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**Plugging and Abandonment  
Summary Report for Boreholes  
49-10046, 49-10047, 49-10048,  
Coreholes CH-1, CH-3, CH-4,  
Test Holes TH-4, TBM-1, TBM-2,  
and Layne Western Well**

Prepared by the Environmental Programs Directorate

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# Plugging and Abandonment Summary Report for Boreholes 49-10046, 49-10047, 49-10048, Coreholes CH-1, CH-3, CH-4, Test Holes TH-4, TBM-1, TBM-2, and Layne Western Well

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## **EXECUTIVE SUMMARY**

This report details the methods Los Alamos National Laboratory (LANL or the Laboratory) used to plug and abandon boreholes 49-10046, 49-10047, 49-10048, coreholes (CH) 1, CH-3, CH-4, test holes (TH) 4, TBM-1, TBM-2, and the Layne Western well. Plugging and abandonment activities occurred from February 14 to February 28, 2013. Before the holes and wells were abandoned, all above- and belowground appurtenances were removed. The Layne Western well was video and gamma-ray logged from ground surface to 107.5 ft below ground surface (bgs) in 2012. Water-level measurements and the total depths of the boreholes, coreholes, test holes, and well were verified using a water-level meter before the holes and well were abandoned.

Boreholes 49-10046, 49-10047, 49-10048, CH-1, CH-3, CH-4, and TH-4 were plugged and abandoned without the use of an auger rig or pump hoist. Boreholes 49-10046, 49-10047, 49-10048, CH-1, CH-3, and CH-4 were plugged with Portland Type I/II cement and municipal water. TH-4 was plugged with hydrated bentonite chips and Portland Type I/II cement. A CME-75 auger rig and ancillary equipment were used during plugging and abandonment activities at TBM-1 and TBM-2. TBM-1 and TBM-2 were reamed to remove polyvinyl chloride casing and well construction material. The boreholes were plugged with Portland Type I/II cement. A pump hoist rig was used during plugging and abandonment activities at the Layne Western well. An attempt was made to remove the well casing from the well using hydraulic casing jacks assisted by the pump hoist (used to power the jacks only due to overhead powerlines). The Layne Western well was plugged with hydrated bentonite chips and Portland Type I/II cement.

The boreholes, coreholes, test holes, and well were cement-grouted to approximately 2 ft bgs, and a small concrete surface plug was installed near ground surface with an aluminum survey marker. The surface completion was surveyed in accordance with Section IX.B.2.f of the Compliance Order on Consent.



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**Acronyms and Abbreviations**

ags	above ground surface
amsl	above mean sea level
bgs	below ground surface
CH	corehole
Consent Order	Compliance Order on Consent
I.D.	inside diameter
LANL	Los Alamos National Laboratory
NES	nuclear environmental site
NMED	New Mexico Environment Department
O.D.	outside diameter
OSE	Office of the State Engineer
PVC	polyvinyl chloride
RPF	Records Processing Facility
TA	technical area
TH	test hole



## 1.0 INTRODUCTION

This report summarizes the methods Los Alamos National Laboratory (LANL or the Laboratory) used to plug and abandon boreholes 49-10046, 49-10047, 49-10048, coreholes (CH) 1, CH-3, CH-4, Test Holes (TH) 4, TBM-1, TBM-2, and the Layne Western Well. The boreholes, coreholes, test holes, and well are located in and around Los Alamos County, New Mexico, as shown in Figure 1.0-1. The boreholes, coreholes, test holes, and well were plugged and abandoned with direction from NMED and in accordance with the Laboratory's "Work Plans to Plug and Abandon Wells and Boreholes at Los Alamos National Laboratory" (LANL 2010, 111131), and NMED's "Notice of Approval with Modifications Work Plans to Plug and Abandon Wells and Boreholes at Los Alamos National Laboratory (NMED 2011, 201231).

Well abandonment was consistent with the requirements and guidelines in Sections IV.B.1.b.v and X.D (Well Abandonment) of the Compliance Order on Consent (the Consent Order). Additionally, the plugging and abandonment procedures complied with 19.27.4 New Mexico Administrative Code Rules and Regulations Governing Well Driller Licensing; Construction, Repair and Plugging of Wells. The following documents helped guide the implementation of the scope of work for the plugging and abandonment project: "Work Plans to Plug and Abandon Wells and Boreholes at Los Alamos National Laboratory" (LANL 2010, 111131) and the "Field Implementation Plan to Plug and Abandon Boreholes 49-10046, 49-10047, 49-10048, Core Holes CH-1, CH-3, CH-4, Test Holes TH-4, TBM-1, TBM-2, and Layne Western Well" (TerranearPMC 2012, 238466). A plugging plan of operations was filed for the Layne Western Well with the New Mexico Office of the State Engineer (OSE).

