image should be named with the following conventions in order to be searchable in the database:

1. If it is a photo of a grid and a level then name it P23-1 B1 L2 where P23-1 refers to the Box number, B1 refers to the grid and L2 refers to the level. Notice a space between P23-1 and B1 and also between B1 and L2. This is on purpose and helps the database find the files. If there is no level just enter the information that you have.
2. If it is just an image of several grids just name it with the box number e.g. P23-14.

3. If it is a photo of a possible associated skeleton or a specimen in the ground include some more information such as what it might be e.g. P23-1 B1 L2 bird skeleton

## Data entry of field notes

Write field notes in pre-bound notebooks. For each day compile a daily journal that includes notes on the weather, who was working, general work done that day, grids being worked on, etc. as well as geological information on open grids and specimen measurements. On a weekly basis all excavation notes, photographs and grid drawings will be captured electronically.

- Type journal entries into word documents with each day saved as a new file. The naming convention of the file should be "project yearmonthday initials" (e.g. P23 20090201 ABF). Within the word doc file at the top of the page type the initials of the excavator and the date. This serves as a search tool for the database. Save these to the flash drive that is provided. The Collections Manager will import these data into the database.

- Type specimen measurement data into a pre-prepared Excel spreadsheet and save to the flash drive provided. The Collections Manager will import these data into the database.

- The floor and wall drawings and photographs for each grid must be scanned and downloaded onto the archive computer at the Page Museum.

## Matrix processing

There are two different ways that matrix from the excavation is processed. All asphaltic matrix from or adjacent to asphaltic bone concentrations needs to be processed with solvent in a vapor degreaser in order to release small bones and other plant, insect, invertebrate and vertebrate remains from the asphalt. After degreasing, the matrix is dried and dry screened to remove the clay-to-silt fraction. The remaining concentrate is sorted for microfossils under a microscope.

Samples of other (apparently non-fossiliferous) non-asphaltic sediments are screen-washed in water on 20 mesh screens and the concentrates are sorted for microfossils under a microscope. If there is no evidence of microfossils in the sample, the remaining material from that facies of that grid may be discarded (except for the 15 cm archival cube that was collected during excavation of the grid).

# Laboratory Protocols

All material sent to the Lab for cleaning is triaged to resolve appropriate methodology, account for the skill level of available lab workers, and for research and collection priorities. An n-propyl bromide solvent is used to remove asphalt from the bones. Trade names for this solvent include Lenium, GenTech and EcoMax. Elmers white glue is used to repair broken bones and Acryloid (Paraloid) B-72 (Ethyl methacrylate copolymer) is occasionally used to consolidate dry bones.

## Prioritize new specimens

1. For cleaning method
   - Sort and store by locality, grid, depth.
   - Sub-sort by best cleaning method: ultrasonic, soaking, or hand prep.
2. For significance
   - Rareness of taxon
   - Incomplete section of previously excavated specimen
   - New element of known individual skeleton from that locality
   - Unrecognizable to element or taxon.

## Ultrasonic cleaning

Ultrasonic cleaning can be used for the following types of specimens:

- Complete or sturdy bones measured in individually (examples include *Smilodon* or *Canis dirus* carpals, tarsals, phalanges)
- Complete or mostly intact avian bones. The feasibility of processing other fragile bones, including broken small bones, should be assessed by the person who will be re-assembling them.
- Shells, insects, and concentrations of mollusks or insects from within known locality with measurements.

**Steps to be followed**

1. Place each specimen or sample in a baby food-sized jar with all contents of envelope.
2. With pencil, number the envelope and the top of the jar (on masking tape).
3. Prepare six jars as above.
4. Fill with solvent to an equal level in all jars.
5. Place in ultrasonic tank and fill with water up to the level of solvent in jars.
6. Buzz for fifteen minutes.
7. Strain contents of jar through 20 mesh screen on top of pitcher.
8. Rinse with clean solvent.
9. Check specimen or sample for matrix, detail with brush or skewer as needed.
10. Place each specimen or sample on separate paper tray, with flipped out matrix, data, and masking tape number from jar top.
11. Let dry over night, polish, and sort matrix.
12. Solvent that was strained into pitcher can be reused for setting up next batch of six jars if not too dirty.

## Pre-soaking

- Large bone masses: If there is no single identifiable bone, put it in a large jar or a bucket with more solvent than volume of mass. Mass may require a second rinse if solvent becomes too thick with asphalt.
- Unusually hard matrix: Put all of the specimen and loose matrix in jar with data taped to lid.
- Broken *in situ* specimens: If matrix is in internal structure of bone, soak and rinse.

# Hand preparation

- Individual specimens with positional data include vertebrae, ribs, long bones, etc. that are relatively complete.

**Steps to be followed**

1. Rubber stamp, date, and write the signature of preparator on back of data card.
2. Empty all contents of plastic bag or envelope into stainless steel pan.
3. Wet specimen with solvent from squirt bottle.
4. Scrub with tooth brush, dipped in small jar of solvent (n-propyl bromide)
5. DISOLVE MATRIX, DO NOT PUSH OFF WITH BRUSH OR OTHER TOOL.
6. Wood skewers or sticks can be used to loosen or nudge matrix off (If the stick breaks, the matrix is not soft enough yet)
7. When specimens appear clean, rinse thoroughly with solvent and immediately hold in front of vent for quick dry. Matrix still adhering to specimen will be black or darker than bone.
8. DENTAL TOOLS ARE TO BE USED FOR THE REMOVAL OF VISIBLE ROCKS ONLY!
9. When the entire matrix has been removed, place specimen, data card and jarred contents of metal pan matrix on paper tray lined with paper towels to dry.
10. DO NOT GLUE UNTIL ALL MATRIX IS SORTED.

- Multiple pieces of one specimen.

1. Should be prepared by one person but treated as separate projects.
2. Finished elements held until all parts are done.
3. If glued, the part that goes with which data should be recorded in pencil on back of data card.

- Possibly associated elements of one individual

1. Treat as above but can be cleaned by multiple preparators.
2. Label for possible association with a known skeleton or a single other element. [more specific].

- Skulls

  1. External surfaces should be freed of larger associated specimens and gross matrix clumps using toothbrushes and solvent.
  2. DO NOT POKE IN EARS, NOSE OR BRAIN CASE.
  3. At the end of session, immerse in solvent in sealable bucket with copy of data on lid.
  4. Soak for two or three days.
  5. Hold skull over bucket and flush with clean solvent to remove loose matrix.
  6. Working in metal tray, nudge with skewers to loosen softened matrix and rinse off.
  7. Add removed matrix back into bucket.
  8. Replace skull in bucket at end of session.
  9. If the tympanic bulla is intact, nudge and rinse ear region over metal pan and process matrix separately for ear ossicles.
  10. When brain case and nasal region are mostly free of matrix, skull will not need to continue to soak and can dry between sessions.
  11. Strain contents of bucket.

## Polishing

- When specimen has dried overnight, go over small sections of solid bone with a dampened **soft cloth**, then go over the same space with a dry cloth. Exposed cancellous tissue should be <u>blotted</u> with a damp rag. Not rubbed!
- If there are small spaces that cannot be reached with a rag use a pipe cleaner or Q-tip. Dip it in solvent and blot off some liquid before applying. IF THE SPECIMEN GETS DARKER OR BEGINS TO LEAK ASPHALT, IT IS TOO WET. Put aside for a day and begin again.

## Processing Matrix from Individual specimens

- Processing sediment that has been soaked in solvent. (most common situation)

1. Pour contents through 20 mesh screen sitting on funnel into carboy.
2. Rinse with clean solvent.
3. With one motion, flip contents onto paper toweling on a paper tray.
4. Make sure everything is out of jar and out of screen.
5. Place tray near vent to dry.
6. When completely dry, sift and put in appropriate sized jar for later sorting.
7. If matrix appears clumpy after sifting, re-soak in solvent.
8. If matrix appears dirty with clay or silt after sifting, soak in hot water with a small amount (1 tsp) of detergent)

- Processing soaked in water sediment.
  1. Pour contents of jar through 20 mesh screen in a basin in the sink.
  2. Agitate the screen in clean warm water.
  3. Flip contents onto newspaper and leave screen on top to thoroughly dry.

## Microfossil sorting

When the matrix from an individual specimen is clean and dry it is ready for microfossil sorting.

Take the entire project (specimen, data and matrix) to a sorting station.

Do not pour out more matrix than you have time to sort.  Only 1½ to 2 Tbs. may take several hours.

1. Sifting
   - Always sift matrix before sorting even if it was sifted before putting in a jar.
   - Sift through a designated 20 mesh screen with 2 inch sides.
   - Shake back and forth, (not up and down) over a paper towel.

- Empty contents of screen onto a clean piece of white sorting paper and shape matrix into a pile.
- Discard the fine soil that went through the sifter.

2. Sorting
    - Examine matrix, several grains at a time, by moving it across the paper with a fine paintbrush.
    - Create a “discard pile” for sediment and oxidized asphalt.
    - Move bone, plant, shell and insect fossils into distinct piles on one side of the paper.
    - Create a “questions” pile for indeterminate fossils.
    - When the entire matrix has been categorized, review fossils and “discard pile”.
    - Have a staff person double check sorting.
    - It may be necessary to examine some specimens under the microscope.
3. Temporary packaging of categories
    a. <u>If all of the matrix of a individual project is sorted</u>
        - Review bone and separate into three categories:
        - 1. Broken pieces of the main bone (put aside for possible gluing);
        - 2. Identifiable bones (put into individual capsules or plastic containers);
        - 3. Unidentifiable bone fragments (put into one capsule or larger container).
        - Review plant material (separate seeds and put into capsule) and put into glass vial.
        - Review insect and put into one capsule.
        - Review shell and put into one capsule.

    b. <u>If only a portion of the matrix is sorted</u>
        - Place complete identifiable bones in capsules.
        - Place all bone fragments, plant, insect and shell into their own labeled containers.

When a large project is complete, all of the bone fragments must be reviewed and sorted to the above categories.  It will be necessary to look at the small bone fragments under the microscope to determine the final number of Identifiable bones.

## Gluing

DO NOT GLUE UNTIL ALL MATRIX REMOVAL, POLISHING AND MATRIX SORTING IS DONE.

Use white glue for reconstructing most bones because it is reversible with warm water.

If a specimen is shattered, first reconstruct it holding the pieces together with masking tape.  Do not glue until all of the fragments have been tested in available holes.  Determine where all the major fragments go first and then glue from one direction.  Have small strips of masking tape cut before the glue is applied.  Apply glue with stick or dental pick in small amounts to the broken edges.  Tape glued pieces in place and/or balance in sandbox for drying.  Allow large pieces to dry overnight.

## Envelopes for finished projects

A copy of the original data must be made for every identifiable bone and one copy each for vial containing plant, insect, shell and unidentifiable bone.  A rubber stamp template for “Found in assoc. w/” data is stamped on the face of a #5 ½ coin envelope.  An exact copy of the original is then filled in.  Note: Do not change the tentative field identification that is part of the original data even if it is wrong.  The back of the envelope is stamped with a template for the scientific identification.  If an “assoc. w/ bone “or the plant fragment is too large to fit inside an envelope, it should be put in a small plastic bag with an envelope. The envelopes are stapled shut and the entire project is put in one large plastic bag.

The finished bag should include the main bone, fragments of the main bone that could not be glued on, the original data and all the “associated with” specimens.

# Pre-Curation

After the specimens have been cleaned, the microfossils sorted and put into individual capsules and individual envelopes have been made for each specimen with all of the provenance data written on each envelope (see laboratory procedures) they are sent to the curation station. Identification of all of the fossils takes place near the comparative collection in the lab in order to facilitate identification. The principal measured out specimen with its original 3”x 5” field data card is identified first. The card is stamped on the back with a custom stamp with Scientific Name, Element, Identifier, and Notes. The specimen is identified as much as possible but identifications necessarily range from class identification such as Aves to genus and species. The identifier also describes the element according to an established list of bone terminology. Then each of the microfossils associated with that main bone are also identified in the same manner. After all of the microfossils that accompany that main specimen are identified, they are placed in a clear plastic bag with a twist tie and sent to the cataloging station. Below are detailed step-by-step instructions on how to identify specimens.

For each specimen follow the steps below in the order given.

1. Choose a specimen from the ‘to be identified’ box. If several envelopes are fastened together you must keep them together and complete the work on all of them.
2. Check the bone to see if it is clean and that all broken pieces have been glued if possible. If the bone is not clean then do not proceed with that one and send it back to the lab
3. Identify the bone using the reference collection and write the identification on the back of the envelope or card in pencil. Only use paperclips to join envelopes together.
4. Check to see if the main identified bone is in the original envelope or with the original 3” x 5” card.
5. Send identified specimen to be cataloged

- Always put the comparative bone back in the box it came from!
- if you find a ‘found in association with’ envelope which is not still with its original envelope, find the original envelope and fasten them together
- put all tools away and empty bags and containers

## Associated groups

If there is more than one specimen in an envelope the principal bone for which the measurements were recorded should remain in the original envelope. The other specimens should be treated as follows;

- all plants in one envelope
- all insects in one envelope
- all shells in one envelope
- each identifiable bone in a separate envelope, along with any of its broken pieces
- all unidentifiable bone in one envelope
- all difficult to identify bones in one envelope

Use envelopes stamped "Found in Association with" and make a complete copy of the information from the original envelope on each one.

## Identifiable and Unidentifiable Specimens

Identifiable bone characteristics:

- presence of an articular surface
- cross-sectional shape
- foramina
- distinctive curves
- relative size combined with other features

Bones are rated in three different grades of how easy they are to identify

- identifiable
- difficult to identify
- unidentifiable

Double check all identifications

## Identification of Specimens

The back of each envelope is marked with a custom stamp (stamp in bold below). Identifications are printed in pencil. An example below

- **Scientific name:** *Smilodon* (use both genus and species if more than one species)
- **Element:** prox. rt. tibia
- **Special Notes:** Pathology
- **Identifier:** ABF

1. Avoid using terms such as "frag" or "portion". Use prox. or dist. if appropriate.
2. You must not abbreviate scientific names but you may use abbreviations for the elements as long as they are the ones listed in this manual.
3. When identifying skulls and mandibles always list the teeth that are present and if they are erupting, fully erupted or worn.
4. The format of the identification is very important. Do not invert the word sequence e.g. prox. rt. rib is correct but rib, rt. prox. is not.
5. For incomplete bones name both the bone e.g. XIII thoracic vert and either the represented part e.g. centrum or the missing portion, e.g., w/o right transverse process. Make sure that the identity of the bone and its qualifier are both listed.
6. Be specific about the identity of any represented epiphysis, e.g., proximal or distal epiphysis of a limb bone, or head epiph of lt femur or ant cent epiph of thoracic vert.

7. Ordinal numbers of ribs, vertebrae, metapodials and digits are written in Roman numerals e.g. rt. II rib or XII thoracic vert

8. Number of phalanges and teeth are written in Arabic numerals e.g. 2$^{nd}$ phalanx or rt. M1. Note that abbreviations for upper molars are written in upper case letters (I, C, P, M) whereas those for lower teeth are written in lower case (i, c, p, m). For clarity of handwritten entries, put a line below the number for upper teeth (e.g. P4/) and a line above the number for lower teeth (e.g. m/1).

9. The side, either left or right comes before a number e.g. rt. II metatarsal

10. There are two special cases:

    - Phalanges that can be precisely named include sloth phalanges, carnivore 'thumb' phalanges and bird carpal phalanges e.g. rt. 1$^{st}$ carpal phalanx, digit I

    - Teeth which can be specifically named e.g. lt. p2

11. Skull fragments: if the facial or cranial region of the skull is mostly intact this can be recorded as 'ant' or 'post' skull. However if there are only a few fragments the individual bones are named e.g. basisphenoid, occipital and rt. temporal or indicate if some parts are missing, e.g. post. skull w/o rt. occipital.

12. Juvenile specimens: it is important to note if an epiphysis is missing as the order of ephiphyseal fusion is used to detect the age of an animal. Also mark "juv." in the special notes section of the identification.

## Abbreviations chart for elements

| | | |
|---|---|---|
| Left: lt. | Posterior: post. | With: w/ |
| Right: rt. | Ventral: vent. | Without: w/o |
| Proximal: prox. | Dorsal: dors. | Juvenile: juv. |
| Distal: dist. | Medial: med. | Pathological: path. |
| Anterior: ant. | Lateral: lat. | Unidentifiable: unid. |

Difficult to identify: diff.

Zygomatic: zygo.

Epiphysis: epiph.

Diaphysis: diaph.

Tuberosity: tub.

Trochanter: troch.

Articular: artic.

Vertebra: vert.

Transverse: trans.

Process: proc.

Centrum: cent.

Prezygapophysis: prezyg.

Postzygapophysis: postzyg.

Incisor: I (upper) or i (lower)

Canine: C (upper) or c (lower)

Premolar: P (upper) or p (lower)

Molar: M (upper) or m (lower)

Deciduous: D

## Dental formulae for Rancho La Brea fauna

Dental formulae are a short hand way of indicating the number and kind of teeth that are present. The upper jaw is indicated first and the teeth are in order: incisor, canine, premolar, molar.

Ruminant artiodactyls

0,0,3,3 / 3,1,3,3

*(Antilocapra*, *Bison, Capromeryx, Odocoileus)*

Camelids

*Camelops:* 1,1,2,3 / 3,1,1,3

*Hemiauchenia:* 1,1,2,3 / 3,1,1-3,3

Peccaries

*Platygonus:* 3,1,4,3 / 3,1,4,3

Horses

*Equus:* 3,1,3,3 / 3,1,3,3

Tapirs

*Tapirus:* 3,1,4,3 / 3,1,4,3

Dogs and bears

3,1,4,2 / 3,1,4,3

*(Arctodus, Canis dirus, Canis latrans, Urocyon, Ursus)*

Cats

3,1,3,1 / 3,1,2,1

*(Felis atrox: Felis concolor: Lynx)*

Sabertoothed cats

*Smilodon:* 3,1,2,1 / 3,1,1,1

Skunks, weasels, & badgers

3,1,3,1 / 3,1,3,2

*(Mephitis, Mustela, Spilogale, Taxidea)*

Hares and rabbits

2,0,3,3 / 1,0,2,3

*(Lepus: Sylvilagus*)

Shrews

*Notiosorex:* 3,1,1,3 / 2,0,1,3

*Sorex:* 3,1,3,3 / 1,1,1,3

Wood rat, grasshopper mice, deer mice, & harvest mice

1,0,0,3 / 1,0,0,3

*(Neotoma: Onychomys: Peromyscus: Reithrodontomys)*

Ground squirrel

*Otospermophilus:* 1,0,2,3 / 1,0,1,3

Pocket mice, gophers, and kangaroo rats

1,0,1,3 / 1,0,1,3

*(Perognathus: Thomomys, Dipodomys)*

Proboscideans

1,0,3,3/0,0,3,3

(*Mammuthus, Mammut*)

Special Cases

Ground sloths (cheek teeth only)

*Paramylodon:* 4-5 / 4

*Nothrotheriops:* 4 /3

## Bone terminology

**Skull**

- Alisphenoid
- Basioccipital
- Basisphenoid
- Frontal
- Interparietal
- Lacrimal
- Jugal
- Mastoid
- Maxilla
- Nasal
- Occipital
- Occipital condyle
- Palatine
- Paramastoid process
- Paraoccipital
- Parietal
- Postglenoid process
- Postorbital process
- Premaxilla
- Presphenoid
- Pterygoid
- Squamosal
- Temporal

- Tympanic bulla
- Vomer

**Auditory ossicles**

- Malleus
- Incus
- Stapes

**Mandible**

- Angular process
- Coronoid
- Articular condyle
- Symphysis

**Hyoid**

- Basihyal
- Epihyal
- Thyrohyal
- Ceratohyal
- Stylohyal

**Teeth**

- Permanent upper and lower. Upper denoted by upper case abbreviation and lower by lower case abbreviation.
    - Incisor – I (upper) or i (lower)
    - Canine – C (upper) or c (lower
    - Premolar – P (upper) or p (lower)
    - Molar – M (upper) or m (lower)
- Deciduous upper and lower. Upper denoted by upper case abbreviation and lower by lower case abbreviation.
    - Incisor – DI (upper) or di (lower)
    - Canine – DC (upper or dc (lower)
    - Premolar –DP (upper) or dp (lower)

**Vertebra (e)**

- Atlas
- Axis
- Caudal
- Centrum
- Cervical
- Lumbar
- Neural spine
- Odontoid process
- Postzygapophysis
- Prezygapohysis
- Sacral
- Sacrum
- Thoracic
- Transverse process
- Wing

**Ribs**

- Capitulum
- Shaft
- Tuberculum

**Sternum**

- Manubrium
- Sternebra
- Xiphisternum

**Scapula**

- Acromium process
- Coracoid process
- Glenoid fossa
- Metacromion
- Spine
- Vertebral border

**Humerus**

- Deltoid tuberosity
- Entepicondylar foramen
- Greater tuberosity
- Head
- Lateral condyle
- Lateral epicondyle
- Lesser tuberosity
- Medial condyle
- Medial epicondyle

**Radius**

- Styloid process
- Radial tuberosity

**Ulna**

- Coronoid process
- Olecranon
- Semilunar notch
- Styloid process
- Radial notch

**Carpals**

- Cuneiform
- Trapezium
- Lunar
- Magnum
- Trapezoid
- Central
- Pisiform
- Unciform
- Radial sesamoid
- Scapholunar
- Scaphoid

**Metacarpal**

- Plantar tubercle

**Sesamoids**

- Proximal sesamoid
- Distal sesamoid

**Phalanges**

- 1st, 2nd, 3rd, 4th, 5th
- Carpal
- Tarsal

**Inominate**

- Acetabulum
- Iliac crest
- Ilium

- Ischial tuberosity
- Ischium
- Pubic symphysis
- Pubis

**Fabella**

- Lateral
- Medial

**Femur**

- Greater trochanter
- Head
- Lateral condyle
- Lateral epicondyle
- Lesser trochanter
- Medial condyle
- Medial epicondyle
- Neck
- Patellar track
- Third trochanter

**Patella**

**Tibia**

- Lateral condyle
- Medial condyle
- Medial malleolus
- Tibial tuberosity

**Fibula**

- Head
- Lateral malleolus
- Distal fibula (herbivore)

**Tarsals**

- Astragalus
- Calcaneum
- Cuboid
- Ectocuneiform
- Entocuneiform
- Mesocuneiform
- Navicular
- Sustentaculum
- Naviculocuboid

- Mesoectocuneiform

**Metatarsal**

- Plantar tubercle

**Non-articulating bones**

- Baculum (male)
- Dermal ossicle (sloth)
- Sclerotic ossicles (birds and lizards)
- Falciform (sloth)
- Tracheal ring (birds)
- Dermal scale (lizard)

**Variations for juveniles**

- Diaphysis – shaft of juvenile long bone
- Epiphysis – the unfused articular surfaces of juvenile bone

**Numbers**

- Ribs – roman numerals
- Metapodials – roman numerals
- Digits – roman numerals
- Phalanges – Arabic numerals—1st, 2nd, 3rd, 4th, 5th, terminal

# Curation

In order to curate specimens into the collections of the George C. Page Museum, all of the above-mentioned steps for excavation, preparation, and identification must be followed. The field number, orientation measurements, and pertinent field notes and photographs are all integral parts of the specimen information and must be readily available. Each specimen will receive an individual catalog number that is first recorded in an archival catalog book and then entered into the electronic database EMu, which is stored on the Natural History Museum's server. Once cataloged, each specimen is stored taxonomically in the collections. Specimens are housed in metal or wooden drawers within standard metal Lane cabinets. On average each drawer holds about seventy five specimens and each cabinet contains nine drawers.

Based on a typical deposit for Project 23, a 1m X 1m x 25cm grid yields approximately 1000 macro-vertebrate specimens per one (1) cubic meter. Additionally each cubic meter can have up to 2000 micro-vertebrate fossils. A typical conical shaped deposit can be up to 30 cubic meters.

# Appendix A

Table 1. Anatomical codes used for orienting specimens in the 2- and 3-point measurement system.

| | |
|---|---|
| A -- Anterior | Px -- Proximal |
| P -- Posterior | Dt -- Distal |
| M -- Medial | Lt -- Left |
| L -- Lateral | Rt -- Right |
| D -- Dorsal | R -- Root |
| V -- Ventral | C -- Crown |

Table 2. Anatomical codes of osteologic points used for orienting specimens in the 3-point measurement system.

## MAMMALS

Skull:
- AP - Anterior Premaxillae
- OC - Occipital Condyles
- POP- Postorbital Process (Rt or Lt)

Mandible;
- A - Anterior
- CP - Coronoid Process
- P - Posterior

Vertebra:
- AC - Anterior Centrum
- ANS- Anterior Neural Spine
- NS - Neural Spine
- PC - Posterior Centrum
- TP - Transverse Process (Rt and Lt)

Rib:
- Dt - Distal
- GC - Greatest Curve
- Px - Proximal
- Tub- Tuberculum

Scapula:
- AP - Acromion Process
- CP - Coracoid Process
- D - Dorsal
- PA - Posterior Angle
- V - Ventral

Humerus;
- Dt - Distal
- LEP- Lateral Epicondyle
- MEP- Medial Epicondyle
- Px - Proximal

Radius:
- Dt - Distal
- Px - Proximal
- RT - Radial Tuberosity

Ulna:
- CP - Coronoid Process
- Dt - Distal
- Px - Proximal

Innominate:
- IC - Iliac Crest
- IS - Ischial Tuberosity
- PU - Anterior Pubic Symphysis

Femur:
- Dt - Distal
- FC - Fovea Capitis
- Px - Proximal

Tibia:
- Dt - Distal
- Px - Proximal
- TT - Tibial Tuberosity

Fibula;
- Dt - Distal
- LM - Lateral Malleolus
- Px - Proximal

Calcaneus:
- Dt - Distal
- Px - Proximal
- S - Sustentaculum

Metapodial:
- Dt - Distal
- PT - Plantar Tubercle
- Px - Proximal

## BIRDS

Skull:
Same as Mammals

Mandible:
Same as Mammals

Vertebra:
- NS - Neural Spine
- TP - Transverse Process (Rt and Lt)

Sternum:
- A - Anterior
- CA - Carinal Apex
- P - Posterior





WESTSIDE SUBWAY EXTENSION

Project No. PS-4350-2000

**Attachment 3**

# Wilshire / Fairfax Station Construction Methodology

Task No. 7.04.__

*Prepared for:*

Metro

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# 1.0 BACKGROUND

The Wilshire/Fairfax station box excavation will be approximately 860-ft long, 70-ft wide, and 60 to 70-ft below street level. The station extends beneath the intersection of Wilshire Boulevard and Fairfax Avenue - see Figure 1-1. The station entrance is planned to be located near the northwest corner of Wilshire and Fairfax between the 99 Cent Only Store and Johnie's Coffee Shop. Two alternative entrances under consideration; the south side of Wilshire between South Orange Grove Avenue and South Ogden Drive and; within the LACMA building at the north east corner of Fairfax Avenue and Wilshire Boulevard (May Company). A construction staging and materials laydown area is planned for the south side of Wilshire between South Orange Grove Avenue and South Ogden drive. Side access shafts will be located at the construction staging and materials laydown area and at the location selected for the station portal. The side access shafts will be excavated to the full depth of the station. The station box will be excavated by the cut and cover method and most probably use a temporary shoring system to support the excavation and decking system during construction, though a permanent shoring system that would be integrated into the permanent station structure could also be used. The side access shafts will be excavated by the open cut method and would most probably use the same type of shoring system that is used on the station box.