## 2.0 BACKGROUND

This section describes the location, construction, and conditions of each borehole, corehole, test hole, and well before plugging and abandonment activities.

All plugging and abandonment tasks within the Technical Area 49 (TA-49) nuclear environmental site (NES) were completed in compliance with the December 2010 "Documented Safety Analysis for the Nuclear Environmental Sites at Los Alamos National Laboratory," and the December 2010 "Technical Safety Requirements for the Nuclear Environmental Sites at Los Alamos National Laboratory, Revision 4." Specifically, no vehicles or equipment were driven across or parked on the NES surface. Foot traffic was restricted to defined access routes and was limited to required travel to and from the boreholes and coreholes that were abandoned. No materials were staged within the NES boundary. In addition, only authorized personnel required for performing the job tasks were allowed within the NES boundary. This restriction ensured that the integrity of the Inventory Isolation System (essentially, the soil overburden) was maintained and was not adversely altered or modified.

Grouting of the boreholes and coreholes located within the NES was performed using a diaphragm pump, air compressor, various hoses, and a spool of 1.25-in.-diameter poly tubing. The diaphragm pump, air compressor, and hoses remained outside the NES fence, and the poly tube was run through the fence to the boreholes and coreholes. The poly tube was inserted into the boreholes and coreholes and used as a tremie pipe to pump cement from the bottom up to ensure the holes were completely filled. The poly tubing was either retracted as the hole was filled or was cut off and grouted in place.

After the boreholes and coreholes were cemented, the pump and hoses were flushed through with water to remove residual cement. Cement washout water was initially containerized in drums that were later discharged to the ground in a designated cement washout area outside the NES fence.

Equipment that contacted the ground surface within the NES was decontaminated with Fantastik. Equipment removed from the NES and personnel exiting the NES were swiped for a radiological survey by a radiological control technician, per the radiological work permit.

## **2.1 Boreholes 49-10046, 49-10047, and 49-10048**

Boreholes 49-10046, 49-10047, and 49-10048 are located at TA-49 inside the NES boundary.

Boreholes 49-10046, 49-10047, and 49-10048 were installed in 2000 as shallow cased neutron logging holes for moisture monitoring at Area 2 shafts at TA-49 (LANL 2008, 102215). The boreholes were 2 in. in diameter with aluminum casing installed to total depth. The top of the boreholes were completed with an 18-in. × 18-in. × 6-in.-thick concrete pad (approximate). The ground surface around the boreholes was covered with a steel mesh gopher barrier.

### *Preabandonment Conditions*

The total depth of borehole 49-10046 was measured to 14.1 ft below ground surface (bgs) with no water present on February 19, 2013. Total depth and lack of water were verified with a water-level meter.

The total depth of borehole 49-10047 was measured to 11.5 ft bgs with no water present on February 19, 2013. Total depth and lack of water were verified with a water-level meter.

The total depth of borehole 49-10048 was measured to 12.2 ft bgs with no water present on February 19, 2013. Total depth and lack of water were verified with a water-level meter.

Figures 2.1-1, 2.1-2, and 2.1-3 are well construction diagrams depicting the construction details and preabandonment conditions of boreholes 49-10046, 49-10047, and 49-10048, respectively.

## **2.2 CH-1, CH-3, and CH-4**

CH-1 and CH-4 are located at TA-49 inside the NES boundary, and CH-3 is located outside the TA-49 NES boundary.

CH-1 was cored in 1959 to 501 ft bgs, CH-3 was cored in 1960 to 300 ft bgs, and CH-4 was cored in 1960 to 303 ft bgs. The coreholes were installed to determine some of the physical and hydrologic properties of the tuff (Purtymun 1995, 045344). The 4.5-in.-diameter coreholes were dry (LANL 2008, 102215). A 2-in.-inside diameter (I.D.) galvanized pipe was installed in the coreholes to total depth and cemented in place (Purtymun 1995, 045344). The surface completions were 2-ft × 3-ft × 12-in.-thick concrete pads (approximate). An approximately 5-ft-high galvanized riser was threaded into a coupling that was flush with the top of the concrete pad. Each of the coreholes had a rotary vent installed on the top of the riser.

### *Preabandonment Conditions*

The total depth of CH-1 was measured to 491.3 ft bgs with no water present on February 15, 2013. Total depth and lack of water were verified with a water-level meter.

The total depth of CH-3 was measured to 300.3 ft bgs with no water present on February 14, 2013. Total depth and lack of water were verified with a water-level meter.

The total depth of CH-4 was measured to 304.5 ft bgs with no water present on February 14, 2013. Total depth and lack of water were verified with a water-level meter.

Figures 2.2-1, 2.2-2, and 2.2-3 are well construction diagrams that depict the construction details and preabandonment conditions of CH-1, CH-3, and CH-4, respectively.