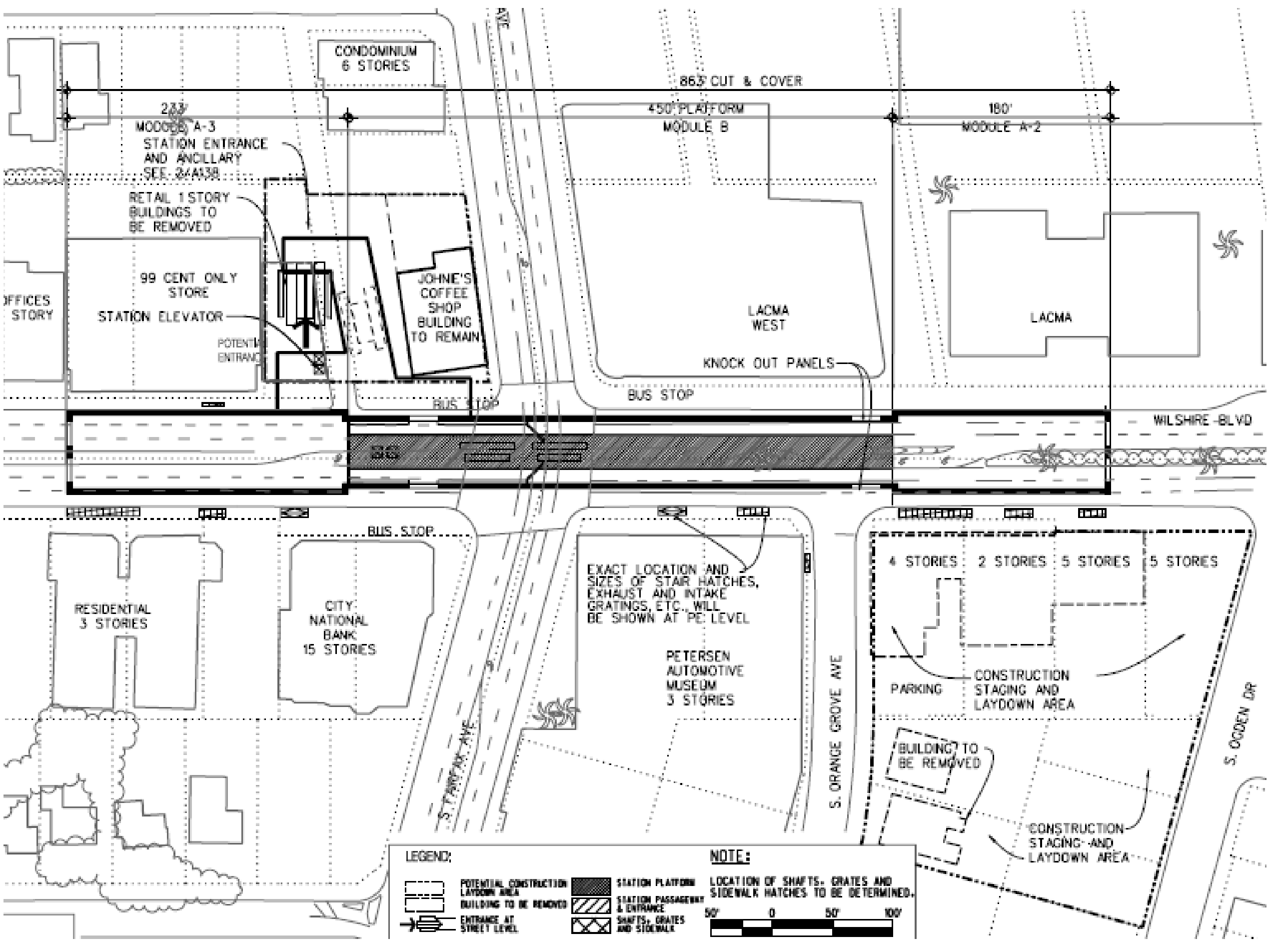



**Figure 1-1: Wilshire/Fairfax Station Box**

# 2.0 GEOLOGIC CONDITIONS

The geologic conditions in this region consist of soft alluvium deposits of sands, silty sand, clayey sand, gravely sand, silty clay, clayey silt, shell fragments, soil saturated with crude oil, and asphaltic (tar) sands. Several borings were taken within the station area; see Figures 2-1 through 2-4. Core G-118 (Figure 2-1) was taken east of the station box between La Brea and Fairfax, the sample at 82-ft below ground surface (bgs) consists of silty clay/clayey silt with traces of crude oil. The portion of ring sample G-123 shown in Figure 2-2 is located just east of Fairfax at 60-ft bgs and consists of predominantly fine grained soil with channels of medium grained sand saturated with crude oil. Heavy tar was reported in G-123 from 38 – 110-ft bgs. Core sample G-124 (Figures 2-3 and 2-4) was obtained just west of Fairfax by the Standard Penetration Test (SPT). The sample pictured was taken from 80-ft bgs and consists of medium to coarse grained sand saturated with tar. Heavy tar was reported in G-124 from 45 – 105-ft bgs. The consistency of tar in this region ranges from dry and hard to wet and oozing. This reach is also known to contain pockets of pressurized gases and dissolved gases in groundwater. The groundwater conditions are measured to have a water table depth of 74-ft bgs, and zones of perched water between 10 – 50-ft bgs. Since the station box invert depth will be located between 60 – 70-ft bgs, perched water can be anticipated during excavation.

Figure 2-1 Core Sample G-118

Figure 2-2 Core Sample G-123

Figure 2-3 Core

Sample G-124 (1 of 2)

Figure 2-4

Core Sample G-124 (2 of 2)

## 2.1 Gassy Ground Conditions

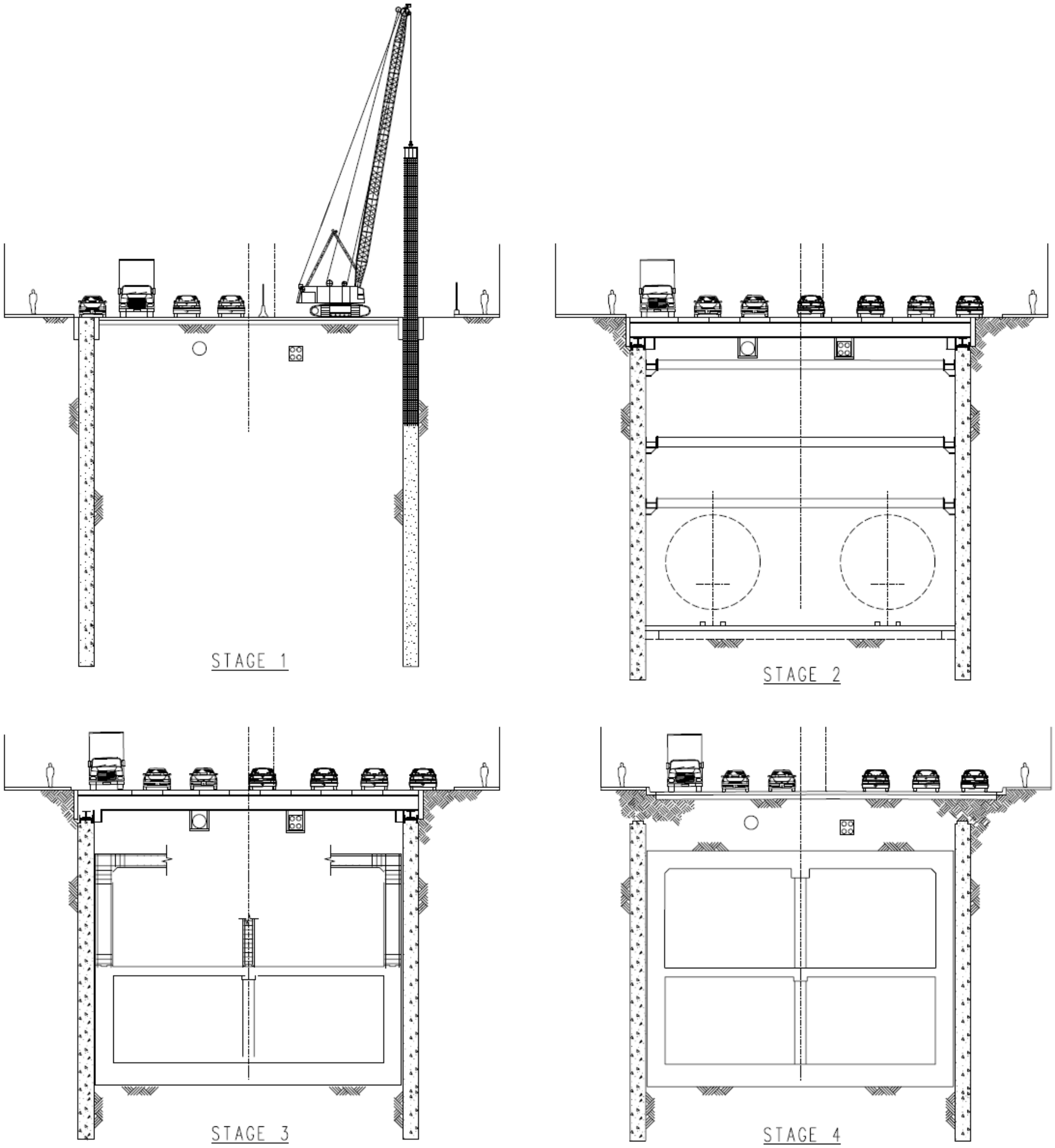
The gases present in the soils of this region are methane ($CH_4$) and hydrogen sulfide ($H_2S$). They are likely to occur in pressurized pockets as well as in a dissolved state in groundwater. These gases can seep into tunnels and other excavations through soil and also through discontinuities (fractures, faults, etc.) in bedrock. $CH_4$ and $H_2S$ are considered hazardous gases due to their explosive properties. $H_2S$ is also highly toxic. Being heavier than air, it tends to accumulate at the bottom of poorly ventilated spaces. Although very pungent at first, it quickly deadens the sense of smell, so potential victims may be unaware of its presence. $CH_4$ is extremely flammable and may form explosive mixtures with air. It is odorless and lighter than air, and it dissipates quickly once at the surface causing no threat of explosion. However, in 1985 an explosion occurred at the Ross Dress-for-Less in the Fairfax area which resulted in injuries requiring hospital treatment of twenty-three people. The explosion took place in a poorly ventilated ancillary room of the building where $CH_4$ gas had accumulated. There was no gas detection equipment at this location.

# 3.0 EXCAVATION SUPPORT TECHNIQUES

Cut and cover excavation is the preferred technique to excavate the station box structure, although cut and cover still leads to lengthy occupation of streets with noise disturbances and interrupted access. Traffic interruptions can be mitigated by performing most excavation below a temporary decking system constructed at an early stage.

**Figure 3-1: Roadway Operations Restored on Temporary Decking System**

Figure 3-2: Open Cut Excavation




Shoring the excavation walls and providing structural support beneath the decking system can be accomplished through a variety of excavation support techniques. The following sections describe several excavation support methods, including: soldier pile and lagging, slurry walls, tangent piles, secant piles, and deep soil mix walls.

Figure 3-3 Initial Excavation at Soto Station


Figure 3-4 Precast Concrete Decking


**Figure 3-5: Installation of Decking (1 of 2)**


**Figure 3-6: Installation of Decking (2 of 2)**

## 3.1 Soldier Piles and Lagging

Soldier pile and lagging walls are a type of shoring system typically constructed along the perimeter of excavation areas to hold back the soil around the excavation. This support system consists of installing soldier piles (vertical structural steel members) at regular intervals and placing lagging in between the piles to form the retaining structure. Pre-augering is necessary for installation of the soldier piles. Pre-augering involves drilling holes for each pile from the street surface to eliminate the need for pile driving equipment and thereby reduces project noise and vibration levels that would otherwise occur while pile driving. Pre-augering also provides better accuracy of location than pile driving. The lagging, which spans and retains the soil between the piles, is typically timber or shotcrete (sprayed-on concrete) and is installed in a continuous downward operation taking place concurrently with excavation. The installation of soldier piles and lagging is a relatively clean process. The majority of construction materials, such as, drilled earth spoils, concrete, backfill, and H-piles are easy to contain within the construction site. The soldier piles and deck beams are installed first with excavation and lagging installation taking place from beneath the street decking. A soldier piles and lagging earth retention system is shown in Figures 3-7 through 3-9. The equipment required for installation of the soldier piles includes drill rigs, concrete trucks, cranes, and dump trucks.

Soldier piles and lagging are generally used where groundwater inflow is not a consideration, or where grouting, or lowering of the groundwater level (dewatering) can be used to mitigate water leakage between piles. Based on findings from core samples, the geologic conditions in this area consist of soils containing deposits of oil and tar. Where these deposits occur along the excavation perimeter, oil or tar may tend to seep between the joints in the lagging. This is not considered to be a hazard to workers, although some cleanup may be necessary.

Alternatives to soldier pile and lagging walls being considered for this station include tangent pile or secant pile walls, slurry walls, and deep soil mix walls (see next sections below).

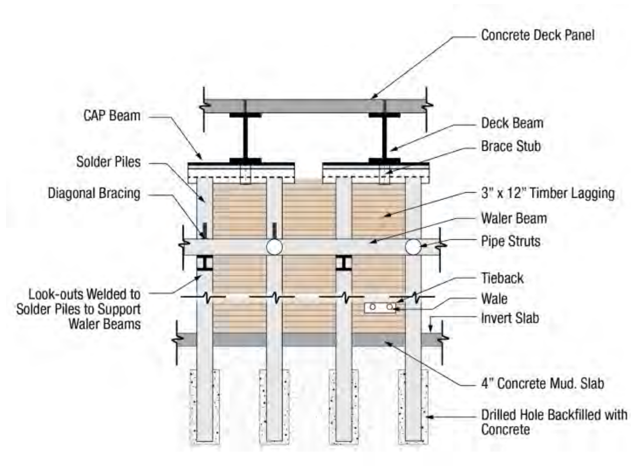




**Figure 3-7: Pre-augering for Soldier Pile** **Figure 3-8: Cut and Cover with Soldier Pile and Lagging**

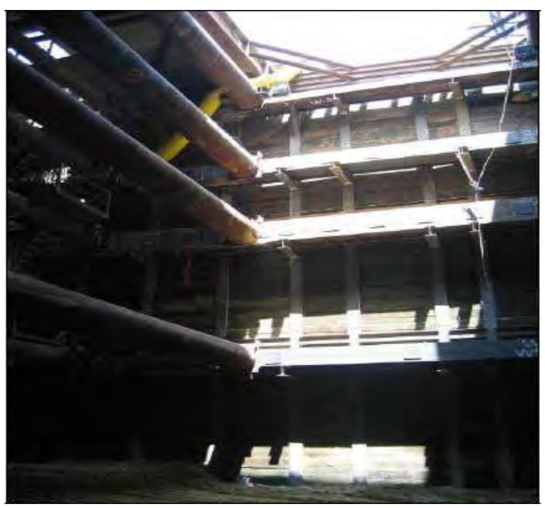


**Figure 3-9: Soldier Pile and Lagging**

## 3.2 Tangent Pile or Secant Pile Walls

Tangent pile walls consist of contiguous cast-in-drilled-hole (CIDH) reinforced concrete piles – see figure 3-10. The contiguous wall generally provides a better groundwater seal than the soldier pile and lagging system, but some grouting or dewatering could still be needed to control leakage between piles.

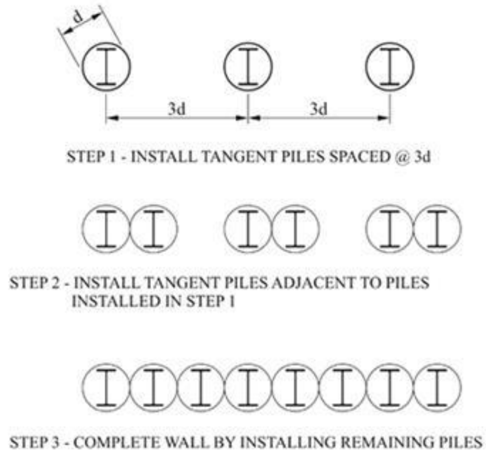



**Figure 3-10: Tangent Pile Installation**

A secant pile wall system is similar to the tangent pile wall but the piles have some overlap, facilitating better water tightness and rigidity - see figure 3-11. This method consists of boring and concreting the primary piles at centers slightly less than twice the pile diameter. Secondary piles are then bored in between the primary piles, prior to the concrete achieving much of its strength.

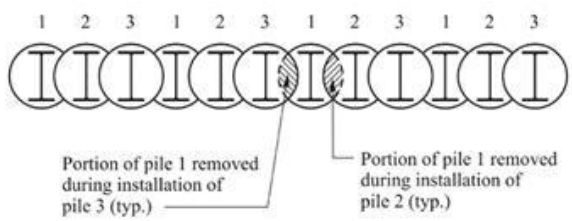



**Figure 3-11: Secant Pile Installation**

In terms of relative cleanliness, tangent pile and secant pile walls are comparable to one another and both are more difficult to contain than soldier piles and lagging due to the greater amount of pumped concrete and the expected larger diameter of drilled holes. The completed secant pile wall for the Barnsdall Shaft in Hollywood for the Metro Red Line project is shown on Figure 3-12. Secant and Tangent pile shoring systems are slower to construct that soldier pile and lagging and therefore have the disadvantage of requiring longer lane closures on Wilshire while they are being constructed. Furthermore, because of the close spacing of tangent piles, utilities crossing the wall often require relocation whereas a soldier pile system can often be built around the existing utilities. The equipment required for installation of the tangent pile or secant pile walls includes drill rigs, concrete trucks, cranes, and dump trucks.

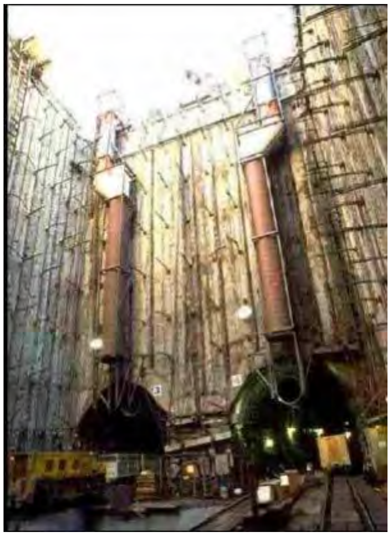


**Figure 3-12: Secant Pile Wall at Barnsdall Shaft on Metro Red Line**

## 3.3 Diaphragm/Slurry Walls

Diaphragm walls (commonly known as slurry walls) are structural elements used for retention systems and permanent foundation walls. Use of slurry wall construction can provide a nearly watertight excavation, eliminating the need to dewater. Slurry walls are constructed using deep trenches or panels which are kept open by filling them with a thick bentonite slurry mixture. After the slurry filled trench is excavated to the required depth, structural elements (typically a steel reinforcement cage - see Figure 3-15) are lowered into the trench and concrete is pumped from the bottom of the trench, displacing the slurry. Figure 3-13 and Figure 3-14 illustrate slurry wall excavation equipment.

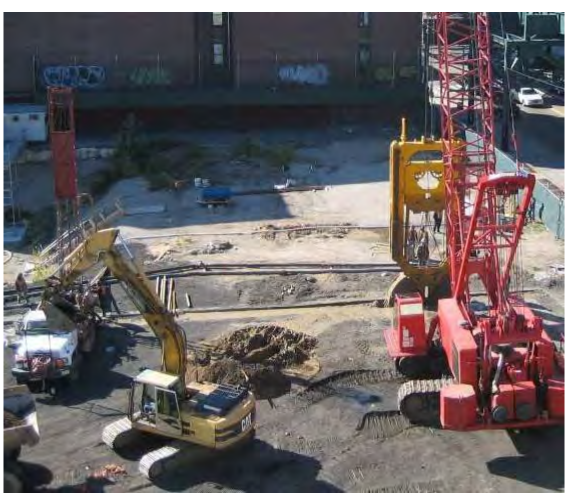


**Figure 3-13: Slurry Wall Construction Equipment**

**Figure 3-14: Clamshell Digger for Slurry Wall Construction**

Tremie concrete is placed in one continuous operation through one or more pipes that extend to the bottom of the trench. The concrete placement pipes are extracted as the concrete fills the trench. Once all the concrete is placed and cured, the result is a structural concrete panel. Grout pipes can be placed within slurry wall panels to be used later in the event that leakage through wall sections, particularly at panel joints, is observed. The slurry that is displaced by the concrete is saved and reused for subsequent panel excavations.

**Figure 3-15: Steel Reinforcement Cage for Slurry Wall**

Slurry wall construction advances in discontinuous sections such that no two adjacent panels are constructed simultaneously. Stop-end steel members are placed vertically at each end of the primary panel to form joints and guides for adjacent secondary panels. In some cases, these members are withdrawn as the concrete sets. Secondary panels are constructed between the primary panels to create a continuous wall. Panels are usually to full depth and 8 – 20-ft long and vary from 2 – 5-ft wide.

Similar to other shoring systems, slurry wall construction would occur in stages, working on one side of the street at a time. These walls have been constructed in virtually all soil types to provide a watertight support system in addition to greater wall stiffness to control ground movement. Because slurry walls are thicker and more rigid than many other shoring methods, the walls may in some cases be used as the permanent structural wall, although this application is not anticipated for this project. Where slurry walls are used, the thickness of the permanent structural walls can sometimes be reduced, i.e. when compared to wall thicknesses used with a conventional soldier pile and lagging system after removal of internal bracing.

Slurry wall construction materials are the most difficult to contain within the construction site of all the shoring types being considered due to the inherent messy nature of bentonite slurry combined with the operational characteristics of the clamshell digger which will likely be used to excavate large volumes of soil from the wall trench. Slurry walls are generally not adaptable to utility crossings and all utilities crossed by the wall would require temporary or permanent relocation. The equipment required for installation of the slurry walls includes clamshell or rotary head excavators, concrete trucks, slurry mixing equipment, cranes, slurry treatment plant, and dump trucks. The bentonite slurry would require disposal after a number of re-use cycles. Slurry walls are also slow to construct and will be very disruptive to traffic on Wilshire Boulevard.

## 3.4 Deep Soil Mix Walls

Deep soil mix walls are another type of temporary or permanent shoring system for deep excavation. Mechanical soil mixing is performed using single or multiple shafts of augers and mixing paddles. See Figure 3-16. The auger is rotated into the ground and slurry is pumped through the hollow shaft feeding out at the tip of the auger as the auger advances. Mixing paddles blend the slurry and soil along the shaft above the auger to form a soilcrete mixture with high shear strength, low compressibility, and low permeability. Spoils come to the surface comprised of cement slurry and soil with similar consistency to what remains in the ground. Steel beams are typically inserted in the fresh mix to provide structural reinforcement. A continuous soil mix wall is constructed by overlapping adjacent soil mix elements. Similar to secant pile walls, soil mix elements are constructed in alternating sequence; primary elements are formed first and secondary elements follow once the first have gained sufficient strength.

Deep soil mix wall construction materials are also difficult to contain. Most of the construction process is performed by a single piece of equipment which mixes cement and soil in situ. Cement and soil mixture can be expected to escape beyond the confines of the drilling operation creating problems for traffic and pedestrians. The equipment required for installation of deep soil mix walls includes multi-shaft drill rigs, concrete trucks, cranes, and dump trucks.

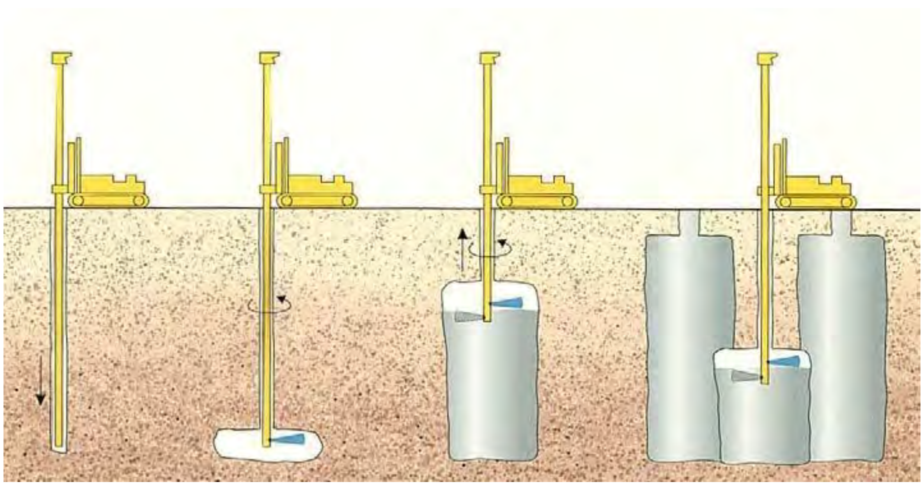


**Figure 3-16: Deep Soil Mix Construction**

## 3.5 Comparison of Excavation Support Techniques

Due to the speed of construction, and the ability to work around utilities, soldier piles and lagging is preferred unless site conditions dictate the use of other methods. Soldier piles and lagging is the predominant shoring system used in the Los Angeles area and has been used successfully by Metro on construction of both Red and Gold Line stations. Experience at the LACMA parking garage excavation suggests that soil off-gasses immediately after being exposed but with a short period of time, the off gassing slows to levels acceptable for work. This suggest that the relatively impervious seal achieved by slurry walls, secant piles, and deep soil mix walls may only provide very short term benefits and that gas entering the station box excavation through a soldier pile and lagging system could be controlled with a well designed ventilation system.

Since it is anticipated that gassy soils will be encountered regardless of shoring system type, various methods of providing a safe and hazard free workplace will be implemented in all situations. No matter which type of temporary shoring system is selected; other measures such as, partially open decking, ventilation, gas detection, and Personal Protective Equipment (PPE), will be in use to protect workers from gases that may enter the excavation site.

**Table 3-1: Comparison of Excavation Support Types**

| Shoring Method | Permeability | Installation Duration | Containment Impacts | Noise / Vibration Impacts | Traffic Impacts | Utility Impacts | Business Impacts |
|---|---|---|---|---|---|---|---|
| Soldier Pile & Lagging | High | concurrent w. excavation | Low | Moderate | Moderate | Moderate | Moderate |
| Slurry Wall | Low | 3 Months | High | Moderate | High | High | High |
| Secant Pile | Low | 3 Months | Moderate | Moderate | High | High | High |
| Tangent Pile | Moderate | 3 Months | Moderate | Moderate | High | High | High |
| Deep Soil Mix | Low | 3 Months | Moderate | Moderate | High | High | High |

## 3.6 Construction Staging

For all types of shoring, the contractor would first occupy one side of the street to install one line of excavation support piles or wall panels. The installation will require extended closures of 2 – 3 traffic lanes on the side of the street where the equipment would be staged. After installation of piles or walls on both sides of the street at the station excavations, piles or walls would then be installed across the street at the station ends. This operation would also require lane closures, and is often done during night-time or weekend periods. The contractor would then proceed with installation of deck beams, installation of the deck panels and excavation and bracing. Deck panels (decking) allow continued traffic and pedestrian circulation since they will typically be installed flush with the existing street or sidewalk levels, though raised decking, which requires less excavation during installation is being discussed with the traffic authority. Raised decking does have particular advantages at Wilshire / Fairfax Station as less excavation during the weekend closures while installing the decking makes it less likely that fossils will be encountered during the decking operation.

Deck installation will require successive full road closures on weekends with traffic detours. The decking would be installed in stages, commensurate with the amount of decking that can be installed during a weekend closure. Typical decking installation rates range from 50 -100 ft / weekend for an installation crew. Multiple crews will be used wherever possible to reduce the number of full road closures

## 3.7 General Approach to Handling Utilities

Prior to beginning construction of shoring and decking, it will be necessary to relocate, modify or protect in place all utilities and underground structures that would conflict with excavations. The contractor will verify locations through potholing methods and where feasible, the utility will be relocated so as to stay out of station or other surface structure excavation. Where the utility cannot be relocated outside the excavation footprint, it will be exposed and hung from the supporting structure (deck beams) for the roadway decking over the cut-and-cover structure. See figures 3-17 and 3-18.

**Figure 3-17: Utilities Hung from Deck Beams**

**Figure 3-18: Utilities Hung from Deck Beams (Close Up)**

Shallow utilities, such as maintenance holes or pull boxes, which would interfere with excavation work, will require relocation. The utilities alignments will be modified and moved away from the proposed facilities. Utility relocation takes place ahead of station and other underground structure excavation. During this time, it will be necessary to close traffic lanes.

It is possible that in some instances, block-long sections of streets would be closed temporarily for utility relocation and related construction operations. Pedestrian access (sidewalks) would remain open and vehicular traffic would be re-routed. Temporary night sidewalk closures may be necessary in some locations for the delivery of oversized materials. Special facilities, such as handrails, fences, and walkways will be provided for the safety of pedestrians.

Minor cross streets and alleyways may also be temporarily closed but access to adjacent properties will be maintained. Major cross streets would require partial closure, half of the street at a time, while relocating utilities.

Utilities, such as high-pressure water mains and gas lines, which could represent a potential hazard during cut-and-cover and open-cut station construction and that are not to be permanently relocated away from the work site, would be removed from the cut-and-cover or open-cut area temporarily to prevent accidental damage to the utilities, to construction personnel and to the adjoining community. These utilities would be relocated temporarily by the contractor at the early stages of the operations and reset in essentially their original locations during the final backfilling above the constructed station. See Figure 3-19

**Figure 3-19: Backfilling Utilities in Final Location beneath Road Surface**

# 4.0 PALEONTOLOGICAL ISSUES

The Wilshire/Fairfax Station is situated within the vicinity of the Hancock Park Rancho La Brea Tar Pits. The San Pedro Sand layer exists beneath the older and younger alluvium deposits near the surface in this region. This formation has a high likelihood for producing significant paleontological resources. Because of the high likelihood of fossil discovery while excavating the Wilshire/Fairfax station box, station construction at Wilshire/Fairfax will be given the maximum time available within the overall project schedule, so that excavation can proceed slowly and carefully and fossils located and removed without schedule pressures.

Before fossil recovery can begin, utility relocation and shoring for the station excavation using one or more of the shoring methods outlined above must occur. Utility relocations, by their nature (narrow trenches beneath paved streets) will make recovery of fossils during this phase of the work unlikely. Then, any fossils that lie within the footprint of the shoring will necessarily be destroyed when the shoring is constructed, as there is no way to remove them in in advance of the shoring. However, shoring will at worst occupy less than 10% of the footprint of the station excavation, leaving 90% of the footprint unaffected and suitable for fossil recovery.

The plan for fossil removal has been based on the methods used by the Page Museum for the removal of fossils from the nearby LACMA parking garage excavation, referred to from here-on by the Page Museum name, Project 23. The ground will be excavated in shallow lifts, with museum staff on land to inspect the excavated surfaces as earth is removed and to mark the locations of fossils when discovered. It is assumed that the fossils will occur in a manner similar to that at Project 23, i.e concentrated in vertical tar "pipes" which, once located, can be boxed in place and then removed from the site for further analysis. As with Project 23, fossils can also be found away from the tar pipes so all excavated surfaces must be inspected, and the contractor's team must be altered to the possibility of finding fossils anywhere with the excavation. Again, using the Project 23 experience as a guide, fossils of most likely to be found between 10 ft bgs and 30 ft bgs, though this may not turn out to be the case at Wilshire/Fairfax.

The Project 23 site was an open excavation, not constrained by a deck at ground level. This made boxing and removal of the fossil boxes a good deal more straight forward than will be the case at Wilshire/Fairfax. Figure 4-1 shows fossils in a pit at the Page Museum, and Figure 4-2 a boxed "pipe" containing fossils being prepared at the

Project 23 site.

**Figure 4-1: Tar Deposit Containing Fossils**

**Figure 4-2: Fossil Box Construction at Project 23**

**Figure 4-3: Smilodon (Sabre Tooth Cat) Pelvic Bone  Figure 4-4: Smilodon Skull in Fossil Box**

## 4.1 Minimize Excavation Done Before Decking Installation

Although the Project 23 experience suggests that fossils will mainly be 10 ft or more below street level, fossils must be anticipated anywhere within undisturbed ground. Using the cut and cover excavation technique, deck beams which support the deck panels are installed in the road bed after the piles or shoring walls are complete. The top of the deck beams sit just below the roadway surface so that the decking is flush with the roadway. The deck beams are approximately 6-ft tall and joined together with cross bracing so a minimum of 7-ft of excavation is required for their installation. On Red line and Gold Line stations, contractors have normally excavated 10 ft deep when installing the deck beams to provide clear space beneath the beams for better access when commencing to dig out from beneath the decking and to expose utilities immediately below the deck beams.

Because the street decking requires a full street closure to install, only limited times are available in which to close the street. Full street closures, especially along Wilshire Boulevard will be limited to approximately 52 hours duration on week-ends, and this will not provide time to carefully remove soil in layers to expose fossils nor to box and remove any fossils found in this initial excavation. Therefore, opportunities fossil recovery from the initial excavation for the street decking will be limited. It therefore requires a construction approach to try and reduce the depth of the initial excavation. Two strategies are being pursued in this regard. One approach is to use raised decking so that the bottoms of the deck beams can be raised up by the same height that the station decking is installed above street level. Metro is in discussions with traffic authorities regarding the acceptability of using raised decking at Fairfax. See appendix 1 for details of raised decking. The other approach is to use shallower deck beams, either for a flush deck system or in conjunction with a raised decking approach. Shallower beams will almost certainly require installing the deck beams at closer centers, probably 7 ft centers instead of the usual 14 ft centers but the shallow beams will reduce the likelihood of finding fossils during decking.

It should be noted that many utilities in the street are much deeper than the bottom of the deck beams, and any fossils would have been destroyed during the construction of such utilities.  Utilities already have disturbed a significant percentage of the station excavation footprint, and this will increase with the relocations required prior to the installation of the shoring and decking. Nevertheless, there will remain areas of undisturbed soil within the 10 ft immediately below street level and fossils therefore could be found in these locations. These areas can be mapped in advance so that they can be excavated carefully.

## 4.2 Excavation of the topmost layers beneath the street decking

Once the street decking has been installed, excavation beneath the decking will commence. The side access shaft(s) from the contractor's laydown area and from the station portal site will be excavated in shallow lifts, using methods similar to those of Project 23. Any fossils found will be removed. Once the side access shafts are deep enough to allow equipment to commence digging beneath the street decking, equipment will be lowered into then shaft to commence digging. One scenario will be for the contractor to dig the initial lift by scraping down the face, using low headroom equipment such as a Gradall or other equipment acceptable to Metro and to the Page Museum. The working face would be inclined at probably a 2:1 slope and would be accessible for inspection. The excavation would proceed in this manner until the first lift was completely removed. The height of the first lift will be determined by the head room needed by the equipment needed for the subsequent lifts, but probably of the order of 12-14 ft. depending on the equipment selected, subsequent lifts could continue to be inclined or horizontal. Fossils and tar pipes containing fossils would be removed under the supervision of Page Museum staff, probably using the boxing techniques developed for Project 23. Because the Fairfax Station will be decked, handling large boxes beneath the decking will be very difficult. Boxes of not more than 500 cubic ft (approximately 30 tons) are proposed as an upper limit, and smaller boxes for the first lift below the decking may be necessary so that low headroom equipment will be able to carry the boxes back to the side access shaft. Actual box sizes can be determined in the field by the contractor and paleontologists. Figures 4-5 and 4-6 show the proposed excavation sequence.

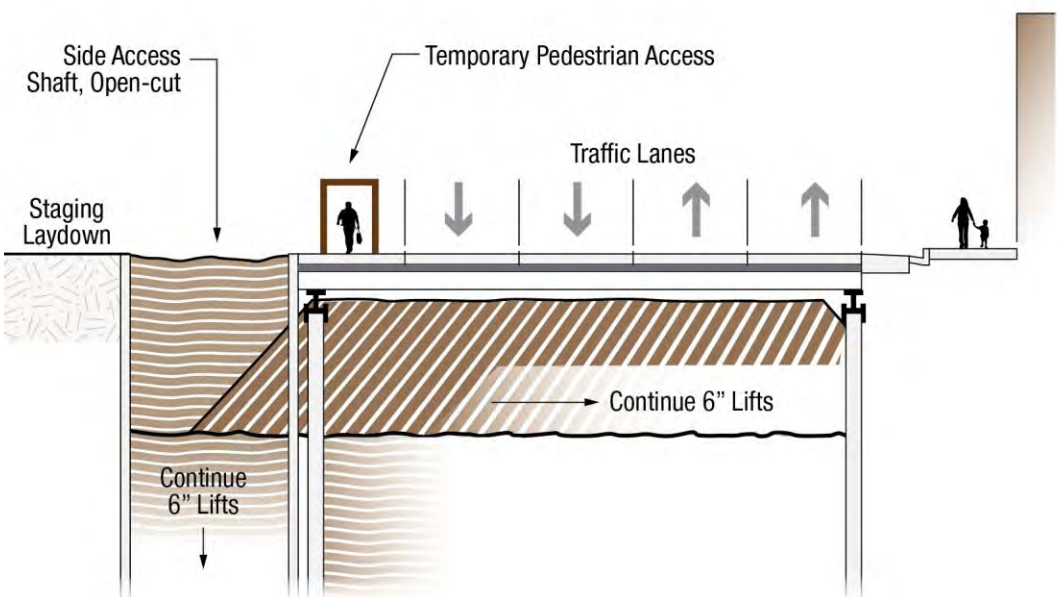



**Figure 4-5: Cross Section Showing Excavation Procedure of Shallow Lifts at 2:1 Slope Beginning from the Side Access Shaft**

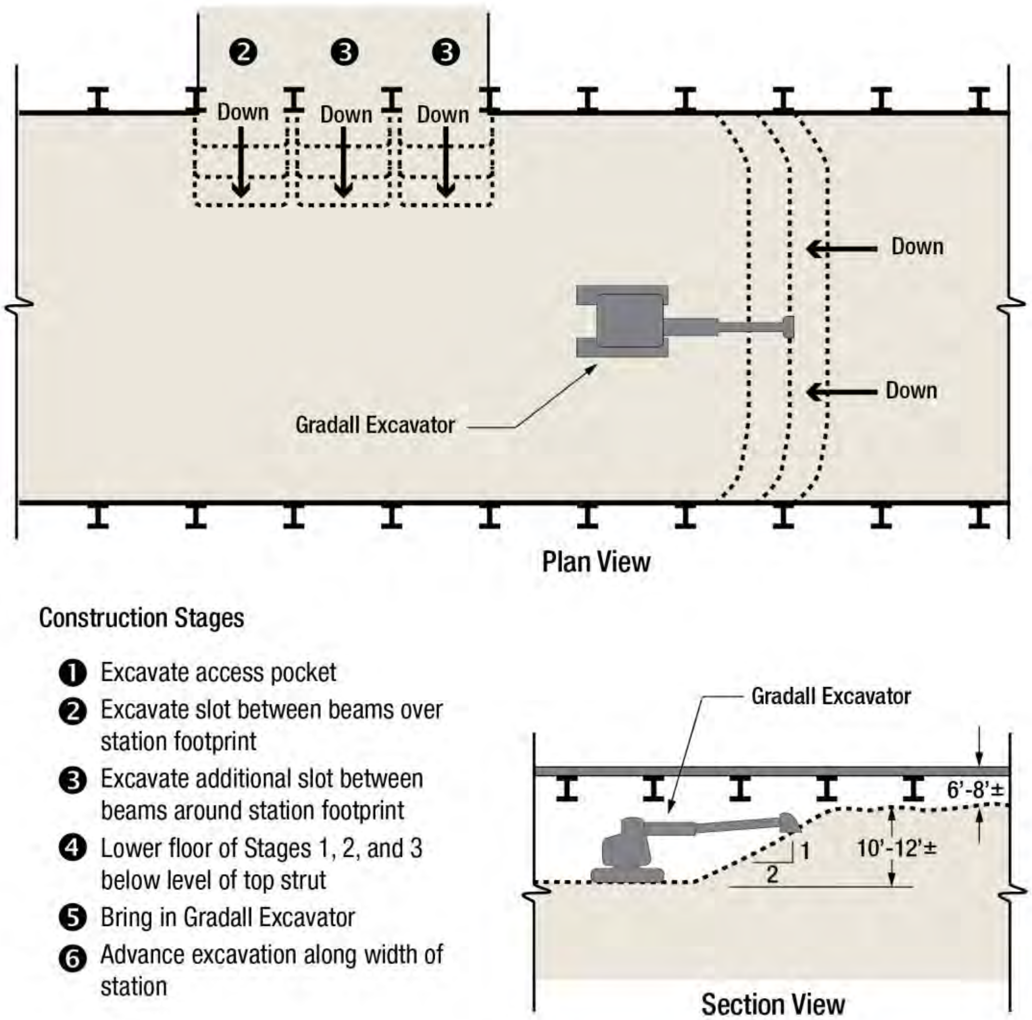



**Figure 4-6: Plan Showing Excavation Procedure of Shallow Lifts with Low-Profile Gradall Excavator**

**Figure 4-7: Open Cut Excavation of Side Access Shaft**

**Figure 4-8: Tracked Loader Removing Muck from Beneath Struts**

**Figure 4-9: Compact Track Loader**

**Figure 4-10: Compact Excavator – 6.75′-Tall/12′-Long/6.5′-Wide**

## 4.3 Excavate in Layers

The station box and side access shafts will be excavated in shallow lifts to carefully expose and locate fossils. The Page Museum is suggesting 6" lifts based on experience at the Los Angeles County Museum of Art (LACMA) parking garage. From previous experience with fossil recovery from tar-laden soils in this region, fossils generally, though not always, reside in tar deposits only. Other soil types should be generally free of fossils and can be removed with less concern for damage to fossils, though non-tarry areas will also require continuous surveillance.

Compact track loaders and compact excavators are likely necessary for initial soil removal directly beneath the deck beams due to their low vertical clearance, and relatively small bucket size capable of excavating precise lifts. Continuous tracks improve vehicle traction on soft and sticky terrain and reduce the amount of pressure exerted on the soil below. A pressurized cab would increase protection from gas intrusion although this may not be an option due to tight clearances and proper ventilation will still be needed regardless. If soil conditions permit, a rubber tire vehicle like skid steer loaders or equipment fitted with floatation tires may be used instead of compact track loaders. Gradalls operate a bucket at the end of a telescopic arm in a linear motion. The linear shoveling motion enhances depth control improving the ability to cut in precise shallow lifts. These should be considered as well. Track loaders, wheeled dozers and hydraulic excavators should be employed to remove the bulk of the soils in order to maintain efficiency in excavating. Excavation with these tools will require careful observation to identify the location of tar deposits. When tar deposits are located, smaller equipment should step in to avoid damaging fossil resources with heavier machines.

**Figure 4-11: Hydraulic Excavator between Struts**

**Figure 4-12: Track Loader beneath Struts**

It is possible that the discovery and removal of fossils could lead to schedule delays and the station box structure would not be completed in time to precede the TBM breakthrough. As long as station box excavation has not breached a reasonable depth above where the top of the tunnel liner will be so that it would compromise the operation of the TBM, then the TBM drive should continue through the station box location and station excavation would work its way down and eventually break through the tunnel liner.

It may be possible to use an imaging technique to locate fossils ahead of excavating operations thus allowing the pace of excavation to accelerate beyond the recommended 6" lift limit. If the imaging technique produces a reliable indication, the boxing of fossils can be pre-planned. Some techniques of scanning for objects below the surface that should be considered are Ground Penetrating Radar (GPR), HAARP Detection using ELF and VLF radio waves, electrical resistivity imaging, and geophysical diffraction tomography.

If an Early Work Authorization is obtained, construction can begin on an exploratory shaft to test the effectiveness of the anticipated geophysical methods. The shaft could be located within the limits of a side access shaft and would ideally reach full station depth in order to learn as much as possible from this process. The length and width of the shaft should be a minimum size to allow a variety of the equipment under consideration to perform excavation operations during the exploration process. Construction methods will be tested to determine the best techniques and tools for station box excavation. Shoring types will be tested to determine the effectiveness of the planned shoring in the soils present in the area. Gas levels will be measured to gauge the specifics of the ventilation scheme.



**Figure 4-13: Skid Steer Loader** **Figure 4-14: Compact Track Loader**


**Figure 4-15: Gradall with Large Bucket**

## 4.4 Fossil Box Size

As layers of soil are removed, tar-laden sand deposits containing fossils are likely to be uncovered. When this happens, work is halted within proximity of the fossil to allow the paleontologists on site to assess the discovery and begin preparations for boxing and removal of the deposit. The technique of boxing and removing fossil deposits to an off-site facility for additional paleontological work is an efficient process that was first implemented during the construction of Project 23.

**Figure 4-16: Fossil Boxes at Project 23**

**Figure 4-17: Fossil Boxes with Worker Donning Oxygen Respirator at Project 23**

The box construction technique used on Project 23 is similar to that which is used for boxing palm trees for transport. See figure 4-16. First, the paleontologist defines the location of the fossil deposit. Next, trenches are dug around the sides and excavation continues by removing sterile soil from around the fossil zone with heavy equipment leaving an island where the deposit sits. The bottom of the box is most challenging. After the box is supported by blocks and shims at each of the four corners, workers must crawl beneath the box and dig by hand while inserting the timber boards which make up the base of the box (Figure 4-18). An alternative approach to creating the bottom of the box which would improve worker safety and expedite the excavation process would require an auger to drill holes in the island beneath the fossil deposit. Timbers would be inserted through the auger holes, thus beginning to form the base of the box. The auger would then remove the balance of soil between the timbers allowing completion of the box and freeing the deposit from the soil below. See Figure 4-19. During the excavation of Project 23, sixteen tar deposits were discovered. From the sixteen deposits, twenty-three boxes were recovered, thus giving the parking garage project its name. The boxes range in size from 5x5x5-ft (weighing 3 tons) to 12x15x10-ft (weighing 56 tons).

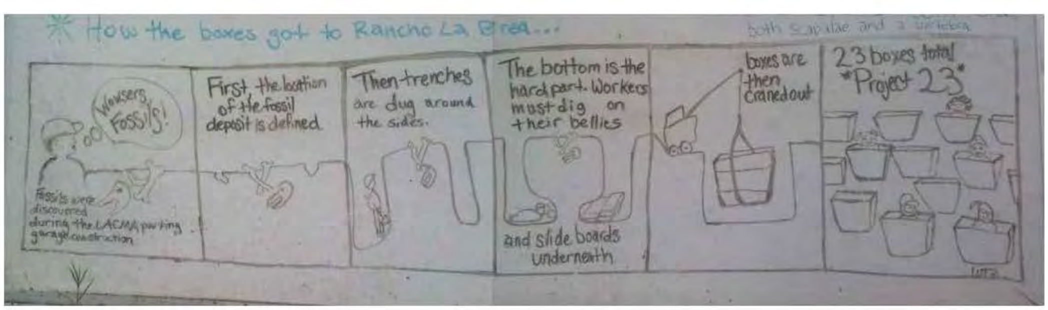



**Figure 4-18: Fossil Relocation Process. (From Page Museum Whiteboard)**

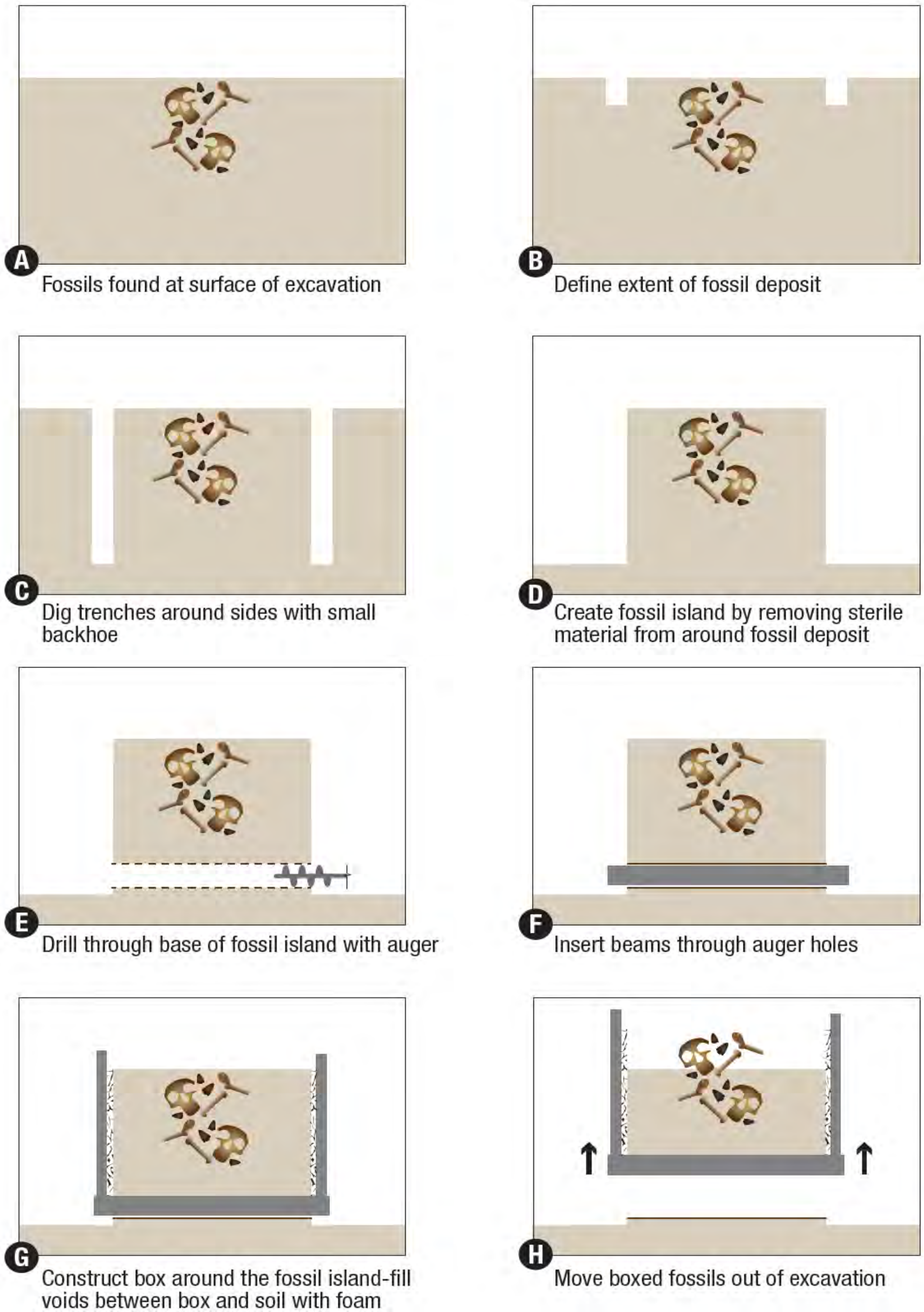



**Figure 4-19: Alternative Boxing Technique Using Auger for Floor Construction**

Depending on the size and weight of each box, fossils located beneath deck panels may be lifted in place by crane through temporary openings in the decking. However, this may prove to be impossible if street closure are not possible or the crane cannot be positioned on the street decking in a way to perform the lift. It is proposed to limit the size of fossil boxes to about 30 tons, i.e 500 cubic feet which will make boxes easier to lift or to move around below the decking with low headroom equipment or with a system of skids and temporary tracks constructed within the station box. Once positioned adjacent to the side access shaft, fossil boxes can be lifted by mobile cranes positioned on "terra firma". The crane would lift the box out through the access shaft and load it on a truck which will transport the tar and fossils either to the Page Museum site where paleontologists can continue their work or to the contractor's laydown area at South Orange Grove/ Ogden for storage and processing. Offsite processing is preferred as there is less potential for damage by heavy equipment that will be operating at the South Orange Grove/Ogden laydown area.

## 4.5 Construction Issues in Tar-Laden Soils

The asphaltic sands have unique properties and the engineering characteristics are not as well documented as compared to other soils. However, contrary to common expectations, it is proven that these sands possess shear strength. Design parameters for excavation support systems in asphaltic sands will need to consider some additional pressure due to the makeup of these soils. There are numerous cases of successful experience in construction of deep basements and underground parking structures in the Wilshire/Fairfax area soils, such as construction of underground structures at LACMA. Similar design elements, construction techniques and operating methods and procedures can be applied to the planned excavations.

**Figure 4-20: Aerial View of Project 23 Excavation with Dark Tar Seeps**

## 4.6 Potential Impacts to Construction Methods from Anticipated Tar-Laden Soils

When excavating in tar-laden soil, efforts will be undertaken to avoid excessive disturbance. Excavation methods will be closely controlled to minimize over-excavation or vibrations. When grade is achieved within these soils, a mud slab could be applied to minimize disturbance. In some cases, a layer of gravel may be placed over the asphaltic sands to increase traction and reduce the amount of soil compaction caused by construction traffic. The contractor can also apply various other materials on top of the tar such as cement, lime, or other additives to prevent it from fouling the tracked equipment. Wide tracked machinery can be used to reduce the pressure exerted on the soils below. Timber mats can make a sturdy foundation to drive equipment on. Rubber tire vehicles are considerably lighter than their tracked counterparts and could be operated with floatation tires specifically designed to minimize the amount of soil compaction caused by heavy equipment. Because the tar is rather sticky or tacky in some areas, it is anticipated that the equipment's tracks, axles, or buckets could become fouled and would require occasional cleaning. Steam cleaners would handle the task well, by heating the tar to a less viscous consistency.

## 4.7 Handling Gas Intrusions during Construction Operations

Previous projects in the Methane Risk Zone have been successfully and safely excavated. Multiple underground parking garages have been constructed in this area. For example, LACMA built a two-level subterranean parking structure in the Methane Risk Zone, previously referred to as Project 23. During the excavation, $H_2S$ (above safe working levels) was encountered on several occasions. Workers donned PPE to protect against exposure during these events. Further investigation of operating underground structures will be undertaken during future design phases to assess effectiveness of barrier systems and detection equipment used.

Since the majority of gas is expected to enter the excavation through the excavation surface, the release of gases may be constricted by applying a ground cover to all areas except the area where current excavation operations are taking place. An impervious membrane of Visqueen plastic sheeting or geotextile fabric may serve this purpose.