### **2.3 TH-4**

Test hole TH-4 is located at TA-49 inside the NES boundary.

TH-4 was installed in 1980 to 123 ft bgs for neutron moisture logging in Area 2 at TA-49. The dry borehole was 5-in. in diameter. A 4-in.-I.D. polyvinyl chloride (PVC) surface casing was installed from approximately 3 ft bgs to 2 ft above ground surface (ags). The surface casing was not cemented in place, and no concrete pad or other surface completion was installed at ground surface.

#### *Preabandonment Conditions*

The total depth of TH-4 was measured to 88.1 ft bgs with no water present on February 19, 2013. Total depth and lack of water were verified with a water-level meter.

Figure 2.3-1 is a well construction diagram that depicts the construction details and preabandonment conditions of TH-4.

### **2.4 TBM-1 and TBM-2**

Test holes TBM-1 and TBM-2 are located at TA-49 outside the NES boundary.

TBM-1 and TBM-2 were barometric measurement holes that were drilled immediately next to one another at TA-49 in 1993. TBM-1 was drilled to 139 ft bgs, and TBM-2 was drilled to 64 ft bgs (Purtymun 1995, 045344). The 7.25-in.-diameter test holes were dry.

Three 0.5-in.-diameter PVC casings were installed in TBM-1 with 1-ft screened intervals at 19 ft bgs, 79 ft bgs, and 124 ft bgs, respectively (each 0.5-in.-diameter casing had one screened interval). Sand was placed around each screened zone, with cement above and below, and the intervals between the screens were filled with drill cuttings.

A 4-in.-I.D. PVC pipe was installed in TBM-2 to 40 ft bgs with a biaxial tiltmeter at the bottom to measure tuff deformation. The annulus, open borehole beneath the pipe, and PVC pipe were filled with sand.

#### *Preabandonment Conditions*

Figures 2.4-1 and 2.4-2 are well construction diagrams that depict the construction details and preabandonment conditions of TBM-1 and TBM-2, respectively.

### **2.5 Layne Western Well**

The Layne Western well is located in Guaje Canyon a few miles north of the Laboratory boundary.

The Layne Western well was installed in 1950 to 157 ft bgs to supply water for the drilling of the Guaje well field (Purtymun and Swanton 1998, 099096). The depth to water in 1960 was 105 ft bgs. The borehole was approximately 10-in. in diameter, and the well was constructed as follows:

- 0–0.3 ft bgs: 9-in. surface casing
- 0–127 ft bgs: 8-in. casing (Purtymun and Swanton 1998, 099096)

- 127–147 ft bgs: 8-in. screen
- 147–157 ft bgs: open borehole

#### *Preabandonment Conditions*

A video and a gamma-ray log were collected using Laboratory's camera trailer and logging equipment on February 28, 2012. The well was filled with sediment/fill to approximately 107.5 ft bgs, and no water was present. The outer casing was 9 in. I.D. with little to no annulus between it and the 8-in.-I.D. casing. The total depth of the well was measured to 106.8 ft bgs with no water present on February 27, 2013. Total depth and absence of water were verified with a water-level meter.

The video log collected is presented in Appendix A (on DVD). The gamma log is presented in Appendix B (on CD).

Figure 2.5-1 is a well construction diagram that depicts the construction details and pre-abandonment conditions of the Layne Western well.

### **3.0 PLUGGING AND ABANDONMENT**

Plugging and abandonment activities included mobilization, casing removal, perforating, pressure-grouting/sealing, and demobilization. All activities were performed following appropriate standard operating procedures and Laboratory-approved health and safety documents. The boreholes, coreholes, test holes, and well were plugged and abandoned in accordance with NMED-approved work plans. The Layne Western well was plugged and abandoned in accordance with a New Mexico OSE plugging plan.

#### **3.1 Boreholes 49-10046, 49-10047, and 49-10048**

Plugging and abandonment activities at boreholes 49-10046, 49-10047, and 49-10048 occurred between February 19 and February 20, 2013. Boreholes 49-10046, 49-10047, and 49-10048 were abandoned by cutting the 2-in. aluminum casing as flush as practicable with the top of the concrete pad. Approximately 6 ft of 1.25-in.-I.D. poly tubing was inserted into the well casings. Neat cement was mixed outside the NES fence and pumped through the poly tubing. The same poly tube was used for all three boreholes and grouted in place at TH-4. Final surface completions were conducted on February 20, 2013.

##### *Borehole 49-10046*

Borehole 49-10046 was plugged with approximately 0.2 ft<sup>3</sup> of neat cement grout from 14.1 ft bgs (total depth) to 2.0 ft bgs. The volume and type of abandonment materials used to abandon borehole 49-10046 are presented in Table 3.1-1. The final borehole configuration is shown in Figure 3.1-1.