In areas of potential H2S exposure, there are a number of techniques that can be used to lower the risk of H2S release or exposure. Because station excavations are less confined than tunnels, gas exposure issues are anticipated to be less significant. Although pre-treatment of the ground water prior to excavation, with additives such as hydrogen peroxide or copper-zinc, is an option, it is not expected to be required. If released, H2S will not naturally dissipate because it is heavier than air, hence it would build up around the bottom of the excavation. The first line of defense is dewatering since H2S occurs in a dissolved state in ground water. Dewatering will remove any contaminated water from the excavation area. At the surface, a sealed tank would capture the water and treat the air for H2S off-gassing before discharging it to the surrounding environment. Additionally, a ventilation system will be used to introduce fresh air in the workspace. Fans will be used to circulate the air while a gas detection system monitors levels of hazardous gas. A suction system fitted with scrubbers may be required to collect H2S from the bottom of the excavation and treat the air before discharging clean air at the street surface.

CH4 is a hazard in confined spaces. As such, it is essential that workers be sufficiently protected, and thus detection and monitoring equipment would be required. Fans similar to those used to dilute H2S concentrations would also dilute CH4 concentrations in the station box. Once above-ground, CH4 dissipates rapidly in the atmosphere and would not be a health hazard.

## 4.8 Ventilation Schemes

Ventilation is required to combat harmful or dangerous gasses when present in underground construction. Cal OSHA classifies subterranean work areas as “gassy”, “potentially gassy”, “non-gassy”, or “extra hazardous”. Excavation equipment in “gassy” spaces must be manufactured to resist accidental sparks and either be sealed or of explosion proof design.

Since CH4 and H2S gases are expected to be encountered during the excavation of Wilshire/Fairfax station, adequate ventilation and continuous air quality monitoring will be in use throughout construction. In addition to maintaining acceptable levels of CH4 and H2S in the air supply, the ventilation system must maintain a certain level airflow for workers present in the work space. The size of the system is dependent on the number of persons and the size of diesel equipment underground. The air supply shall not be less than 200 CFM (cubic feet per minute) per person underground, plus 100 CFM per diesel horse brake power.

**Figure 45: Underground Ventilation Ducts**

Use of perforated deck panels, either perforated steel or concrete integrated with steel could be used in place of concrete only deck panels to allow the free flow of air between the excavation area and the surface, especially if full decking is required across the entire station box.

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

The project is committed to recover fossils and to work closely with the Page Museum to minimize the loss of fossils due to the construction of a station at Wilshire/Fairfax.

The project plans to use the same recovery methods that have been proven at Project 23, and with the corporation of Page Museum staff will seek to customize and improve on these methods to tailor them for the site conditions at Wilshire / Fairfax.

Further studies are on-going to find ways to raise the height of the beams used for street decking, which in turn, will leave more soil beneath the beams for controlled excavation and fossil recovery.

The fastest and lowest cost shoring method is preferred. This means that a soldier pile and lagging system will be employed provided that continuing geotechnical investigation do not find ground conditions that preclude this system. Soldier pile and lagging shoring has the added advantage of disturbing less of the station excavation footprint than other methods, mimimizing the loss of fossils in this phase.

Gases will be controlled by installing adequate ventilation within the excavation, and by designing the street decking system with gaps for natural ventilation and elimination of pockets where gases could accumulate.

# Attachment C: Fairfax Exception Memo

cogstone
PALEONTOLOGY - ARCHAEOLOGY - HISTORY

October 21, 2013 Cogstone 2604

To: Steven Sabo, WEST Construction Manager
From: Sherri Gust, WEST Principal Paleontologist

RE: Special Exception for Cut and Cover Work at Fairfax Station

PB Engineer Amanda Elioff relayed to me the concerns of the proposers for the Design Build in regard to use of 6 inch excavation lifts for the initial 10 feet of cut due to the extremely limited time frame available to install the decking and supports (about 53 hours). I have discussed the situation with Dr. John Harris of the Page Museum this morning.

Dr. Harris and I agree that regular excavation lifts may be used for these initial 10 feet only due to the logistics of the situation. Monitors are not necessary for any work in fill but due to the use of regular excavation lifts, any work in native sediments will require use of two paleontological monitors.

The 6 inch lift requirement was only for Fairfax Station as no asphaltic matrix was observed in any geotechnical borings at Western, La Brea or La Cienega Avenues. Regular excavation lifts may be used for all work at these stations in conjunction with paleontological monitoring.

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Los Angeles County
Metropolitan Transportation Authority

March 2012

# Westside Subway Extension

*Final Environmental Impact Statement/Environmental Impact Report—Volume 4*

APPENDIX G: *Memorandum of Understanding for Paleontological Resources*


Metro

U.S. Department of Transportation
Federal Transit Administration

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# Memorandum of Understanding

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MEMORANDUM OF UNDERSTANDING

**THIS MEMORANDUM OF UNDERSTANDING** ("MOU") is entered into as of this 2nd day of November 2011 by and between the Los Angeles County Metropolitan Transportation Authority ("MTA") and the Los Angeles County Museum of Natural History, including the Page Museum at the La Brea Tar Pits ("Museum") (collectively, "the Parties"), for the preservation of paleontological and archaeological resources associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station.

BACKGROUND

**WHEREAS**, the MTA has the responsibility under Federal and State law to recover and preserve for future scientific and educational use paleontological, archaeological, and historical resources that may be impacted by the Westside Subway Extension Project and associated records; and

**WHEREAS**, the Museum has established expertise in recovery, management, curation and research of paleontological resources and is willing to permanently curate paleontological and asphalt-related archaeological resources recovered from the Westside Subway Extension Project in asphaltic deposits associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station and recognizes the benefits which will accrue to it, the public and scientific interests by housing and maintaining the Paleontological Resources and Records Collection for study and other educational purposes; and

**WHEREAS**, the Parties hereto recognize the mutual benefits to be derived by having paleontological and archaeological resources suitably housed and maintained by Museum;

**NOW, THEREFORE**, in consideration of the terms, conditions, covenants and performances herein contained, and other consideration the receipt and sufficiency of which is hereby acknowledged, and with the intent to be legally bound hereby, the Parties agree to incorporate the above recitals into this MOU and further contract, promise and agree as follows:

1. **MTA shall:**

a. Retain a qualified principal paleontologist (minimum of graduate degree, ten years of experience as a principal paleontologist and having demonstrated expertise in vertebrate paleontology) approved by the Museum to plan, implement and supervise paleontological monitoring, preservation, fossil recovery, fossil preparation, fossil documentation and reporting of significant paleontological resources within the areas of disturbance for the Wilshire/Fairfax Station or other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station. The principal paleontologist will be responsible to ensure that all subordinate personnel are appropriately qualified.

b. Require the principal paleontologist to prepare a mitigation plan, subject to approval by the MTA and Museum, to address monitoring, preservation and, recovery of any paleontological resources. The mitigation plan shall be consistent with best practices guidelines for both field and laboratory work on project paleontological resources to meet state and federal laws and guidelines and Museum standards (Attachments 1 and 2).

c. Require the principal paleontologist to monitor all ground-disturbing activities where sub-surface soils are exposed. The areas to be examined will be determined based on project plans and in consultation with construction staff and the qualified paleontologist during pre-construction meetings and as needed throughout the construction process.

d. Ensure that if subsurface paleontological resources are identified by the principal paleontologist during construction, all construction activities in the area of identified paleontological resources will be temporarily halted so that the resources may be documented and recovered. All resources shall be documented on appropriate forms approved by the Museum and these will be placed on file in the Museum.

e. Ensure that any paleontological resources, including asphaltic deposits containing fossils and/or archaeological objects, will be recovered in accordance with best practices outlined by the Museum (Attachment 1).

f. Require that the principal paleontologist have designated and secure space sufficient to store and, if necessary, analyze and process boxed or individual fossil deposits for preparation [but see section 2.c].

g. Require that the principal paleontologist record all data and, if necessary, perform excavation of boxed deposits or individual fossils, prepare fossils and store fossils prior to curation in accordance with best practices outlined by the Museum (Attachment 2).

h. Require that the principal paleontologist provide periodic progress reports including copies of all field notes to the MTA and Museum in addition to a comprehensive final report meeting all state and federal standards. The original copies of the field notes will be archived in the Page Museum at the time that the fossils are transferred to its jurisdiction.

i. Provide funding for required fossil recovery, cleaning, preservation, curation and storage and any other fossil-related Museum activities specified in Paragraph 2 based on a cost per amount recovered to be agreed upon by the MTA and Museum in a subsequent detailed Agreement to be signed between the MTA and Museum during further Project Design. Such agreement will be based in part on the Museum's cost for processing and storage of its Project 23 materials, taking into account the possible variation in the density of fossils and in the matrix in which the fossils are found. Such agreement should include contribution to cost of permanent storage premises in the event that significant quantities of fossils are recovered. Such agreement shall prevent unreasonable payment if few fossils are found, but assure payment for vital effort.

j. Allow the Museum to be involved, in an oversight capacity, for all field and laboratory work to ensure that Museum standards are being maintained.

k. Require that paleontological resources be removed expeditiously to allow Project completion according to schedule, but in compliance with Museum standards as recently demonstrated in the construction of the new LACMA Underground Garage and corresponding Project 23 Paleontological Project.

l. Retain responsibility for compliance with all legal and regulatory provisions related to monitoring, reporting, consultation, and repatriation of Native American remains and related material, including under NAGPRA and California law.

m. Assign an MTA Representative to make any further revisions or adjustments to this document necessary in the course of the project, in cooperation with the Museum.

n. Designate the Museum as the sole source for the scientific description of fossils and artifacts recovered from the Westside Subway Extension Project in asphaltic deposits associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station. Publicity concerning the discovery of such fossils and artifacts shall be jointly undertaken by MTA and the Natural History Museum of Los Angeles County.

2. **Museum shall:**

a. Make available Museum personnel to provide oversight for the qualified principal paleontologist's preparation of a mitigation plan, subject to approval by the Agency, to address monitoring, preservation and, recovery of paleontological resources. The mitigation plan shall be consistent with best practices guidelines for both field and laboratory work on project paleontological resources to meet state and federal laws and guidelines and Museum standards (Attachments 1 and 2).

b. Make available Museum personnel to provide oversight of all field and laboratory work on paleontological resources for the duration of the project to ensure that Museum standards are being maintained.

c. Provide an option, dependent upon the volume and number of fossils recovered, that the Museum will directly house boxed fossil deposits and internally perform excavation and preparation of those deposits for compensation comparable to that offered to the principal paleontologist for similar services.

d. Provide for the professional care and management of the curated paleontological resources associated with the Wilshire/Fairfax Station and other portions of the Westside Subway Extension Project alignment within two miles of the Wilshire/Fairfax Station.

e. Ensure that personnel assigned responsibilities related to the Westside Subway Extension Project are qualified museum professionals whose expertise is appropriate to the nature and content of the paleontological resources recovered.

f. Provide and maintain a repository facility having requisite equipment, space and adequate safeguards for the physical security and controlled environment for the paleontological resources (but see 1.i).

g. Perform those conservation treatments necessary to ensure the physical stability and integrity of the paleontological resources prepared by the principal paleontologist.

h. Curate the paleontological resources to ensure adequate scientific documentation of the circumstances of their recovery.

i. Credit the MTA when the Collection or portions thereof are exhibited, photographed or otherwise reproduced and studied in accordance with the terms and conditions of Museum policy with the statement: "In Cooperation with the Federal Transit Administration and Los Angeles County Metropolitan Transportation Authority". The Museum agrees to provide the Agency with copies of any resulting publications.

3. **Paleontological Advisory Board**

The Parties agree to mutually appoint a three person Paleontological Advisory Board comprised of appropriately qualified paleontologists to help guide this effort as previously agreed by the Parties in their Paleontological MOU for this site in 1983.

4. **Amendment**

This MOU may be revised by issuance of a written amendment signed and dated by both parties.

5. **Donation of Paleontological and asphalt-related Archaeological Resources**

Agency agrees to donate title to all paleontological and asphalt-related archaeological resources to the Museum.

**IN WITNESS WHEREOF**, the Parties hereto have executed this MOU.

[signature]
Dr. Jane Pisano
President and Director
Los Angeles County Museum of Natural History

10/25/11
Date

[signature]
Arthur T. Leahy
Chief Executive Officer
Los Angeles County Metropolitan Transportation Authority

11-02-11
Date

**ATTACHMENTS**

Attachment 1. Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

Attachment 2. Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

Attachment 3. Wilshire/Fairfax Station Construction Methodology

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# Attachment 1—Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

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# ATTACHMENT 1

## Paleontological Methods for Mitigation of Fossils in the Vicinity of Hancock Park

# Paleontological methods for mitigation of fossils in the vicinity of Hancock Park.



Images courtesy of ArchaeoPaleo Resource Management, Inc.

2011

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# Introduction

Rancho La Brea is the world's richest Ice Age fossil locality, yielding well over 3 million fossils and representing more than 600 species of animals and plants that lived in the Los Angeles Basin between 11,000 and 50,000 years ago. The asphaltic fossil deposits generally occur in randomly distributed inverted cone-shaped masses between 10 to 35 feet in depth. The sizes of the accumulations vary considerably from less than 5 cubic feet to more than 20 cubic feet. Flat tabular deposits such as that recovered during the construction of the Page Museum are rare. Ideally, the fossil accumulations should be carefully excavated as they are discovered. The fall back position is to remove the deposit intact, preserving it for excavation at a later date. This methodology, developed during the mitigation of the LACMA underground parking structure, preserves stratigraphic integrity, permits less hurried excavation under more optimum conditions, maximizes fossil and information retrieval, and enhances opportunities for major discoveries and new scientific contributions. All data pertaining to the location and condition of newly discovered fossil deposits must be recorded and photographed as outlined later in this document.

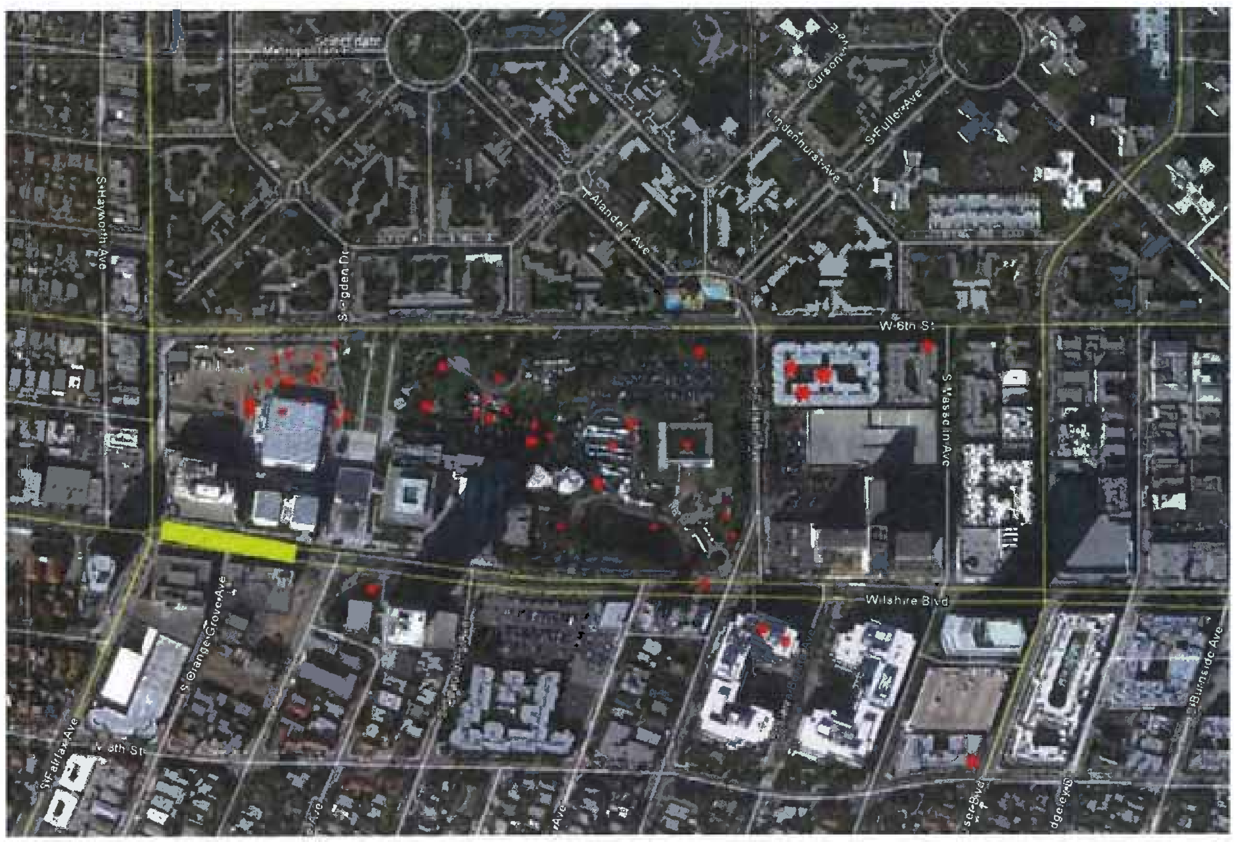



**Fig 1: Map of Hancock Park** and vicinity with known asphalt preserved fossil localities (red stars) and the approximate location of the proposed MTA subway station (yellow rectangle)

**Fig 2: Monitoring**

All excavation activity must be carefully monitored. In areas of asphaltic sediment or other areas where fossils have been discovered, sediment should be removed in 4-6" levels while paleontologists monitor closely. The monitors are empowered to halt the process as soon as fossils are located.

**Fig 3: Fossils are discovered**

After a fossil deposit has been located the surrounding area must be roped off so that paleontologists can determine the extent of the deposit or if it is an isolated fossil. In the case of an accumulation deposit this may range from 5 feet to 20 or more feet across. Construction work in the immediate vicinity of the fossil deposit must be halted temporarily but may proceed normally elsewhere in the construction site. Asphalt saturated conical shaped deposits and isolated fossil mitigation are described separately below.

## Taking Field notes

Whether an accumulation of fossils are discovered or an isolated fossil is found, detailed field notes must be taken. The precise locality of each fossil deposit must be recorded with a resource-grade GPS device, its extent clearly described, mapped, and photographed on site using conventional field data collection methods, and its context including represented lithologies and depositional environments must be described. Types of geologic information to be collected should include: the nature of bounding contacts (erosional, sharp, gradational), thickness, geometry, grain size, shape, and sorting, color (fresh and weathered, use a color chart), sedimentary structures (physical and biogenic), cement type, pedogenic features (rooting, nodules, slickensides, etc.), halos, mineral crusts, microstructures around bio-clasts, and other fossils. Types of taphonomic information to be collected should include: taxonomic

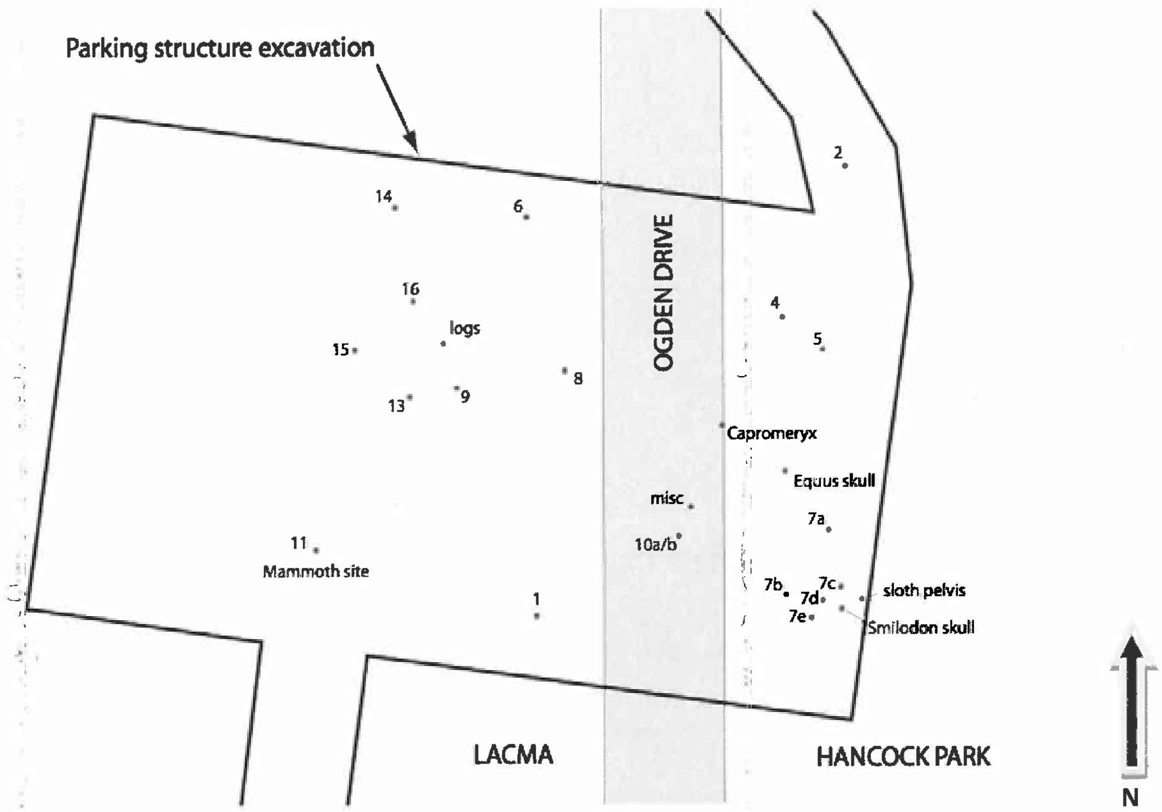
representation, skeletal articulation and association, scale and geometry of assemblage, density, and orientation of bones. Bone modification information to be collected should include: weathering, polishing, abrasion, scratch/tooth marks, root traces, borings, fragmentation/breakage, and distortion. Each isolated fossil and each individual fossil deposit must be given an individual field number. This number should be written in permanent ink on individual fossils and clearly marked in permanent marker or paint on the box containing a deposit.

## Asphalt saturated conical shaped deposits

**Fig 4: Pedestal a deposit**
Once the extent of the fossil accumulation has been determined, the sediment surrounding the fossiliferous deposit is carefully removed, isolating the accumulation on a pedestal. It may be necessary for monitors to wear a SCBA, as in this image, because of the high concentrations of hydrogen sulfide.

**Fig 5: View of east end of LACMA construction site**

It is possible that there will be a number of fossil deposits within the construction site. Work may continue at non-fossiliferous locations while the deposits are being salvaged.




## Fig 6: Map of fossil localities from LACMA parking garage

These were mostly asphaltic fossiliferous masses but included some occurrences of isolated bones, trees, and other fossils.

**Fig 7: Fossil accumulation pedestals before tree box**

After the deposit has been isolated it will be surrounded by metal bands to conserve its integrity before the box is built and a brightly colored strong plastic or a tarp to keep the deposit dirt separated from the 'fill' dirt.

**Fig 8: Building a tree box around a fossil deposit**

A custom sized box is then built around each deposit by a 'tree boxing' company. Valley Crest was used on the LACMA project. Any space between the plastic-wrapped deposit and the edge of the box must be filled with polyurethane foam, distinctly different sediment or gravel to preserve the integrity of the deposit and to prevent its deformation during subsequent transportation and storage. It is important that the 'fill' sediment be easily recognizable from the matrix during later excavation of the deposit.

**Fig 9: Secure the tree box with metal bands**

After the sides of the box are nailed into place, metal bands are added to secure and strengthen the sides of the box.

**Fig 10: Tunnel under the tree box**

After the sides of the box are secured and banded, the sediment beneath the box is removed by tunneling so that the box floor can be constructed. The field number and locality data must be clearly written on the outside of the box in permanent marker or paint. The orientation of the box and the depth below datum of the top and bottom of the deposit must also be clearly and permanently marked on the box, as well as added to the field notes for that deposit.

**Figs 11, 12 & 13: Relocating the tree boxes by crane and truck**

A crane is used to lift the completed boxes, load them onto a flat bed truck, and to relocate them to the place where their excavation will take place.

## Isolated fossils

In addition to conical and flat tabular asphaltic accumulations, construction activities may encounter isolated fossils in non-asphaltic or asphaltic sediments such as the trees, mammoth skeleton, and bison and horse skulls that were discovered during the recent construction of the LACMA's underground parking structure. Similar procedures pertain. The area must be roped off in order for the monitors to determine the extent of the fossil occurrence, which may then be removed using conventional paleontological field techniques. Large or fragile bones must be pedestaled (with sediments immediately surrounding the fossil) and covered in a plaster and burlap jacket. The type of plaster used determines the time it takes to dry. Once the plaster is dry, it is flipped over and the other side is covered with plaster and burlap and left to dry completely. In the meantime paleontologists need to determine the extent of other isolated fossils in the area looking in particular for other elements of the skeleton of the jacketed specimen or sediments in which microfossils such as rodent, bird and reptile remains may occur.

It is crucial; that all isolated fossil occurrences be given a field number, their location recorded with a resource-grade GPS device, and these data entered into the field notes together with a map and description of the fossil, its orientation and its locality including description of the lithology in which the fossil was preserved. Standard guides such as Munsell Soil Color Charts should be used. The field number should be clearly and permanently affixed to the fossil and written on its container or jacket as appropriate. Maps must have a legend and scale to the show the orientation and depths of each fossil as well as a datum point. In addition to the field number, plaster jackets should also be marked "field side up" on the appropriate surface.

**Fig 14: Excavating isolated fossils**

Paleontologists need to excavate around large bones with hand tools before covering them with a protective plaster jacket for later removal and transport.

**Fig 15: Mammoth discovered**

This image show the mammoth locality in the context of the construction site during the LACMA underground parking garage.

# Attachment 2—Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

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# ATTACHMENT 2

## Techniques for Excavation, Preparation and Curation of Fossils from the Project 23 Salvage at Rancho La Brea

# Techniques for excavation, preparation and curation of fossils from the Project 23 salvage at Rancho La Brea.

A MANUAL FOR THE RESEARCH AND COLLECTIONS STAFF OF THE GEORGE C. PAGE MUSEUM



2011

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# Introduction

This document was compiled mid project to record and codify best practices for excavation, preparation and curation of specimens from Project 23 and other Rancho La Brea localities that are housed in the George C. Page Museum. Some of the techniques are similar to Pit 91 excavations that were reported by Shaw (1982) and others that are unique to Project 23 because of the nature of the salvage. This provides guidelines for possible future salvage efforts. Documents discussing the nature of the mitigation are available elsewhere.

# Excavation Techniques for Project 23

Excavation of Project 23 deposits began in August, 2008. The measuring techniques used to determine and record data for *in situ* specimens follow those of Shaw (1982) for Pit 91 with some modifications described here (for instance, the imperial measurement system was used prior to Project 23). New excavation procedures have also been devised as a result of the removal of the deposits from their original location due to construction.

In Project 23, a custom-sized wooden box was built around each isolated plastic-wrapped deposit by a 'tree boxing' company (Valley Crest was used for this particular project). Any space between the deposit and the edge of the box was filled with either polyurethane foam or sediment to preserve the integrity of the deposit and to prevent its deformation during subsequent transportation and storage.

Because the deposits are no longer *in situ*, all excavation grids are oriented with respect to the deposits' original north orientation. Where feasible, box walls may be removed in part or in their entirety to allow excavation from the side of the deposit rather than from the top. Each "tree box" from Project 23 is treated differently depending on the type of deposit, size of the box and integrity of the sediments in the box. Refer to paleo mitigation protocol and ArchaeoPaleo report documents for descriptions on how the 'tree boxes' were constructed.

## Preparing a tree box for excavation

First read all the field notes pertinent to that particular deposit. In a field notebook or deposit logbook document the nature of the "box" size, construction, fill, plastic, etc. If the box is taller than 5 feet, erect scaffolding for excavators to safely access the box. Depending on the size of

the tree box it may be necessary to construct a safety railing extending upward from the sides of the box. After the top of the box is safe to access, remove the metal bands that are strapped across the top of box. Use specific snips if recommended by the tree boxing company. Remove supportive fill dirt, foam and plastic to reveal deposit surface, taking care to maintain an appropriate area for excavators to work safely.

Depending on box stability and size, board walls or portions of board walls may be removed to enable excavation from the side of the deposit. Smaller boxes containing deposits with cohesive sediments may allow the removal of all sidewalls. For larger boxes, removal of one wall or a small "window" cut into a sidewall may be feasible.

Before any asphaltic sediment is removed, set up a gas monitor close to where work will be conducted. The Solaris Multigas Detector is an economical, 4-gas instrument providing simultaneous detection of CO, O2, H2S and combustible gas and costs ~$600 from Safety Tek Industries.

## Grid layout

Determine the deposit's north side from field data and data written on the box.

Establish a datum point near the top of the box and record it based on field data. The datum point should not be removed during excavation.

Lay out grids into 1m x 1m squares with origin in the SE corner of the box using an alphanumeric system (N/S = A-Z; W/E = 1, 2, 3). Gridlines can be marked with string, spray paint or chalk and need to be refurbished and maintained periodically. A map of the box showing the grid lines and a north arrow should be drawn for reference.

## Excavation and Documentation

After grids are established, clean surface to remove fill dirt, to determine sediment type and to locate fossils if exposed. Note nature and location of fossils (bones, shells, plant remains, etc.)

Excavate grids in 25 cm spits (i.e. Level 1=0cm-25cm, L2=25cm-50cm, etc). If multiple grids are worked on at the same time, ensure that this doesn't compromise the mapping of each spit wall and floor. If a deposit has been exposed from the side, the spits in any one grid may be excavated sequentially from the top to the base of the deposit.

Depending on degree of consolidation, use small hand tools (hammers, chisels, and screwdrivers as required) on non-fossiliferous areas. Pneumatic or electric hammers can be used on areas with hard matrix where there are no fossils. Use dental picks and small screwdrivers to expose and extract fossils. Hard asphaltic matrix can be softened with clamp lamps or loosened with a small amount of solvent. Measure exposed fossils *in situ* (see below) within each grid and record their data in field notes before extracting them.

Note: Clamp lamps should be placed at least 8" away from the specimens and always monitored. Never leave lamps unattended. If the sediments start to smoke immediately turn off the lamp. 150 watt incandescent unfrosted bulbs should be used.

Save all of the surrounding sediments but separate them based on sediment type into 5 gallon metal buckets with lids. The pre-designated sediment types are A= asphaltic sand, B=brown silts and C=clay. Mark each bucket with box #, grid and level data as well as the sediment type (A, B or C). Note the number of buckets of each sediment type from each grid on an inventory list kept by the lead excavator. This is important because it determines how each bucket is processed later (see matrix processing section).

Keep daily documentation in field notes of who is excavating, a list of the grid or grids being excavated and describe the type of matrix being removed, what is being found within each grid, and any challenges encountered with the excavation. Geologic and paleobiological data should be recorded in field notes for later use to constrain and further refine taphonomic, paleoenvironmental, and paleobiological interpretations. A description of each lithology (soil type) should include color (fresh and weathered), lithologic composition, grain size, sorting and shape, sedimentary structures, induration, type of cement, fossil content, and pedogenic features (rooting, nodules, slickensides, etc.). As excavation proceeds note unit thickness, nature of the bounding contacts (erosional, sharp, gradational), and inferred depositional setting. Note nature and location of fossils (bones, shells, plant remains, etc.). Any visible modifications to the bones (weathering, polish, abrasion, scratch/tooth marks, root traces, borings, pitwear, breakage, distortion) and gross orientation should be recorded. Features of the matrix surrounding the bones, such as alteration halos, mineral crusts, micro-structures, fine root traces (small burrows or borings), and localized invertebrate bioturbation should be noted. The degree and nature of articulated, semi-articulated, associated, and dissociated skeletal elements should be described. Notes should also be taken on the general geometry of the fossil deposit (vertical pipe, tabular, etc.) drawings and/or photographs should be taken when appropriate.

## Measurement system

The most common types of macrofossils recovered from asphaltic deposits are isolated bones. The following measurement system has been devised for capturing data for individual bones.

See the Special Cases section for the treatment of associated skeletons, dermal ossicles, plant masses, etc.

*In situ* measurements are taken from specific anatomical points on each bone (see Table 1 and 2 Appendix A) to define its spatial orientation with reference to its depth below an established datum point (BD), its distance north (N) of the southern grid line and its distance west (W) of the east grid line using the metric system (see Fig 1. of Shaw (1982) but note this uses the imperial measurement system). Recording this data at the time of excavation will facilitate studies of stream current energy and direction, deposition, and taphonomy.

All identifiable bones from 1 cm to 2 cm in size should be measured *in situ* as a 1-point measurement before being excavated. Each Standard Measurement (BD, N, W) is taken to the center point of the longest dimension (Fig. 3)

Bones larger than 2cm in minimum length or diameter should be measured as either a 2-point or a 3-point measurement. The 3-point measurement is used on all bones in which three predetermined identifiable anatomical points are visible. The 2-point measurement is used if the bone lacks three distinct reference points and records the orientation of the long axis of the specimen (proximal-distal, anterior-posterior, medial-lateral, etc.). Detailed instructions for measuring out specimens are provided by Shaw (1982), which also lists the elements that generally fall into each of these categories.

All the data pertinent to the specimen should be recorded in the field notebook and should also accompany the specimen until its preparation and curation have been completed. One method of doing this is to duplicate the field notebook entries onto a 3" x 5" card using carbon paper (Fig 1, 2 and 3 below). This card then accompanies the specimen throughout its preparation, curation, and final cataloging. Only when the data have been recorded in the catalog are they separated.

In addition to measurements on individual bones, the dip of all limb bones and skulls should be recorded with a Brunton compass. Recording these data at the time of excavation will assist with interpretation of stream current energy and direction, and taphonomy which may include possible vertical movement in a vent, trampling, etc.

The soil type surrounding each measured bone should also be noted on the 3" x 5" card by a letter using a pre-designated lettering system. The pre-designated sediment types are A= asphaltic sand, B=brown silts and C=clay.

After a bone has been measured *in situ*, it is placed in an appropriate sized clear plastic bag. The 3" x 5" data card is placed in its own small clear plastic bag for safety and then placed in the bag with the bone.

**Fig 1: Example of excavation data for a 3-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-14 B3/L4

| | GT | Px | Dt |
|---|---|---|---|
| BD = | 58cm | 53cm | 64cm |
| N = | 31cm | 35cm | 31cm |
| W = | 13cm | 10cm | 90cm |

*Canis dirus* femur

Soil type= A
Dip=30°SW
Excavator initials and date

**P23-14 = Project 23-Box 14**
**B3/L4 = grid B3/level 75cm-100cm**

**GT = Greater Trochanter is 58cm below datum, 31cm from the south grid axis and 13cm for the east axis**
**Px = Proximal end is 53cm below datum, 35cm from the south grid axis and 10cm from the east axis**
**Dt = Distal end is 64cm below datum, 31cm from the south axis and 90cm from the east axis**

**Soil type A= asphaltic sand**

**Fig 2: Excavation data for a 2-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-1 B1/L2

| | Px | Dt |
|---|---|---|
| BD = | 53cm | 64cm |
| N = | 35cm | 31cm |
| W = | 10cm | 90cm |

Canid juv. radius

Soil type= B
Dip=1°SW
Excavator initials and date

**P23-1 = Project 23-Box 1**
**B1/L2 = grid B1/level 25cm-50cm**

**Px = Proximal end is 53cm below datum, 35cm from the south grid axis and 10cm from the east axis**
**Dt = Distal end is 64cm below datum, 31cm from the south axis and 90cm from the east axis**

**Soil type B= brown silt**

**Fig 3: Excavation data for a 1-point measurement in a field notebook and transcribed onto a 3" x 5" card template.**

P23-5B D3/L7

BD = 20 cm
N = 10cm
W = 15cm

Rodent tooth

Soil type=C
Excavator initials and date

**P23-5B = Project 23-Box 5B**
**D3/L7 = grid D3/level 150cm-175cm**

**20cm below datum**
**10cm from south gridline**
**15cm from east gridline**

**Soil type=clay**

Specimens smaller than 1 cm, fragments, or unidentifiable smaller bones are placed into "bulk matrix bags" together with field data cards (P23-deposit # and grid/level information, excavator initials and date). Because they are known to contain fossils, the bulk matrix bags will be processed before the rest of the matrix samples. Keep associated fragments together in capsules or envelopes within the bag. Be sure to always place delicate bones into snap cap vials first and then into a clear plastic bag with their data. If a fossil is not in place, identify it and label it "not *in situ*"

## Special cases

Each special case requires consultation by lab and collections staff to assess the best way of documenting each potentially unique occurrence.

- An articulated or associated skeleton should be extensively photographed. If, after consultation with Lab and collection staff this is removed as a small block, be sure to place a white pin in the top surface along the northern middle portion of the block so that it can be oriented later. Draw and annotate a diagram of the block and the elements that are visible on each surface before it is removed. Measure out the block as a 2-point measurement. Elements within the block that can be identified and measured without compromising the specimens should be also noted and can be measured using the 1 or 2-point measurement system but should not be removed from the block. Labeled copies of all photographs should be placed in the bag with the specimen. This is additional to downloading the photographs to the archive computer (see photography section). Articulated or semi-articulated specimens should be extracted in articulation and the sediments around the specimens stabilized to conserve the maximum amount of information derivable from the specimen.

- Bone masses with poorly preserved specimens (fragmented and/or less asphalt-impregnated) are more difficult to measure out individually. Measure out the extent of the mass with the 2-point system rather than the constituent bones. Place a white pin in the top surface along the northern middle portion of the block so that it can be oriented later. Photograph in situ specimens, print and label images and place them in the bag with the specimens.

- As instructed by Lab and collections staff, and depending on their nature and frequency, dermal ossicles and pockets of plant, shell or insect material should either be measured out as a small block with a 2-point measurement (same as above) or placed in pre-labeled bags with locality information for a specific 10cm square within the 1m x 1m grid.

## Geologic Samples

Collect 15 cm by 15 cm soil samples of each sediment type from each grid and level for geologic analysis of composition, weathering, and grain size at a later date. Document each sample in your notebook and measure each one *in situ* as a block using the 2-point measurement system used for fossils and described above. Each sample should have a white pin placed on the upper surface in the northern middle portion of the sample so that later the sample can be oriented. Transcribe all data onto a 3" x 5" card and place in a clear plastic bag with the soil sample. A list of soil samples taken should be kept by the lead excavator for each grid and deposit.

When spits are completed, photograph and map each exposed wall and the floor.

## Floor and Wall mapping

When mapping a wall or floor (Fig. 4, 5 and 6)

- Draw maps on graph paper with a scale of 3 squares = 10 cm.
- Keep the origin point (0, 0) in the southeast corner.
- Mark north arrow.
- Draw in empty spaces and the edge of the box when present.
- Mark asphalt and sediment contacts.
- Use standardized symbols for lithologies and other known sedimentary features. Also
- Indicate where fossils, cobbles, bone, shells and plants masses are located (Fig 4).

**Figure 4: Standard symbols used in mapping each grid's floor and wall**

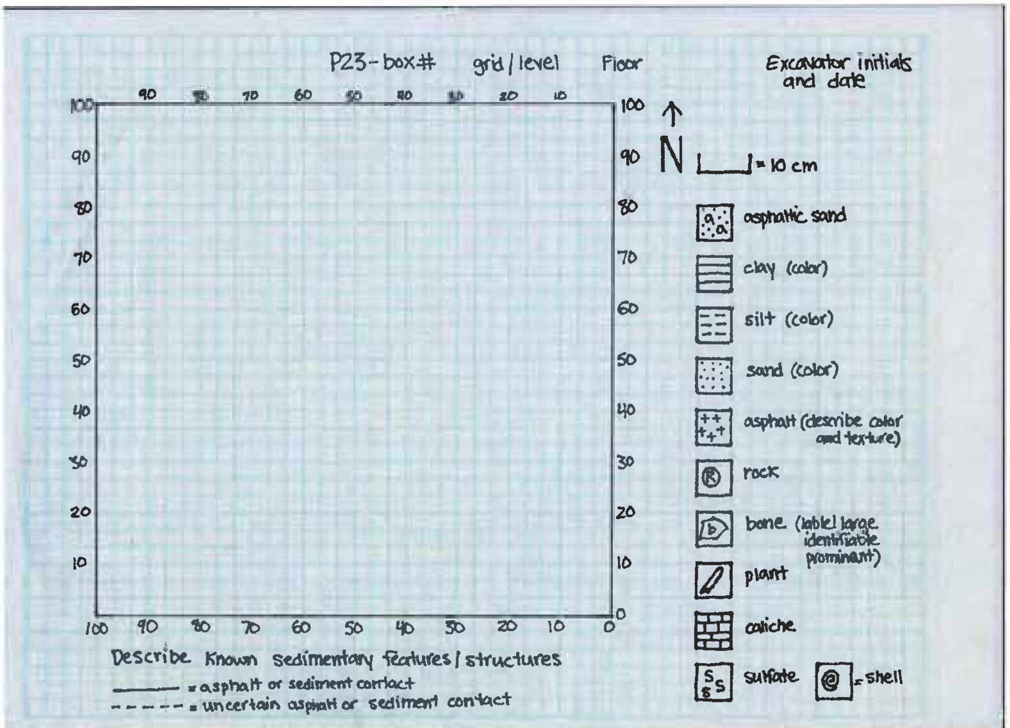



**Figure 5: Sample drawing of the floor of grid C3/L3 of box 14**

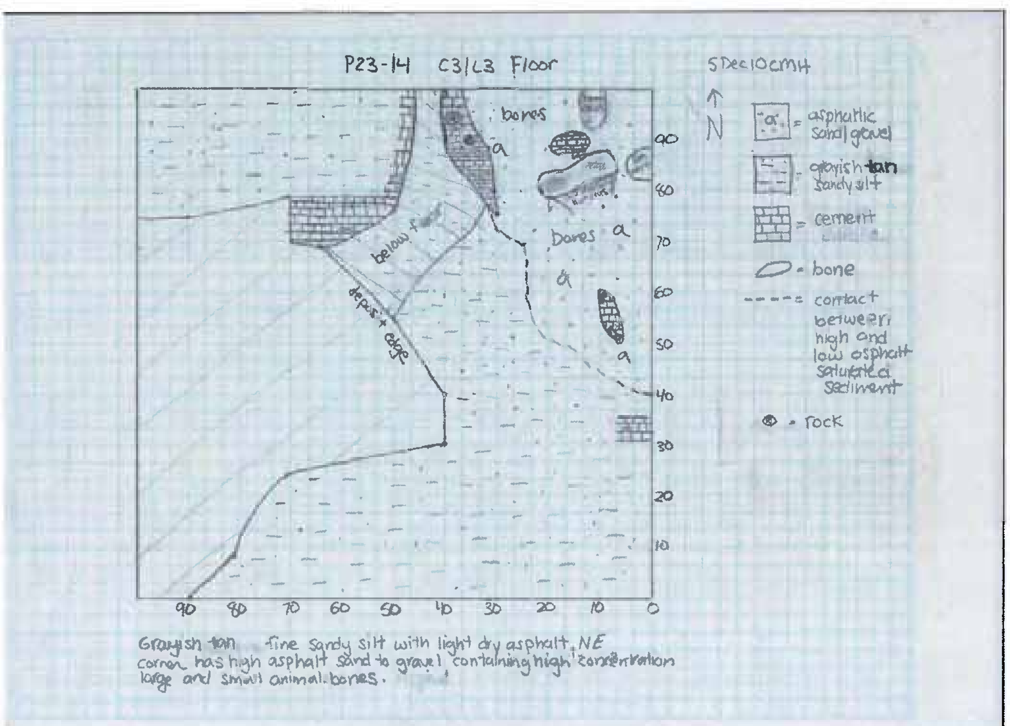
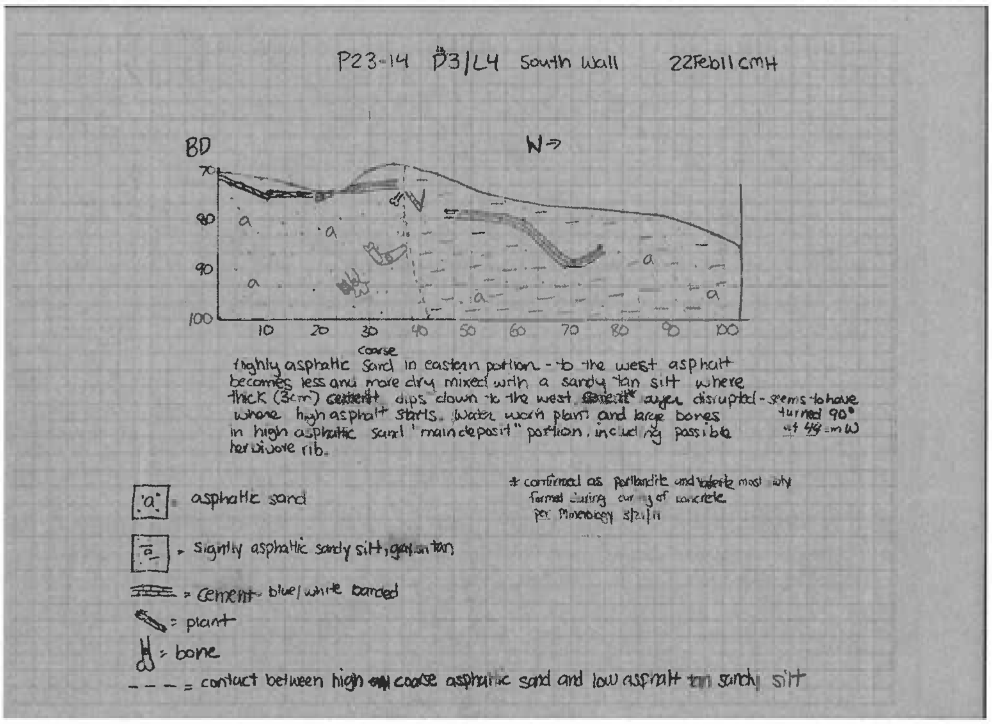


**Figure 6: sample drawing of the south wall of grid D3/L4 of box 14**




# Photography

Photo documentation and the labeling of downloaded images are very important. In the field photo logbook provided, record all the images that you take. This is shared by everyone and has columns for name of photographer, date, box #, grid and level, orientation of image, file number and special notes. Take a photograph whenever it might be useful for lab staff and researchers to see how a specimen was oriented in the ground, broken in a certain way or for any other unusual circumstance. Always photograph the floor and each wall of a grid before starting a new one.

<u>When photographing a specimen:</u>

Write the project name, box #, grid and level #'s, orientation, description of what you are photographing, the date and excavator initials on a 3"x 5" card with a black sharpie and place next to the object you are photographing.

For example:

| | |
|---|---|
| P23-14 C3/L3 | |
| Skull , ventral view | ↑ |
| | N |
| Excavator initials and date | |

Print the photo as soon as possible and place it in the bag with the specimen. This may not be necessary for all the images of *in situ* specimens, so make a judgment call here.

When photographing a floor or wall:

- Write the project name, box #, grid and level #'s, orientation, the date and excavator initials on a 3"x 5" card with a black sharpie.

For example:

| | |
|---|---|
| P23-14 C3/L3 | |
| South Wall | ↑ |
| Excavator initials and date | N |

- Place meter sticks in north and west orientation.
- Take a picture of each exposed wall and floor with the card and meter sticks in frame so as not to cover up any significant features and so the information on the card can be used to tag the photograph in the database.

Download all photographic images to the archive computer and place in the folder "to be sorted" under My Pictures\Project23 under the project 23 login. Rename your files appropriately so that they can be retrieved, tagged in Adobe Bridge and added to the EMu database. This is where the photo logbook will be useful. Each image should be named with the following conventions in order to be searchable in the database:

1. If it is a photo of a grid and a level then name it P23-1 B1 L2 where P23-1 refers to the Box number, B1 refers to the grid and L2 refers to the level. Notice a space between P23-1 and B1 and also between B1 and L2. This is on purpose and helps the database find the files. If there is no level just enter the information that you have.
2. If it is just an image of several grids just name it with the box number e.g. P23-14.

3. If it is a photo of a possible associated skeleton or a specimen in the ground include some more information such as what it might be e.g. P23-1 B1 L2 bird skeleton

## Data entry of field notes

Write field notes in pre-bound notebooks. For each day compile a daily journal that includes notes on the weather, who was working, general work done that day, grids being worked on, etc. as well as geological information on open grids and specimen measurements. On a weekly basis all excavation notes, photographs and grid drawings will be captured electronically.

- Type journal entries into word documents with each day saved as a new file. The naming convention of the file should be "project yearmonthday initials" (e.g. P23 20090201 ABF). Within the word doc file at the top of the page type the initials of the excavator and the date. This serves as a search tool for the database. Save these to the flash drive that is provided. The Collections Manager will import these data into the database.

- Type specimen measurement data into a pre-prepared Excel spreadsheet and save to the flash drive provided. The Collections Manager will import these data into the database.

- The floor and wall drawings and photographs for each grid must be scanned and downloaded onto the archive computer at the Page Museum.

## Matrix processing

There are two different ways that matrix from the excavation is processed. All asphaltic matrix from or adjacent to asphaltic bone concentrations needs to be processed with solvent in a vapor degreaser in order to release small bones and other plant, insect, invertebrate and vertebrate remains from the asphalt. After degreasing, the matrix is dried and dry screened to remove the clay-to-silt fraction. The remaining concentrate is sorted for microfossils under a microscope.

Samples of other (apparently non-fossiliferous) non-asphaltic sediments are screen-washed in water on 20 mesh screens and the concentrates are sorted for microfossils under a microscope. If there is no evidence of microfossils in the sample, the remaining material from that facies of that grid may be discarded (except for the 15 cm archival cube that was collected during excavation of the grid).

# Laboratory Protocols

All material sent to the Lab for cleaning is triaged to resolve appropriate methodology, account for the skill level of available lab workers, and for research and collection priorities. An n-propyl bromide solvent is used to remove asphalt from the bones. Trade names for this solvent include Lenium, GenTech and EcoMax. Elmers white glue is used to repair broken bones and Acryloid (Paraloid) B-72 (Ethyl methacrylate copolymer) is occasionally used to consolidate dry bones.

## Prioritize new specimens

1. For cleaning method
   - Sort and store by locality, grid, depth.
   - Sub-sort by best cleaning method: ultrasonic, soaking, or hand prep.
2. For significance
   - Rareness of taxon
   - Incomplete section of previously excavated specimen
   - New element of known individual skeleton from that locality
   - Unrecognizable to element or taxon.

## Ultrasonic cleaning

Ultrasonic cleaning can be used for the following types of specimens:

- Complete or sturdy bones measured in individually (examples include *Smilodon* or *Canis dirus* carpals, tarsals, phalanges)
- Complete or mostly intact avian bones. The feasibility of processing other fragile bones, including broken small bones, should be assessed by the person who will be re-assembling them.
- Shells, insects, and concentrations of mollusks or insects from within known locality with measurements.

**Steps to be followed**

1. Place each specimen or sample in a baby food-sized jar with all contents of envelope.
2. With pencil, number the envelope and the <u>top</u> of the jar (on masking tape).
3. Prepare six jars as above.
4. Fill with solvent to an equal level in all jars.
5. Place in ultrasonic tank and fill with water up to the level of solvent in jars.
6. Buzz for fifteen minutes.
7. Strain contents of jar through 20 mesh screen on top of pitcher.
8. Rinse with clean solvent.
9. Check specimen or sample for matrix, detail with brush or skewer as needed.
10. Place each specimen or sample on separate paper tray, with flipped out matrix, data, and masking tape number from jar top.
11. Let dry over night, polish, and sort matrix.
12. Solvent that was strained into pitcher can be reused for setting up next batch of six jars if not too dirty.

## Pre-soaking

- Large bone masses: If there is no single identifiable bone, put it in a large jar or a bucket with more solvent than volume of mass. Mass may require a second rinse if solvent becomes too thick with asphalt.
- Unusually hard matrix: Put all of the specimen and loose matrix in jar with data taped to lid.
- Broken *in situ* specimens: If matrix is in internal structure of bone, soak and rinse.

# Hand preparation

- Individual specimens with positional data include vertebrae, ribs, long bones, etc. that are relatively complete.

**Steps to be followed**

1. Rubber stamp, date, and write the signature of preparator on back of data card.
2. Empty all contents of plastic bag or envelope into stainless steel pan.
3. Wet specimen with solvent from squirt bottle.
4. Scrub with tooth brush, dipped in small jar of solvent (n-propyl bromide)
5. DISOLVE MATRIX, DO NOT PUSH OFF WITH BRUSH OR OTHER TOOL.
6. Wood skewers or sticks can be used to loosen or nudge matrix off (If the stick breaks, the matrix is not soft enough yet)
7. When specimens appear clean, rinse thoroughly with solvent and immediately hold in front of vent for quick dry. Matrix still adhering to specimen will be black or darker than bone.
8. DENTAL TOOLS ARE TO BE USED FOR THE REMOVAL OF VISIBLE ROCKS ONLY!
9. When the entire matrix has been removed, place specimen, data card and jarred contents of metal pan matrix on paper tray lined with paper towels to dry.
10. DO NOT GLUE UNTIL ALL MATRIX IS SORTED.

- Multiple pieces of one specimen.

1. Should be prepared by one person but treated as separate projects.
2. Finished elements held until all parts are done.
3. If glued, the part that goes with which data should be recorded in pencil on back of data card.

- Possibly associated elements of one individual

1. Treat as above but can be cleaned by multiple preparators.
2. Label for possible association with a known skeleton or a single other element. [more specific].

- Skulls

    1. External surfaces should be freed of larger associated specimens and gross matrix clumps using toothbrushes and solvent.
    2. DO NOT POKE IN EARS, NOSE OR BRAIN CASE.
    3. At the end of session, immerse in solvent in sealable bucket with copy of data on lid.
    4. Soak for two or three days.
    5. Hold skull over bucket and flush with clean solvent to remove loose matrix.
    6. Working in metal tray, nudge with skewers to loosen softened matrix and rinse off.
    7. Add removed matrix back into bucket.
    8. Replace skull in bucket at end of session.
    9. If the tympanic bulla is intact, nudge and rinse ear region over metal pan and process matrix separately for ear ossicles.
    10. When brain case and nasal region are mostly free of matrix, skull will not need to continue to soak and can dry between sessions.
    11. Strain contents of bucket.

## Polishing

- When specimen has dried overnight, go over small sections of solid bone with a dampened **soft cloth**, then go over the same space with a dry cloth. Exposed cancellous tissue should be <u>blotted</u> with a damp rag. Not rubbed!
- If there are small spaces that cannot be reached with a rag use a pipe cleaner or Q-tip. Dip it in solvent and blot off some liquid before applying. IF THE SPECIMEN GETS DARKER OR BEGINS TO LEAK ASPHALT, IT IS TOO WET. Put aside for a day and begin again.

## Processing Matrix from Individual specimens

- Processing sediment that has been soaked in solvent. (most common situation)

1. Pour contents through 20 mesh screen sitting on funnel into carboy.
2. Rinse with clean solvent.
3. With one motion, flip contents onto paper toweling on a paper tray.
4. Make sure everything is out of jar and out of screen.
5. Place tray near vent to dry.
6. When completely dry, sift and put in appropriate sized jar for later sorting.
7. If matrix appears clumpy after sifting, re-soak in solvent.
8. If matrix appears dirty with clay or silt after sifting, soak in hot water with a small amount (1 tsp) of detergent)

- Processing soaked in water sediment.
  1. Pour contents of jar through 20 mesh screen in a basin in the sink.
  2. Agitate the screen in clean warm water.
  3. Flip contents onto newspaper and leave screen on top to thoroughly dry.

## Microfossil sorting

When the matrix from an individual specimen is clean and dry it is ready for microfossil sorting.

Take the entire project (specimen, data and matrix) to a sorting station.

Do not pour out more matrix than you have time to sort. Only 1½ to 2 Tbs. may take several hours.

1. Sifting
   - Always sift matrix before sorting even if it was sifted before putting in a jar.
   - Sift through a designated 20 mesh screen with 2 inch sides.
   - Shake back and forth, (not up and down) over a paper towel.

- Empty contents of screen onto a clean piece of white sorting paper and shape matrix into a pile.
- Discard the fine soil that went through the sifter.

2. Sorting

    - Examine matrix, several grains at a time, by moving it across the paper with a fine paintbrush.
    - Create a "discard pile" for sediment and oxidized asphalt.
    - Move bone, plant, shell and insect fossils into distinct piles on one side of the paper.
    - Create a "questions" pile for indeterminate fossils.
    - When the entire matrix has been categorized, review fossils and "discard pile".
    - Have a staff person double check sorting.
    - It may be necessary to examine some specimens under the microscope.

3. Temporary packaging of categories

    a. <u>If all of the matrix of a individual project is sorted</u>

    - Review bone and separate into three categories:
    - 1. Broken pieces of the main bone (put aside for possible gluing);
    - 2. Identifiable bones (put into individual capsules or plastic containers);
    - 3. Unidentifiable bone fragments (put into one capsule or larger container).
    - Review plant material (separate seeds and put into capsule) and put into glass vial.
    - Review insect and put into one capsule.
    - Review shell and put into one capsule.

    b. <u>If only a portion of the matrix is sorted</u>

    - Place complete identifiable bones in capsules.
    - Place all bone fragments, plant, insect and shell into their own labeled containers.

When a large project is complete, all of the bone fragments must be reviewed and sorted to the above categories. It will be necessary to look at the small bone fragments under the microscope to determine the final number of Identifiable bones.

## Gluing

DO NOT GLUE UNTIL ALL MATRIX REMOVAL, POLISHING AND MATRIX SORTING IS DONE.

Use white glue for reconstructing most bones because it is reversible with warm water.

If a specimen is shattered, first reconstruct it holding the pieces together with masking tape. Do not glue until all of the fragments have been tested in available holes. Determine where all the major fragments go first and then glue from one direction. Have small strips of masking tape cut before the glue is applied. Apply glue with stick or dental pick in small amounts to the broken edges. Tape glued pieces in place and/or balance in sandbox for drying. Allow large pieces to dry overnight.

## Envelopes for finished projects

A copy of the original data must be made for every identifiable bone and one copy each for vial containing plant, insect, shell and unidentifiable bone. A rubber stamp template for "Found in assoc. w/" data is stamped on the face of a #5 ½ coin envelope. An exact copy of the original is then filled in. Note: Do not change the tentative field identification that is part of the original data even if it is wrong. The back of the envelope is stamped with a template for the scientific identification. If an "assoc. w/ bone "or the plant fragment is too large to fit inside an envelope, it should be put in a small plastic bag with an envelope. The envelopes are stapled shut and the entire project is put in one large plastic bag.

The finished bag should include the main bone, fragments of the main bone that could not be glued on, the original data and all the "associated with" specimens.

# Pre-Curation

After the specimens have been cleaned, the microfossils sorted and put into individual capsules and individual envelopes have been made for each specimen with all of the provenance data written on each envelope (see laboratory procedures) they are sent to the curation station. Identification of all of the fossils takes place near the comparative collection in the lab in order to facilitate identification. The principal measured out specimen with its original 3"x 5" field data card is identified first. The card is stamped on the back with a custom stamp with Scientific Name, Element, Identifier, and Notes. The specimen is identified as much as possible but identifications necessarily range from class identification such as Aves to genus and species. The identifier also describes the element according to an established list of bone terminology. Then each of the microfossils associated with that main bone are also identified in the same manner. After all of the microfossils that accompany that main specimen are identified, they are placed in a clear plastic bag with a twist tie and sent to the cataloging station. Below are detailed step-by-step instructions on how to identify specimens.

For each specimen follow the steps below in the order given.

1. Choose a specimen from the 'to be identified' box. If several envelopes are fastened together you must keep them together and complete the work on all of them.
2. Check the bone to see if it is clean and that all broken pieces have been glued if possible. If the bone is not clean then do not proceed with that one and send it back to the lab
3. Identify the bone using the reference collection and write the identification on the back of the envelope or card in pencil. Only use paperclips to join envelopes together.
4. Check to see if the main identified bone is in the original envelope or with the original 3" x 5" card.
5. Send identified specimen to be cataloged

- Always put the comparative bone back in the box it came from!
- if you find a 'found in association with' envelope which is not still with its original envelope, find the original envelope and fasten them together
- put all tools away and empty bags and containers

## Associated groups

If there is more than one specimen in an envelope the principal bone for which the measurements were recorded should remain in the original envelope. The other specimens should be treated as follows;

- all plants in one envelope
- all insects in one envelope
- all shells in one envelope
- each identifiable bone in a separate envelope, along with any of its broken pieces
- all unidentifiable bone in one envelope
- all difficult to identify bones in one envelope

Use envelopes stamped "Found in Association with" and make a complete copy of the information from the original envelope on each one.

## Identifiable and Unidentifiable Specimens

Identifiable bone characteristics:

- presence of an articular surface
- cross-sectional shape
- foramina
- distinctive curves
- relative size combined with other features

Bones are rated in three different grades of how easy they are to identify

- identifiable
- difficult to identify
- unidentifiable

Double check all identifications

## Identification of Specimens

The back of each envelope is marked with a custom stamp (stamp in bold below). Identifications are printed in pencil. An example below

- **Scientific name:** *Smilodon* (use both genus and species if more than one species)
- **Element:** prox. rt. tibia
- **Special Notes:** Pathology
- **Identifier:** ABF

1. Avoid using terms such as "frag" or "portion". Use prox. or dist. if appropriate.
2. You must not abbreviate scientific names but you may use abbreviations for the elements as long as they are the ones listed in this manual.
3. When identifying skulls and mandibles always list the teeth that are present and if they are erupting, fully erupted or worn.
4. The format of the identification is very important. Do not invert the word sequence e.g. prox. rt. rib is correct but rib, rt. prox. is not.
5. For incomplete bones name both the bone e.g. XIII thoracic vert and either the represented part e.g. centrum or the missing portion, e.g., w/o right transverse process. Make sure that the identity of the bone and its qualifier are both listed.
6. Be specific about the identity of any represented epiphysis, e.g., proximal or distal epiphysis of a limb bone, or head epiph of lt femur or ant cent epiph of thoracic vert.

7. Ordinal numbers of ribs, vertebrae, metapodials and digits are written in Roman numerals e.g. rt. II rib or XII thoracic vert

8. Number of phalanges and teeth are written in Arabic numerals e.g. 2$^{nd}$ phalanx or rt. M1. Note that abbreviations for upper molars are written in upper case letters (I, C, P, M) whereas those for lower teeth are written in lower case (i, c, p, m). For clarity of handwritten entries, put a line below the number for upper teeth (e.g. P4/) and a line above the number for lower teeth (e.g. m/1).

9. The side, either left or right comes before a number e.g. rt. II metatarsal

10. There are two special cases:

    - Phalanges that can be precisely named include sloth phalanges, carnivore 'thumb' phalanges and bird carpal phalanges e.g. rt. 1$^{st}$ carpal phalanx, digit I

    - Teeth which can be specifically named e.g. lt. p2

11. Skull fragments: if the facial or cranial region of the skull is mostly intact this can be recorded as 'ant' or 'post' skull. However if there are only a few fragments the individual bones are named e.g. basisphenoid, occipital and rt. temporal or indicate if some parts are missing, e.g. post. skull w/o rt. occipital.

12. Juvenile specimens: it is important to note if an epiphysis is missing as the order of ephiphyseal fusion is used to detect the age of an animal. Also mark "juv." in the special notes section of the identification.

## Abbreviations chart for elements

| | | |
|---|---|---|
| Left: lt. | Posterior: post. | With: w/ |
| Right: rt. | Ventral: vent. | Without: w/o |
| Proximal: prox. | Dorsal: dors. | Juvenile: juv. |
| Distal: dist. | Medial: med. | Pathological: path. |
| Anterior: ant. | Lateral: lat. | Unidentifiable: unid. |

Difficult to identify: diff.

Zygomatic: zygo.

Epiphysis: epiph.

Diaphysis: diaph.

Tuberosity: tub.

Trochanter: troch.

Articular: artic.

Vertebra: vert.

Transverse: trans.

Process: proc.

Centrum: cent.

Prezygapophysis: prezyg.

Postzygapophysis: postzyg.

Incisor: I (upper) or i (lower)

Canine: C (upper) or c (lower)

Premolar: P (upper) or p (lower)

Molar: M (upper) or m (lower)

Deciduous: D

## Dental formulae for Rancho La Brea fauna

Dental formulae are a short hand way of indicating the number and kind of teeth that are present. The upper jaw is indicated first and the teeth are in order: incisor, canine, premolar, molar.

Ruminant artiodactyls

0,0,3,3 / 3,1,3,3

*(Antilocapra, Bison, Capromeryx, Odocoileus)*

Camelids

*Camelops:* 1,1,2,3 / 3,1,1,3

*Hemiauchenia:* 1,1,2,3 / 3,1,1-3,3

Peccaries

*Platygonus:* 3,1,4,3 / 3,1,4,3

Horses

*Equus:* 3,1,3,3 / 3,1,3,3

Tapirs

*Tapirus:* 3,1,4,3 / 3,1,4,3

Dogs and bears

3,1,4,2 / 3,1,4,3

*(Arctodus, Canis dirus, Canis latrans, Urocyon, Ursus)*

Cats

3,1,3,1 / 3,1,2,1

*(Felis atrox: Felis concolor: Lynx)*

Sabertoothed cats

*Smilodon:* 3,1,2,1 / 3,1,1,1

Skunks, weasels, & badgers

3,1,3,1 / 3,1,3,2

- Tympanic bulla
- Vomer

**Auditory ossicles**

- Malleus
- Incus
- Stapes

**Mandible**

- Angular process
- Coronoid
- Articular condyle
- Symphysis

**Hyoid**

- Basihyal
- Epihyal
- Thyrohyal
- Ceratohyal
- Stylohyal

**Teeth**

- Permanent upper and lower. Upper denoted by upper case abbreviation and lower by lower case abbreviation.
    - Incisor – I (upper) or i (lower)
    - Canine – C (upper) or c (lower
    - Premolar – P (upper) or p (lower)
    - Molar – M (upper) or m (lower)
- Deciduous upper and lower. Upper denoted by upper case abbreviation and lower by lower case abbreviation.
    - Incisor – DI (upper) or di (lower)
    - Canine – DC (upper or dc (lower)
    - Premolar –DP (upper) or dp (lower)

**Vertebra (e)**

- Atlas
- Axis
- Caudal
- Centrum
- Cervical
- Lumbar
- Neural spine
- Odontoid process
- Postzygapophysis
- Prezygapohysis
- Sacral
- Sacrum
- Thoracic
- Transverse process
- Wing

**Ribs**

- Capitulum
- Shaft
- Tuberculum

**Sternum**

- Manubrium
- Sternebra
- Xiphisternum

**Scapula**

- Acromium process
- Coracoid process
- Glenoid fossa
- Metacromion
- Spine
- Vertebral border

**Humerus**

- Deltoid tuberosity
- Entepicondylar foramen
- Greater tuberosity
- Head
- Lateral condyle
- Lateral epicondyle
- Lesser tuberosity
- Medial condyle
- Medial epicondyle

**Radius**

- Styloid process
- Radial tuberosity

**Ulna**

- Coronoid process
- Olecranon
- Semilunar notch
- Styloid process
- Radial notch

**Carpals**

- Cuneiform
- Trapezium
- Lunar
- Magnum
- Trapezoid
- Central
- Pisiform
- Unciform
- Radial sesamoid
- Scapholunar
- Scaphoid

**Metacarpal**

- Plantar tubercle

**Sesamoids**

- Proximal sesamoid
- Distal sesamoid

**Phalanges**

- $1^{st}$, $2^{nd}$, $3^{rd}$, $4^{th}$, $5^{th}$
- Carpal
- Tarsal

**Inominate**

- Acetabulum
- Iliac crest
- Ilium

- Ischial tuberosity
- Ischium
- Pubic symphysis
- Pubis

**Fabella**

- Lateral
- Medial

**Femur**

- Greater trochanter
- Head
- Lateral condyle
- Lateral epicondyle
- Lesser trochanter
- Medial condyle
- Medial epicondyle
- Neck
- Patellar track
- Third trochanter

**Patella**

**Tibia**

- Lateral condyle
- Medial condyle
- Medial malleolus
- Tibial tuberosity

**Fibula**

- Head
- Lateral malleolus
- Distal fibula (herbivore)

**Tarsals**

- Astragalus
- Calcaneum
- Cuboid
- Ectocuneiform
- Entocuneiform
- Mesocuneiform
- Navicular
- Sustentaculum
- Naviculocuboid

- Mesoectocuneiform

**Metatarsal**

- Plantar tubercle

**Non-articulating bones**

- Baculum (male)
- Dermal ossicle (sloth)
- Sclerotic ossicles (birds and lizards)
- Falciform (sloth)
- Tracheal ring (birds)
- Dermal scale (lizard)

**Variations for juveniles**

- Diaphysis – shaft of juvenile long bone
- Epiphysis – the unfused articular surfaces of juvenile bone

**Numbers**

- Ribs – roman numerals
- Metapodials – roman numerals
- Digits – roman numerals
- Phalanges – Arabic numerals—1st, 2nd, 3rd, 4th, 5th, terminal

# Curation

In order to curate specimens into the collections of the George C. Page Museum, all of the above-mentioned steps for excavation, preparation, and identification must be followed. The field number, orientation measurements, and pertinent field notes and photographs are all integral parts of the specimen information and must be readily available. Each specimen will receive an individual catalog number that is first recorded in an archival catalog book and then entered into the electronic database EMu, which is stored on the Natural History Museum's server. Once cataloged, each specimen is stored taxonomically in the collections. Specimens are housed in metal or wooden drawers within standard metal Lane cabinets. On average each drawer holds about seventy five specimens and each cabinet contains nine drawers.

Based on a typical deposit for Project 23, a 1m X 1m x 25cm grid yields approximately 1000 macro-vertebrate specimens per one (1) cubic meter. Additionally each cubic meter can have up to 2000 micro-vertebrate fossils. A typical conical shaped deposit can be up to 30 cubic meters.

# Appendix A

Table 1. Anatomical codes used for orienting specimens in the 2- and 3-point measurement system.

| | |
|---|---|
| A -- Anterior | Px -- Proximal |
| P -- Posterior | Dt -- Distal |
| M -- Medial | Lt -- Left |
| L -- Lateral | Rt -- Right |
| D -- Dorsal | R -- Root |
| V -- Ventral | C -- Crown |

Table 2. Anatomical codes of osteologic points used for orienting specimens in the 3-point measurement system.

## MAMMALS

**Skull:**
- AP - Anterior Premaxillae
- OC - Occipital Condyles
- POP- Postorbital Process (Rt or Lt)

**Mandible:**
- A - Anterior
- CP - Coronoid Process
- P - Posterior

**Vertebra:**
- AC - Anterior Centrum
- ANS- Anterior Neural Spine
- NS - Neural Spine
- PC - Posterior Centrum
- TP - Transverse Process (Rt and Lt)

**Rib:**
- Dt - Distal
- GC - Greatest Curve
- Px - Proximal
- Tub- Tuberculum

**Scapula:**
- AP - Acromion Process
- CP - Coracoid Process
- D - Dorsal
- PA - Posterior Angle
- V - Ventral

**Humerus:**
- Dt - Distal
- LEP- Lateral Epicondyle
- MEP- Medial Epicondyle
- Px - Proximal

**Radius:**
- Dt - Distal
- Px - Proximal
- RT - Radial Tuberosity

**Ulna:**
- CP - Coronoid Process
- Dt - Distal
- Px - Proximal

**Innominate:**
- IC - Iliac Crest
- IS - Ischial Tuberosity
- PU - Anterior Pubic Symphysis

**Femur:**
- Dt - Distal
- FC - Fovea Capitis
- Px - Proximal

**Tibia:**
- Dt - Distal
- Px - Proximal
- TT - Tibial Tuberosity

**Fibula:**
- Dt - Distal
- LM - Lateral Malleolus
- Px - Proximal

**Calcaneus:**
- Dt - Distal
- Px - Proximal
- S - Sustentaculum

**Metapodial:**
- Dt - Distal
- PT - Plantar Tubercle
- Px - Proximal

## BIRDS

**Skull:**
Same as Mammals

**Mandible:**
Same as Mammals

**Vertebra:**
- NS - Neural Spine
- TP - Transverse Process (Rt and Lt)

**Sternum:**
- A - Anterior
- CA - Carinal Apex
- P - Posterior

# Attachment 3—Wilshire/Fairfax Station Construction. Paleontological Resources Extraction

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WESTSIDE SUBWAY EXTENSION PROJECT

# Wilshire/Fairfax Station Construction. Paleontological Resources Extraction.

Metro

December 2011

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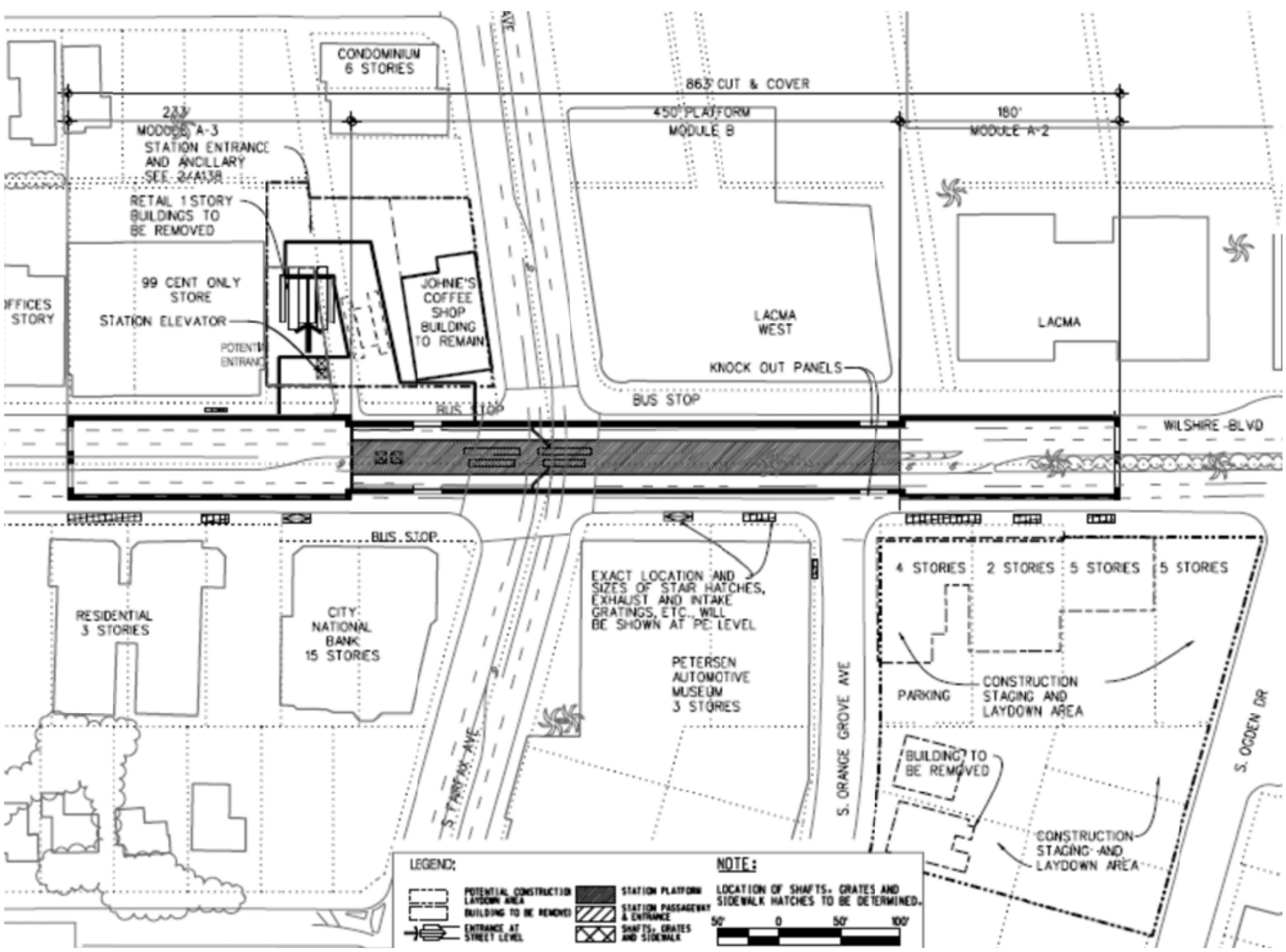
## Appendix

# 1.0 BACKGROUND

The Wilshire/Fairfax station box excavation will be approximately 860-ft long, 70-ft wide, and 60 to 70-ft below street level. The station extends beneath the intersection of Wilshire Boulevard and Fairfax Avenue - see Figure 1-1. The station entrance is planned to be located near the northwest corner of Wilshire and Fairfax between the 99 Cent Only Store and Johnie's Coffee Shop. Two alternative entrances under consideration; the south side of Wilshire between South Orange Grove Avenue and South Ogden Drive and; within the LACMA building at the north east corner of Fairfax Avenue and Wilshire Boulevard (May Company). A construction staging and materials laydown area is planned for the south side of Wilshire between South Orange Grove Avenue and South Ogden drive. Side access shafts will be located at the construction staging and materials laydown area and at the location selected for the station portal. The side access shafts will be excavated to the full depth of the station. The station box will be excavated by the cut and cover method and most probably use a temporary shoring system to support the excavation and decking system during construction, though a permanent shoring system that would be integrated into the permanent station structure could also be used. The side access shafts will be excavated by the open cut method and would most probably use the same type of shoring system that is used on the station box.

Figure 1-1: Wilshire/Fairfax Station Box



# 2.0 GEOLOGIC CONDITIONS

The geologic conditions in this region consist of soft alluvium deposits of sands, silty sand, clayey sand, gravely sand, silty clay, clayey silt, shell fragments, soil saturated with crude oil, and asphaltic (tar) sands. Several borings were taken within the station area; see Figure 2-1 through Figure 2-4. Core G-118 (Figure 2-1) was taken east of the station box between La Brea and Fairfax, the sample at 82-ft below ground surface (bgs) consists of silty clay/clayey silt with traces of crude oil. The portion of ring sample G-123 shown in Figure 2-2 is located just east of Fairfax at 60-ft bgs and consists of predominantly fine grained soil with channels of medium grained sand saturated with crude oil. Heavy tar was reported in G-123 from 38 – 110-ft bgs. Core sample G-124 (Figure 2-3 and Figure 2-4) was obtained just west of Fairfax by the Standard Penetration Test (SPT). The sample pictured was taken from 80-ft bgs and consists of medium to coarse grained sand saturated with tar. Heavy tar was reported in G-124 from 45 – 105-ft bgs. The consistency of tar in this region ranges from dry and hard to wet and oozing. This reach is also known to contain pockets of pressurized gases and dissolved gases in groundwater. The groundwater conditions are measured to have a water table depth of 74-ft bgs, and zones of perched water between 10 – 50-ft bgs. Since the station box invert depth will be located between 60 – 70-ft bgs, perched water can be anticipated during excavation.

Figure 2-1: Core Sample G-118

Figure 2-2: Core Sample G-123

Figure 2-3: Core Sample G-124 (1 of 2)

Figure 2-4: Core Sample G-124 (2 of 2)

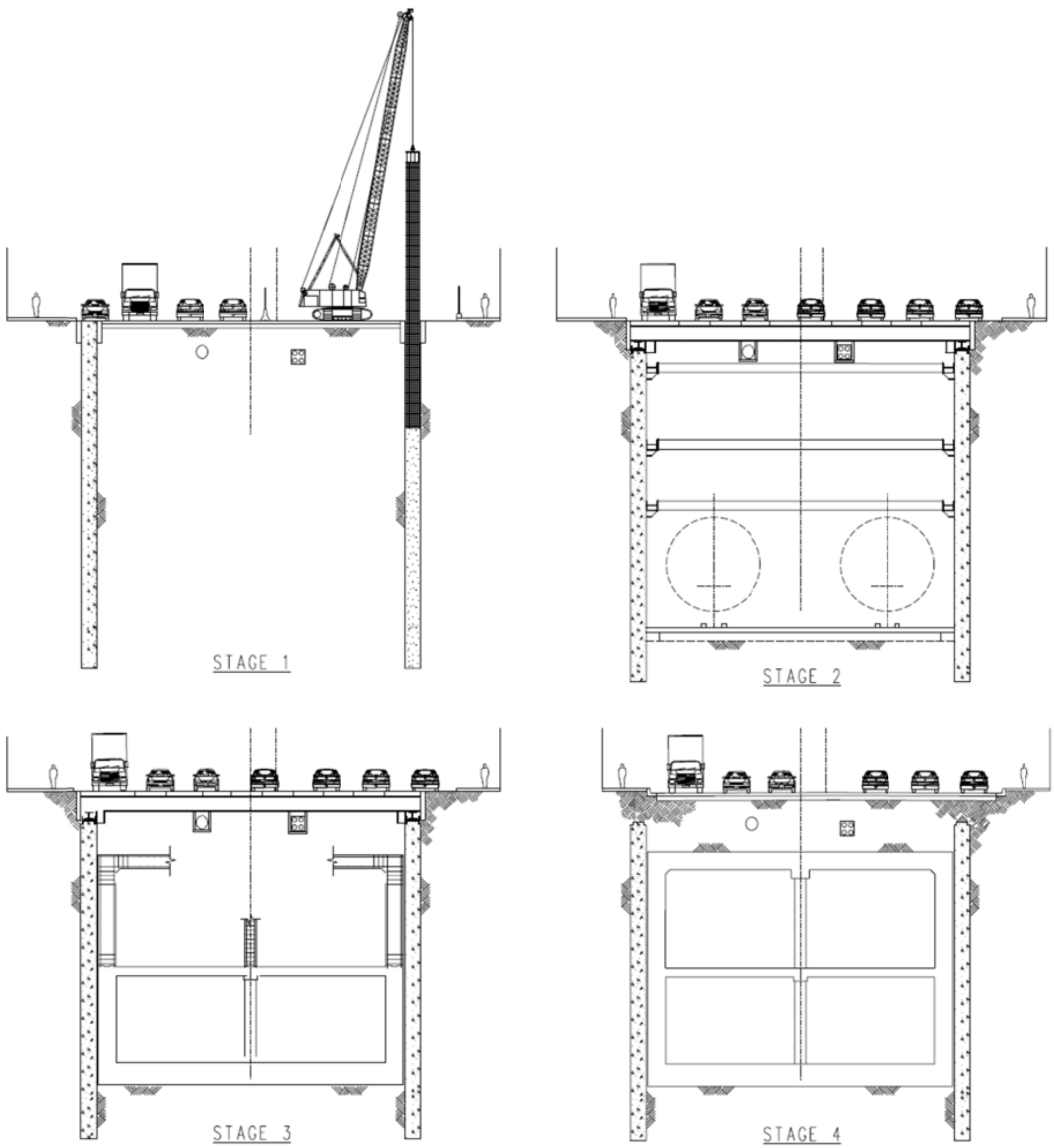
## 2.1 Gassy Ground Conditions

The gases present in the soils of this region are methane ($CH_4$) and hydrogen sulfide ($H_2S$). They are likely to occur in pressurized pockets as well as in a dissolved state in groundwater. These gases can seep into tunnels and other excavations through soil and also through discontinuities (fractures, faults, etc.) in bedrock. $CH_4$ and $H_2S$ are considered hazardous gases due to their explosive properties. $H_2S$ is also highly toxic. Being heavier than air, it tends to accumulate at the bottom of poorly ventilated spaces. Although very pungent at first, it quickly deadens the sense of smell, so potential victims may be unaware of its presence. $CH_4$ is extremely flammable and may form explosive mixtures with air. It is odorless and lighter than air, and it dissipates quickly once at the surface causing no threat of explosion. However, in 1985 an explosion occurred at the Ross Dress-for-Less in the Fairfax area which resulted in injuries requiring hospital treatment of twenty-three people. The explosion took place in a poorly ventilated ancillary room of the building where $CH_4$ gas had accumulated. There was no gas detection equipment at this location.

# 3.0 EXCAVATION SUPPORT TECHNIQUES

Cut and cover excavation is the preferred technique to excavate the station box structure, although cut and cover still leads to lengthy occupation of streets with noise disturbances and interrupted access (see Figure 3-1). Traffic interruptions can be mitigated by performing most excavation below a temporary decking system constructed at an early stage (See Figure 3-2 through Figure 3-6).

Figure 3-1: Open Cut Excavation



Shoring the excavation walls and providing structural support beneath the decking system can be accomplished through a variety of excavation support techniques. The following sections describe several excavation support methods, including: soldier pile and lagging, slurry walls, tangent piles, secant piles, and deep soil mix walls.

Figure 3-2: Initial Excavation at Soto Station


Figure 3-3: Precast Concrete Decking


Figure 3-4: Installation of Decking (1 of 2)

Figure 3-5: Installation of Decking (2 of 2)

Figure 3-6: Roadway Operations Restored on Temporary Decking System

## 3.1 Soldier Piles and Lagging

Soldier pile and lagging walls are a type of shoring system typically constructed along the perimeter of excavation areas to hold back the soil around the excavation. This support system consists of installing soldier piles (vertical structural steel members) at regular intervals and placing lagging in between the piles to form the retaining structure. Pre-augering is necessary for installation of the soldier piles. Pre-augering involves drilling holes for each pile from the street surface to eliminate the need for pile driving equipment and thereby reduces project noise and vibration levels that would otherwise occur while pile driving. Pre-augering also provides better accuracy of location than pile driving. The lagging, which spans and retains the soil between the piles, is typically timber or shotcrete (sprayed-on concrete) and is installed in a continuous downward operation taking place concurrently with excavation. The installation of soldier piles and lagging is a relatively clean process. The majority of construction materials, such as, drilled earth spoils, concrete, backfill, and H-piles are easy to contain within the construction site. The soldier piles and deck beams are installed first with excavation and lagging installation taking place from beneath the street decking. A soldier piles and lagging earth retention system is shown in Figure 3-7 through Figure 3-9. The equipment required for installation of the soldier piles includes drill rigs, concrete trucks, cranes, and dump trucks.

Soldier piles and lagging are generally used where groundwater inflow is not a consideration, or where grouting, or lowering of the groundwater level (dewatering) can be used to mitigate water leakage between piles. Based on findings from core samples, the geologic conditions in this area consist of soils containing deposits of oil and tar. Where these deposits occur along the excavation perimeter, oil or tar may tend to seep between the joints in the lagging. This is not considered to be a hazard to workers, although some cleanup may be necessary. Alternatives to soldier pile and lagging walls being considered for this station include tangent pile or secant pile walls, slurry walls, and deep soil mix walls (see next sections below).

Figure 3-7: Pre-augering for Soldier Pile


Figure 3-8: Cut and Cover with Soldier Pile and Lagging

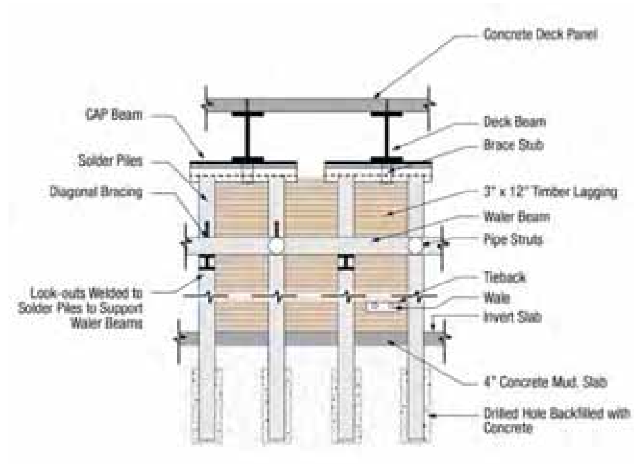


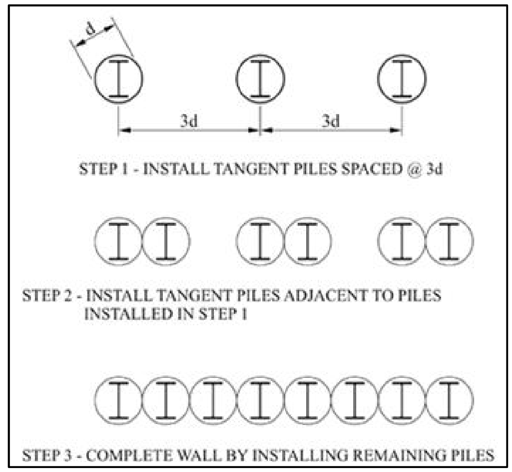

Figure 3-9: Soldier Pile and Lagging

## 3.2 Tangent Pile or Secant Pile Walls

Tangent pile walls consist of contiguous cast-in-drilled-hole (CIDH) reinforced concrete piles – see Figure 3-10. The contiguous wall generally provides a better groundwater seal than the soldier pile and lagging system, but some grouting or dewatering could still be needed to control leakage between piles.

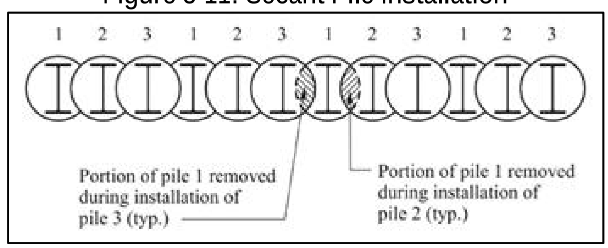
A secant pile wall system is similar to the tangent pile wall but the piles have some overlap, facilitating better water tightness and rigidity - see Figure 3-11. This method consists of boring and concreting the primary piles at centers slightly less than twice the pile diameter. Secondary piles are then bored in between the primary piles, prior to the concrete achieving much of its strength.

Figure 3-10: Tangent Pile Installation




In terms of relative cleanliness, tangent pile and secant pile walls are comparable to one another and both are more difficult to contain than soldier piles and lagging due to the greater amount of pumped concrete and the expected larger diameter of drilled holes. The completed secant pile wall for the Barnsdall Shaft in Hollywood for the Metro Red Line project is shown on Figure 3-12. Secant and Tangent pile shoring systems are slower to construct that soldier pile and lagging and therefore have the disadvantage of requiring longer lane closures on Wilshire while they are being constructed. Furthermore, because of the close spacing of tangent piles, utilities crossing the wall often require relocation whereas a soldier pile system can often be built around the existing utilities. The equipment required for installation of the tangent pile or secant pile walls includes drill rigs, concrete trucks, cranes, and dump trucks.

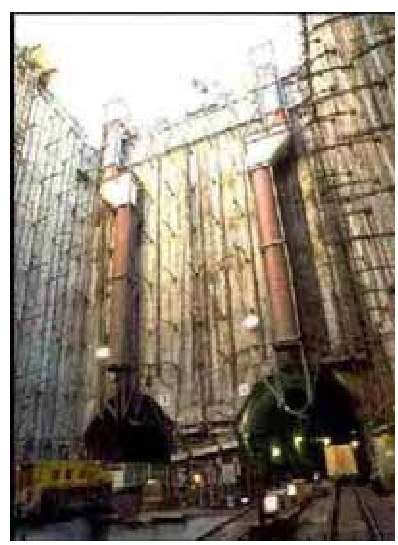
Figure 3-11: Secant Pile Installation




## 3.3 Diaphragm/Slurry Walls

Diaphragm walls (commonly known as slurry walls) are structural elements used for retention systems and permanent foundation walls. Use of slurry wall construction can provide a nearly watertight excavation, eliminating the need to dewater. Slurry walls are constructed using deep trenches or panels which are kept open by filling them with a thick bentonite slurry mixture. After the slurry filled trench is excavated to the required depth, structural elements (typically a steel reinforcement cage - see Figure 3-13) are lowered into the trench and concrete is pumped from the bottom of the trench, displacing the slurry. Figure 3-14 and Figure 3-15 illustrate slurry wall excavation equipment.

Figure 3-12: Secant Pile Wall at Barnsdall Shaft on Metro Red Line



Tremie concrete is placed in one continuous operation through one or more pipes that extend to the bottom of the trench. The concrete placement pipes are extracted as the concrete fills the trench. Once all the concrete is placed and cured, the result is a structural concrete panel. Grout pipes can be placed within slurry wall panels to be used later in the event that leakage through wall sections, particularly at panel joints, is observed. The slurry that is displaced by the concrete is saved and reused for subsequent panel excavations.

Figure 3-13: Steel Reinforcement Cage for Slurry Wall

Slurry wall construction advances in discontinuous sections such that no two adjacent panels are constructed simultaneously. Stop-end steel members are placed vertically at each end of the primary panel to form joints and guides for adjacent secondary panels. In some cases, these members are withdrawn as the concrete sets. Secondary panels are constructed between the primary panels to create a continuous wall. Panels are usually to full depth and 8 – 20-ft long and vary from 2 – 5-ft wide.

Figure 3-14: Slurry Wall Construction Equipment

Figure 3-15: Clamshell Digger for Slurry Wall Construction

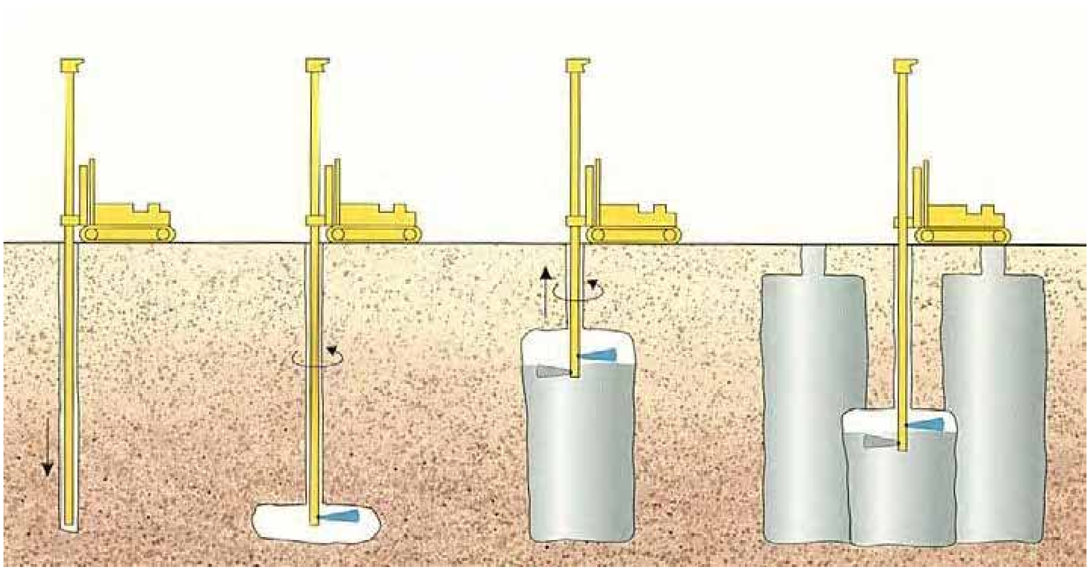
Similar to other shoring systems, slurry wall construction would occur in stages, working on one side of the street at a time. These walls have been constructed in virtually all soil types to provide a watertight support system in addition to greater wall stiffness to control ground movement. Because slurry walls are thicker and more rigid than many other shoring methods, the walls may in some cases be used as the permanent structural wall, although this application is not anticipated for this project. Where slurry walls are used, the thickness of the permanent structural walls can sometimes be reduced, i.e. when compared to wall thicknesses used with a conventional soldier pile and lagging system after removal of internal bracing.

Slurry wall construction materials are the most difficult to contain within the construction site of all the shoring types being considered due to the inherent messy nature of bentonite slurry combined with the operational characteristics of the clamshell digger which will likely be used to excavate large volumes of soil from the wall trench. Slurry walls are generally not adaptable to utility crossings and all utilities crossed by the wall would require temporary or permanent relocation. The equipment required for installation of the slurry walls includes clamshell or rotary head excavators, concrete trucks, slurry mixing equipment, cranes, slurry treatment plant, and dump trucks. The bentonite slurry would require disposal after a number of re-use cycles. Slurry walls are also slow to construct and will be very disruptive to traffic on Wilshire Boulevard.

## 3.4 Deep Soil Mix Walls

Deep soil mix walls are another type of temporary or permanent shoring system for deep excavation. Mechanical soil mixing is performed using single or multiple shafts of augers and mixing paddles. See Figure 3-16. The auger is rotated into the ground and slurry is pumped through the hollow shaft feeding out at the tip of the auger as the auger advances. Mixing paddles blend the slurry and soil along the shaft above the auger to form a soilcrete mixture with high shear strength, low compressibility, and low permeability. Spoils come to the surface comprised of cement slurry and soil with similar consistency to what remains in the ground. Steel beams are typically inserted in the fresh mix to provide structural reinforcement. A continuous soil mix wall is constructed by overlapping adjacent soil mix elements. Similar to secant pile walls, soil mix elements are constructed in alternating sequence; primary elements are formed first and secondary elements follow once the first have gained sufficient strength.

Figure 3-16: Deep Soil Mix Construction



Deep soil mix wall construction materials are also difficult to contain. Most of the construction process is performed by a single piece of equipment which mixes cement and soil in situ. Cement and soil mixture can be expected to escape beyond the confines of the drilling operation creating problems for traffic and pedestrians. The equipment required for installation of deep soil mix walls includes multi-shaft drill rigs, concrete trucks, cranes, and dump trucks.

## 3.5 Comparison of Excavation Support Techniques

Due to the speed of construction, and the ability to work around utilities, soldier piles and lagging is preferred unless site conditions dictate the use of other methods. See Table 3-1 for a comparison of excavation support methods. Soldier piles and lagging is the predominant shoring system used in the Los Angeles area and has been used successfully by Metro on construction of both Red and Gold Line stations. Experience at the LACMA parking garage excavation suggests that soil off-gasses immediately after being exposed but with a short period of time, the off gassing slows to levels acceptable for work. This suggest that the relatively impervious seal achieved by slurry walls, secant piles, and deep soil mix walls may only provide very short term benefits and that gas entering the station box excavation through a soldier pile and lagging system could be controlled with a well designed ventilation system.

Since it is anticipated that gassy soils will be encountered regardless of shoring system type, various methods of providing a safe and hazard free workplace will be implemented in all situations. No matter which type of temporary shoring system is selected; other measures such as, partially open decking, ventilation, gas detection, and Personal Protective Equipment (PPE), will be in use to protect workers from gases that may enter the excavation site.

Table 3-1: Comparison of Excavation Support Types

| Shoring Method | Permeability | Installation Duration | Containment Impacts | Noise / Vibration Impacts | Traffic Impacts | Utility Impacts | Business Impacts |
|---|---|---|---|---|---|---|---|
| Soldier Pile & Lagging | High | concurrent w. excavation | Low | Moderate | Moderate | Moderate | Moderate |
| Slurry Wall | Low | 3 Months | High | Moderate | High | High | High |
| Secant Pile | Low | 3 Months | Moderate | Moderate | High | High | High |
| Tangent Pile | Moderate | 3 Months | Moderate | Moderate | High | High | High |
| Deep Soil Mix | Low | 3 Months | Moderate | Moderate | High | High | High |

## 3.6 Construction Staging

For all types of shoring, the contractor would first occupy one side of the street to install one line of excavation support piles or wall panels. The installation will require extended closures of 2 – 3 traffic lanes on the side of the street where the equipment would be staged. After installation of piles or walls on both sides of the street at the station excavations, piles or walls would then be installed across the street at the station ends. This operation would also require lane closures, and is often done during night-time or weekend periods. The contractor would then proceed with installation of deck beams, installation of the deck panels and excavation and bracing. Deck panels (decking) allow continued traffic and pedestrian circulation since they will typically be installed flush with the existing street or sidewalk levels though raised decking, which requires less excavation during installation is being discussed with the traffic authority. Raised decking does have particular advantages at Wilshire / Fairfax Station as less excavation during the weekend closures while installing the decking makes it less likely that fossils will be encountered during the decking operation.

Deck installation will require successive full road closures on weekends with traffic detours. The decking would be installed in stages, commensurate with the amount of decking that can be installed during a weekend closure. Typical decking installation rates range from 50 -100 ft / weekend for an installation crew. Multiple crews will be used wherever possible to reduce the number of full road closures

## 3.7 General Approach to Handling Utilities

Prior to beginning construction of shoring and decking, it will be necessary to relocate, modify or protect in place all utilities and underground structures that would conflict with excavations. The contractor will verify locations through potholing methods and where feasible, the utility will be relocated so as to stay out of station or other surface structure excavation. Where the utility cannot be relocated outside the excavation footprint, it will be exposed and hung from the supporting structure (deck beams) for the roadway decking over the cut-and-cover structure. See Figure 3-17 and Figure 3-18.

Figure 3-17: Utilities Hung from Deck Beams

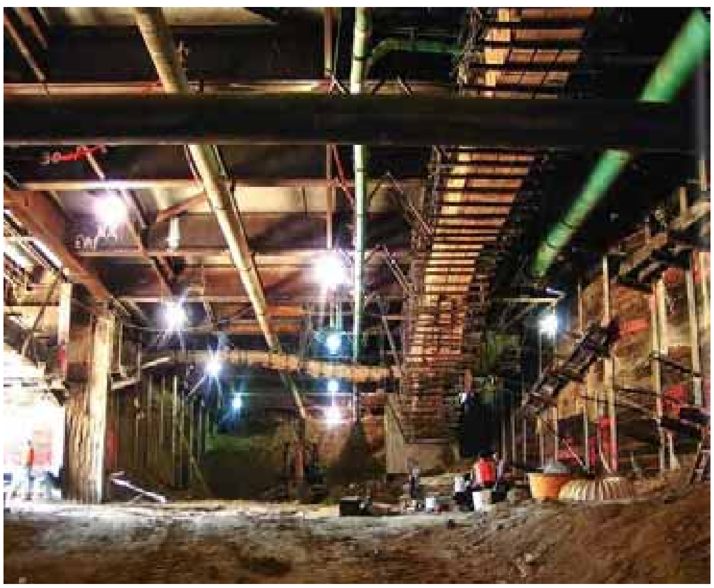


Figure 3-18: Utilities Hung from Deck Beams (Close Up)

Shallow utilities, such as maintenance holes or pull boxes, which would interfere with excavation work, will require relocation. The utilities alignments will be modified and moved away from the proposed facilities. Utility relocation takes place ahead of station and other underground structure excavation. During this time, it will be necessary to close traffic lanes.

It is possible that in some instances, block-long sections of streets would be closed temporarily for utility relocation and related construction operations. Pedestrian access (sidewalks) would remain open and vehicular traffic would be re-routed. Temporary night sidewalk closures may be necessary in some locations for the delivery of oversized materials. Special facilities, such as handrails, fences, and walkways will be provided for the safety of pedestrians.

Minor cross streets and alleyways may also be temporarily closed but access to adjacent properties will be maintained. Major cross streets would require partial closure, half of the street at a time, while relocating utilities.

Figure 3-19: Backfilling Utilities in Final Location beneath Road Surface

Utilities, such as high-pressure water mains and gas lines, which could represent a potential hazard during cut-and-cover and open-cut station construction and that are not to be permanently relocated away from the work site, would be removed from the cut-and-cover or open-cut area temporarily to prevent accidental damage to the utilities, to construction personnel and to the adjoining community. These utilities would be relocated temporarily by the contractor at the early stages of the operations and reset in essentially their original locations during the final backfilling above the constructed station. See Figure 3-19

# 4.0 PALEONTOLOGICAL ISSUES

The Wilshire/Fairfax Station is situated within the vicinity of the Hancock Park Rancho La Brea Tar Pits. The San Pedro Sand layer exists beneath the older and younger alluvium deposits near the surface in this region. This formation has a high likelihood for producing significant paleontological resources. The existing La Brea Tar Pits immediately adjoining the Wilshire/Fairfax Station site is the largest collection of fossils of extinct mammals in the entire world. Because of the high likelihood of fossil discovery while excavating the Wilshire/Fairfax station box, station construction at Wilshire/Fairfax will be given the maximum time available within the overall project schedule, so that excavation can proceed slowly and carefully and fossils located and removed without schedule pressures.

Before fossil recovery can begin, utility relocation and shoring for the station excavation using one or more of the shoring methods outlined above must occur. Utility relocations, by their nature (narrow trenches beneath paved streets) will make recovery of fossils during this phase of the work unlikely. Then, any fossils that lie within the footprint of the shoring will necessarily be destroyed when the shoring is constructed, as there is no way to remove them in advance of the shoring. However, shoring will at worst occupy less than 10% of the footprint of the station excavation, leaving 90% of the footprint unaffected and suitable for fossil recovery.

The plan for fossil removal has been based on the methods used by the Page Museum for the removal of fossils from the nearby LACMA parking garage excavation, referred to from here-on by the Page Museum name, Project 23. The ground will be excavated in shallow lifts, with museum staff on land to inspect the excavated surfaces as earth is removed and to mark the locations of fossils when discovered. It is assumed that the fossils will occur in a manner similar to that at Project 23, i.e. concentrated in vertical tar "pipes" which, once located, can be boxed in place and then removed from the site for further analysis. As with Project 23, fossils can also be found away from the tar pipes so all excavated surfaces must be inspected, and the contractor's team must be alerted to the possibility of finding fossils anywhere with the excavation. The Project 23 site was an open excavation, not constrained by a deck at ground level. This made boxing and removal of the fossil boxes a good deal more straight-forward than will be the case at Wilshire/Fairfax. Figure 4-1 shows fossils in a pit at the Page Museum, and Figure 4-2 a boxed "pipe" containing fossils being prepared at the Project 23 site. Figure 4-3 and Figure 4-4 show examples of fossils recovered from Project 23 after processing.

Figure 4-1: Tar Deposit Containing Fossils

Figure 4-2: Fossil Box Construction at Project 23

Figure 4-3: Smilodon (Sabre Tooth Cat) Pelvic Bone

Figure 4-4: Smilodon Skull in Fossil Box

## 4.1 Minimize Excavation Done Before Decking Installation

Although the Project 23 experience suggests that fossils will mainly be 10 ft or more below street level, fossils must be anticipated anywhere within undisturbed ground. Using the cut and cover excavation technique, deck beams which support the deck panels are installed in the road bed after the piles or shoring walls are complete. The top of the deck beams sit just below the roadway surface so that the decking is flush with the roadway. The deck beams are approximately 6-ft tall and joined together with cross bracing so a minimum of 7-ft of excavation is required for their installation. On Red line and Gold Line stations, contractors have normally excavated 10 ft deep when installing the deck beams to provide clear space beneath the beams for better access when commencing to dig out from beneath the decking and to expose utilities immediately below the deck beams.

Because the street decking requires a full street closure to install, only limited times are available in which to close the street. Full street closures, especially along Wilshire Boulevard will be limited to approximately 52 hours duration on week-ends, and this will not provide time to carefully remove soil in layers to expose fossils nor to box and remove any fossils found in this initial excavation. Therefore, opportunities for fossil recovery from the initial excavation for the street decking will be limited. It therefore requires a construction approach to try and reduce the depth of the initial excavation. Two strategies are being pursued in this regard. One approach is to use raised decking so that the bottoms of the deck beams can be raised up by the same height that the station decking is installed above street level. Metro is in discussions with traffic authorities regarding the acceptability of using raised decking at Fairfax. See Appendix A for details of raised decking. The other approach is to use shallower deck beams, either for a flush deck system or in conjunction with a raised decking approach. Shallower beams will almost certainly require installing the deck beams at closer centers, probably 7 ft centers instead of the usual 14 ft centers but the shallow beams will reduce the likelihood of finding fossils during decking.

It should be noted that many utilities in the street are much deeper than the bottom of the deck beams, and any fossils would have been destroyed during the construction of such utilities. Utilities already have disturbed a significant percentage of the station excavation footprint, and this will increase with the relocations required prior to the installation of the shoring and decking. Nevertheless, there will remain areas of undisturbed soil within the 10 ft immediately below street level and fossils therefore could be found in these locations. These areas can be mapped in advance so that they can be excavated carefully.

## 4.2 Excavation of the topmost layers beneath the street decking

Once the street decking has been installed, excavation beneath the decking will commence. The side access shaft(s) from the contractor's laydown area (see Figure 4-5) and from the station portal site will be excavated in shallow lifts, using methods similar to those of Project 23. Any fossils found will be removed. Once the side access shafts are deep enough to allow equipment to commence digging beneath the street decking, equipment will be lowered into then shaft to commence digging. One scenario will be for the contractor to dig the initial lift by scraping down the face, using low headroom equipment such as a Gradall (see Figure 4-6) or other equipment acceptable to Metro and to the Page Museum. The working face would be inclined at probably a 2:1 slope and would be accessible for inspection (see Figure 4-7). The excavation would proceed in this manner until the first lift was completely removed. The height of the first lift will be determined by the head room needed by the equipment needed for the subsequent lifts, but probably of the order of 12-14 ft. depending on the equipment selected, subsequent lifts could continue to be inclined or horizontal. Fossils and tar pipes containing fossils would be removed under the supervision of Page Museum staff, probably using the boxing techniques developed for Project 23. Because the Fairfax Station will be decked, handling large boxes beneath the decking will be very difficult. Boxes of not more than 500 cubic ft (approximately 30 tons) are proposed as an upper limit, and smaller boxes for the first lift below the decking may be necessary so that low headroom equipment will be able to carry the boxes back to the side access shaft. Actual box sizes can be determined in the field by the contractor and paleontologists. Figure 4-7 and Figure 4-8 show the proposed excavation sequence.

Figure 4-5: Open Cut Excavation of Side Access Shaft

Figure 4-6: Gradall Excavator - East Side Access Project NYC

Figure 4-7: Cross Section Showing Excavation Procedure of Shallow Lifts at 2:1 (Approx) Slope Beginning from the Side Access Shaft

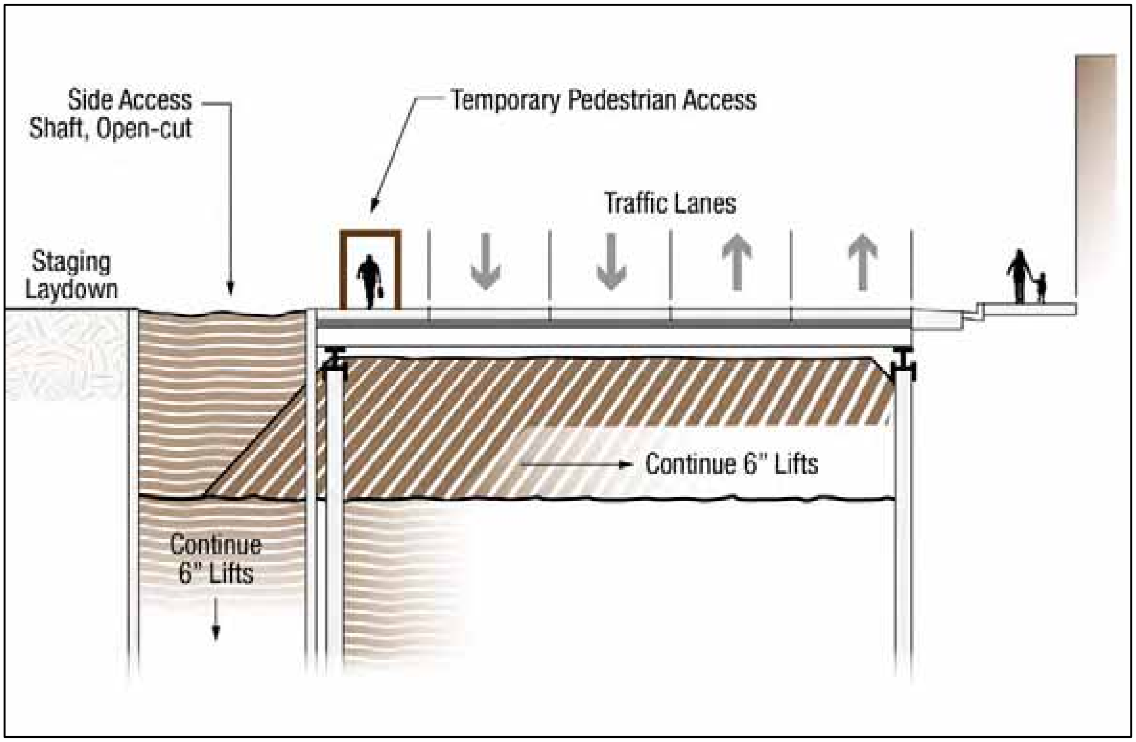
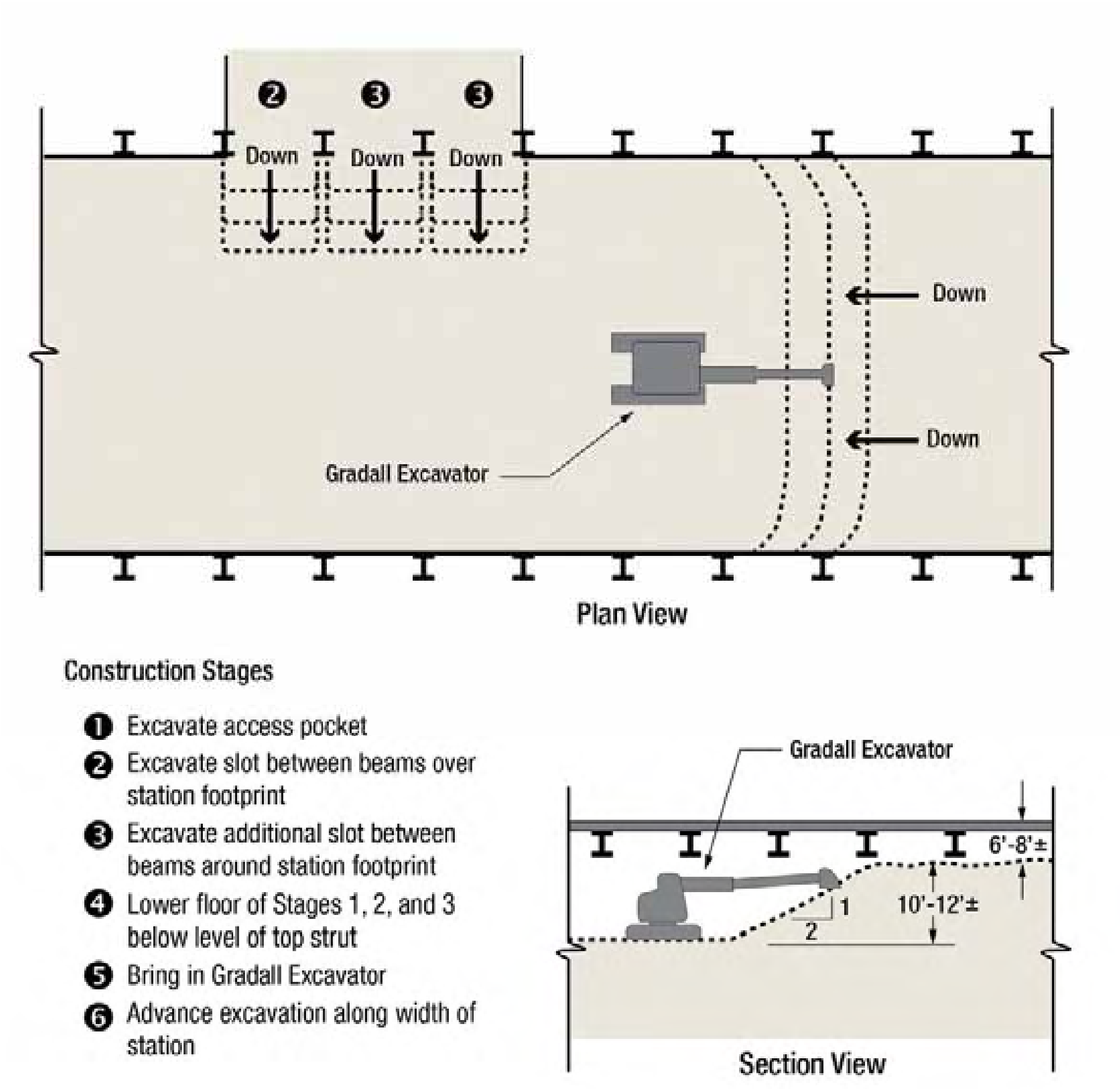


Figure 4-8: Plan Showing Excavation Procedure of Shallow Lifts with Low-Profile Gradall Excavator



## 4.3 Excavate in Layers

The station box and side access shafts will be excavated in shallow lifts to carefully expose and locate fossils. The Page Museum is suggesting 6” lifts based on experience at the Los Angeles County Museum of Art (LACMA) parking garage. As with Project 23, fossils can also be found away from the tar pipes so all excavated surfaces must be inspected, and the contractor’s team must be alerted to the possibility of finding fossils anywhere with the excavation.

Compact track loaders and compact excavators (see Figure 4-9 and Figure 4-10) are likely necessary for initial soil removal directly beneath the deck beams due to their low vertical clearance, and relatively small bucket size capable of excavating precise lifts. Continuous tracks improve vehicle traction on soft and sticky terrain and reduce the amount of pressure exerted on the soil below. A pressurized although this may not be an option due to tight clearances and proper ventilation will still be needed regardless. If soil conditions permit, a rubber tire vehicle like skid steer loaders or equipment fitted with floatation tires may be used instead of compact track loaders. Gradalls operate a bucket at the end of a telescopic arm in a linear motion. The linear shoveling motion enhances depth control improving the ability to cut in precise shallow lifts. These will be considered considered as well. Track loaders, wheeled dozers and hydraulic excavators would be employed to remove the bulk of the soils in order to maintain efficiency in excavating (see Figure 4-11 through Figure 4-13. Excavation with these tools will require careful observation to identify the location of tar deposits. When tar deposits are located, smaller equipment should step in to avoid damaging fossil resources with heavier machines.

Figure 4-9: Compact Track Loader

Figure 4-10: Compact Excavator – 6.75’-Tall/12’-Long/6.5’-Wide

It is possible that the discovery and removal of fossils could lead to schedule delays and the station box structure would not be completed in time to precede the TBM breakthrough. As long as station box excavation has not breached a reasonable depth above where the top of the tunnel liner will be so that it would compromise the operation of the TBM, then the TBM drive should continue through the station box location and station excavation would work its way down and eventually break through the tunnel liner.

Figure 4-11: Tracked Loader Removing Muck from Beneath Struts

Figure 4-12: Hydraulic Excavator between Struts

Figure 4-13: Track Loader beneath Struts

It may be possible to use an imaging technique to locate fossils ahead of excavating operations thus allowing the pace of excavation to accelerate beyond the recommended 6" lift limit. If the imaging technique produces a reliable indication, the boxing of fossils can be pre-planned. Some techniques of scanning for objects below the surface that should be considered are Ground Penetrating Radar (GPR), HAARP Detection using ELF and VLF radio waves, electrical resistivity imaging, and geophysical diffraction tomography.

If an Early Work Authorization is obtained, construction can begin on an exploratory shaft to test the effectiveness of the anticipated geophysical methods. The shaft could be located within the limits of a side access shaft and would ideally reach full station depth in order to learn as much as possible from this process. The length and width of the shaft should be a minimum size to allow a variety of the equipment under consideration to perform excavation operations during the exploration process. Construction methods will be tested to determine the best techniques and tools for station box excavation. Shoring types will be tested to determine the effectiveness of the planned shoring in the soils present in the area. Gas levels will be measured to gauge the specifics of the ventilation scheme.

## 4.4 Fossil Box Size

As layers of soil are removed, tar-laden sand deposits containing fossils are likely to be uncovered. When this happens, work is halted within proximity of the fossil to allow the paleontologists on site to assess the discovery and begin preparations for boxing and removal of the deposit. The technique of boxing and removing fossil deposits to an off-site facility for additional paleontological work is an efficient process that was first implemented at the La Brea Tar Pits in 1915 and more recently during the construction of Project 23. A photo of the 1915 boxing method is contained on Page 8 of Rancho La Brea, Death Trap and Treasure Trove, Edited by John M. Harris, June 2001.

Figure 4-14: Fossil Boxes at Project 23

The box construction technique used on Project 23 is similar to that which is used for boxing palm trees for transport. See Figure 4-14. First, the paleontologist defines the location of the fossil deposit. Next, trenches are dug around the sides and excavation continues by removing sterile soil from around the fossil zone with heavy equipment leaving an island where the deposit sits. The bottom of the box is most challenging. After the box is supported by blocks and shims at each of the four corners, workers must crawl beneath the box and dig by hand while inserting the timber boards which make up the base of the box (Figure 4-15). An alternative approach to creating the bottom of the box which would improve worker safety and expedite the excavation process would require an auger to drill holes in the island beneath the fossil deposit. Timbers would be inserted through the auger holes, thus beginning to form the base of the box. The auger would then remove the balance of soil between the timbers allowing completion of the box and freeing the deposit from the soil below. See Figure 4-16. During the excavation of Project 23, sixteen tar deposits were discovered. From the sixteen deposits, twenty-three boxes were recovered, thus giving the parking garage project its name. The boxes range in size from 5x5x5-ft (weighing 3 tons) to 12x15x10-ft (weighing 56 tons).

Figure 4-15: Fossil Relocation Process. (From Page Museum Whiteboard)

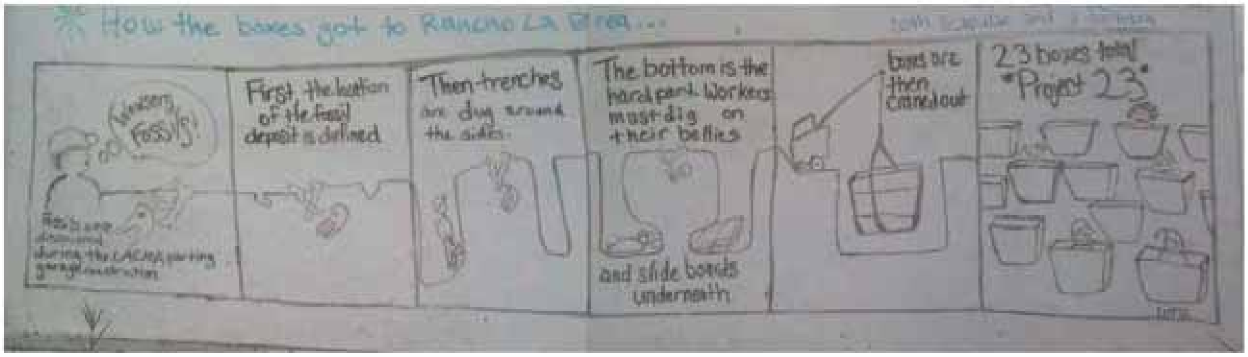
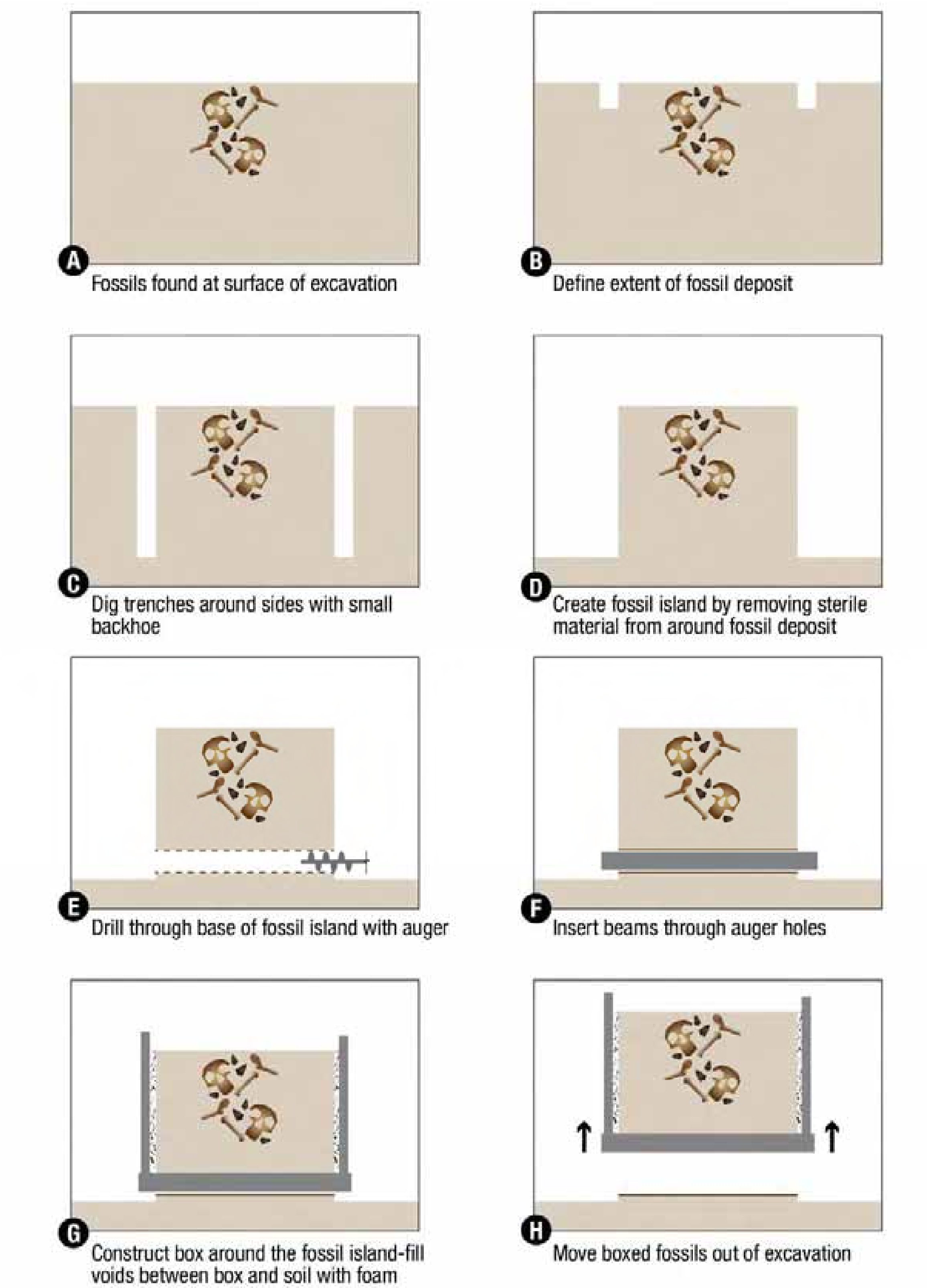


Figure 4-16: Proposed Alternative Boxing Technique Using Auger for Floor Construction



Depending on the size and weight of each box, fossils located beneath deck panels may be lifted in place by crane through temporary openings in the decking. However, this may prove to be impossible if street closure is not possible or the crane cannot be positioned on the street decking in a way to perform the lift. It is proposed to limit the size of fossil boxes to about 30 tons, i.e. 500 cubic feet which will make boxes easier to lift or to move around below the decking with low headroom equipment or with a system of skids and temporary tracks constructed within the station box. Once positioned adjacent to the side access shaft, fossil boxes can be lifted by mobile cranes positioned on "terra firma". The crane would lift the box out through the access shaft and load it on a truck which will transport the tar and fossils either to the Page Museum site where paleontologists can continue their work or to the contractor's laydown area at South Orange Grove/ Ogden for storage and processing. Offsite processing is preferred as there is less potential for damage by heavy equipment that will be operating at the South Orange Grove/Ogden laydown area.

## 4.5 Construction Issues in Tar-Laden Soils

The asphaltic sands have unique properties and the engineering characteristics are not as well documented as compared to other soils. However, contrary to common expectations, it is proven that these sands possess shear strength. Design parameters for excavation support systems in asphaltic sands will need to consider some additional pressure due to the makeup of these soils. There are numerous cases of successful experience in construction of deep basements and underground parking structures in the Wilshire/Fairfax area soils, such as construction of underground structures at LACMA (see Figure 4-17). Similar design elements, construction techniques and operating methods and procedures can be applied to the planned excavations.

Figure 4-17: Aerial View of Project 23 Excavation with Dark Tar Seeps

## 4.6 Potential Impacts to Construction Methods from Anticipated Tar-Laden Soils

When excavating in tar-laden soil, efforts will be undertaken to avoid excessive disturbance. Excavation methods will be closely controlled to minimize over-excavation or vibrations. When grade is achieved within these soils, a mud slab could be applied to minimize disturbance. In some cases, a layer of gravel may be placed over the asphaltic sands to increase traction and reduce the amount of soil compaction caused by construction traffic. The contractor can also apply various other materials on top of the tar such as cement, lime, or other additives to prevent it from fouling the tracked equipment. Wide tracked machinery can be used to reduce the pressure exerted on the soils below. Timber mats can make a sturdy foundation to drive equipment on. Rubber tire vehicles are considerably lighter than their tracked counterparts and could be operated with floatation tires specifically designed to minimize the amount of soil compaction caused by heavy equipment. Because the tar is rather sticky or tacky in some areas, it is anticipated that the equipment's tracks, axles, or buckets could become fouled and would require occasional cleaning. Steam cleaners would handle the task well, by heating the tar to a less viscous consistency.

## 4.7 Handling Gas Intrusions during Construction Operations

Previous projects in the Methane Risk Zone have been successfully and safely excavated. Multiple underground parking garages have been constructed in this area. For example, LACMA built a two-level subterranean parking structure in the Methane Risk Zone, previously referred to as Project 23. During the excavation, H2S (above safe working levels) was encountered on several occasions. Workers donned PPE to protect against exposure during these events (se Figure 4-18). Further investigation of operating underground structures will be undertaken during future design phases to assess effectiveness of barrier systems and detection equipment used.

Figure 4-18: Fossil Boxes with Worker Donning Oxygen Respirator at Project 23

Since the majority of gas is expected to enter the excavation through the excavation surface, the release of gases may be constricted by applying a ground cover to all areas except the area where current excavation operations are taking place. An impervious membrane of Visqueen plastic sheeting or geotextile fabric may serve this purpose.

In areas of potential H2S exposure, there are a number of techniques that can be used to lower the risk of H2S release or exposure. Because station excavations are less confined than tunnels, gas exposure issues are anticipated to be less significant. Although pre-treatment of the ground water prior to excavation, with additives such as hydrogen peroxide or copper-zinc, is an option, it is not expected to be required. If released, H2S will not naturally dissipate because it is heavier than air, hence it would build up around the bottom of the excavation. The first line of defense is dewatering since H2S occurs in a dissolved state in ground water. Dewatering will remove any contaminated water from the excavation area. At the surface, a sealed tank would capture the water and treat the air for H2S off-gassing before discharging it to the surrounding environment. Additionally, a ventilation system will be used to introduce fresh air in the workspace. Fans will be used to circulate the air while a gas detection system monitors levels of hazardous gas. A suction system fitted with scrubbers may be required to collect H2S from the bottom of the excavation and treat the air before discharging clean air at the street surface.

CH4 is a hazard in confined spaces. As such, it is essential that workers be sufficiently protected, and thus detection and monitoring equipment would be required. Fans similar to those used to dilute H2S concentrations would also dilute CH4 concentrations in the station box. Once above-ground, CH4 dissipates rapidly in the atmosphere and would not be a health hazard.

## 4.8 Ventilation Schemes

Ventilation is required to combat harmful or dangerous gasses when present in underground construction. Cal OSHA classifies subterranean work areas as “gassy”, “potentially gassy”, “non-gassy”, or “extra hazardous”. Excavation equipment in “gassy” spaces must be manufactured to resist accidental sparks and either be sealed or of explosion proof design.

Since CH4 and H2S gases are expected to be encountered during the excavation of Wilshire/Fairfax station, adequate ventilation and continuous air quality monitoring will be in use throughout construction. In addition to maintaining acceptable levels of CH4 and H2S in the air supply, the ventilation system must maintain a certain level airflow for workers present in the work space (see Figure 4-19) . The size of the system is dependent on the number of persons and the size of diesel equipment underground. The air supply shall not be less than 200 CFM (cubic feet per minute) per person underground, plus 100 CFM per diesel horse brake power.

Use of perforated deck panels, either perforated steel or concrete integrated with steel could be used in place of concrete only deck panels to allow the free flow of air between the excavation area and the surface, especially if full decking is required across the entire station box.

Figure 4-19: Underground Ventilation Ducts

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

The project is committed to recover fossils and to work closely with the Page Museum to minimize the loss of fossils due to the construction of a station at Wilshire/Fairfax.

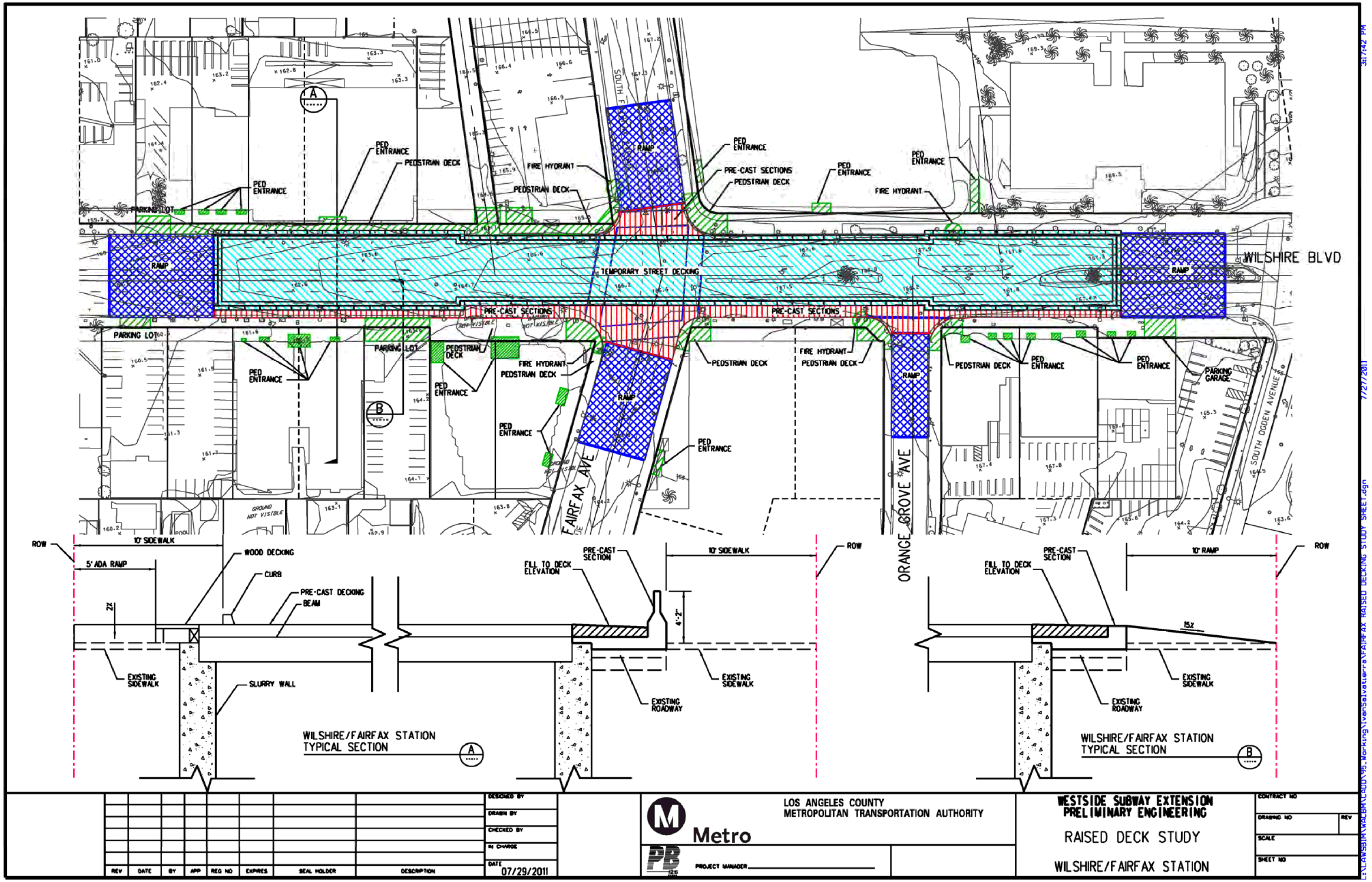
The project plans to use the same recovery methods that have been proven at Project 23, and with the cooperation of Page Museum staff, will seek to customize and improve on these methods to tailor them for the site conditions at Wilshire/Fairfax.

Further studies are on-going to find ways to raise the height of the beams used for street decking, which in turn, will leave more soil beneath the beams for controlled excavation and fossil recovery.

The fastest and lowest cost shoring method is preferred. This means that a soldier pile and lagging system will be employed provided that continuing geotechnical investigation do not find ground conditions that preclude this system. Soldier pile and lagging shoring has the added advantage of disturbing less of the station excavation footprint than other methods, minimizing the loss of fossils in this phase.

Gases will be controlled by installing adequate ventilation within the excavation, and by designing the street decking system with gaps for natural ventilation and elimination of pockets where gases could accumulate.

# APPENDIX A EXAMPLE OF RAISED DECKING




WESTSIDE SUBWAY EXTENSION PROJECT