##### *Borehole 49-10047*

Borehole 49-10047 was plugged with approximately 0.2 ft<sup>3</sup> of neat cement grout from 11.5 ft bgs (total depth) to 2.0 ft bgs. The volume and type of abandonment materials used to abandon borehole 49-10047 are presented in Table 3.1-2. The final borehole configuration is shown in Figure 3.1-2.

##### *Borehole 49-10048*

Borehole 49-10048 was plugged with approximately 0.2 ft<sup>3</sup> of neat cement grout from 12.2 ft bgs (total depth) to 2.0 ft bgs. The volume and type of abandonment materials used to abandon borehole 49-10048 are presented in Table 3.1-3. The final borehole configuration is shown in Figure 3.1-3.

### 3.2 CH-1, CH-3, and CH-4

#### CH-1

Plugging and abandonment activities at CH-1 occurred between February 15 and February 20, 2013. The 2-in. galvanized riser pipe (with rotary vent) was unthreaded from the coupling at the top of the existing concrete surface completion pad. Approximately 515 ft of 1.25-in.-I.D. poly tubing was run through the NES fence and inserted into the 2-in.-I.D. galvanized casing to 440 ft bgs. The neat cement was mixed outside the NES fence and pumped through the poly tubing. CH-1 was plugged with approximately 20.1 ft<sup>3</sup> of neat cement grout from 491.3 (total depth) to 2.0 ft bgs. Approximately twice the calculated volume of cement was required to complete the abandonment. The poly tubing was cut off and grouted in place from 2 to 442 ft bgs. The final surface completion activities were conducted on February 20, 2013. The volume and type of abandonment materials used to abandon CH-1 are presented in Table 3.2-1. The final borehole configuration is shown in Figure 3.2-1.

#### CH-3

Plugging and abandonment activities at CH-3 occurred between February 14 and February 20, 2013. The 2-in. galvanized riser pipe (with rotary vent) was unthreaded from the coupling at the top of the existing concrete surface completion pad. The 1.25-in.-I.D. poly tubing was inserted into the 2-in.-I.D. galvanized casing to 250 ft bgs. The neat cement was mixed and pumped through the poly tubing. CH-3 was plugged with approximately 6.7 ft<sup>3</sup> of neat cement grout from 300.3 (total depth) to 2.0 ft bgs. The poly tubing was retracted approximately 75 ft from the casing during cement emplacement and was cut off and grouted in place from 2 to 177 ft bgs. The final surface completion activities were conducted on February 20, 2013. The volume and type of abandonment materials used to abandon CH-3 are presented in Table 3.2-2. The final borehole configuration is shown in Figure 3.2-2.

#### CH-4

Plugging and abandonment activities at CH-4 occurred between February 15 and February 20, 2013. The 2-in. galvanized riser pipe (with rotary vent) was unthreaded from the coupling at the top of the existing concrete surface completion pad. Approximately 350 ft of 1.25-in.-I.D. poly tubing was run through the NES fence and inserted into the 2-in.-I.D. galvanized casing to 252 ft bgs. The neat cement was mixed outside the NES fence and pumped through the poly tubing. CH-4 was plugged with approximately 6.7 ft<sup>3</sup> of neat cement grout from 304.5 (total depth) to 2.0 ft bgs. The poly tubing was cut off and grouted in place from 2 to 252 ft bgs. The final surface completion activities were conducted on February 20, 2013. The volume and type of abandonment materials used to abandon CH-4 are presented in Table 3.2-3. The final borehole configuration is shown in Figure 3.2-3.

### 3.3 TH-4

Plugging and abandonment activities at TH-4 occurred between February 19 and February 20, 2013. TH-4 was plugged from 88.1 (total depth) to 8.8 ft bgs, with approximately 10.7 ft<sup>3</sup> of 3/8-in. hydrated bentonite chips. The 6-ft piece of poly tube used to cement boreholes 49-10046, 49-10047, and 49-10048 was also used to plug TH-4 with approximately 2.0 ft<sup>3</sup> of neat cement grout from 8.8 to 2.0 ft bgs. The poly tubing was grouted in place from 2 to 8 ft bgs. The 4-in.-diameter surface casing was cut off and removed at ground surface. The final surface completion activities were conducted on February 20, 2013. The volume and type of abandonment materials used to abandon TH-4 are presented in Table 3.3-1. The final borehole configuration is shown in Figure 3.3-1.

### 3.4 TBM-1 and TBM-2

#### *TBM-1*

Plugging and abandonment activities at TBM-1 occurred between February 19 and February 20, 2013, using a CME-75 auger rig and ancillary equipment. The 0.5-in.-diameter PVC casings and sand/cement backfill were overdrilled with 7.25-in.-outside diameter (O.D.) hollow stem augers to 124.0 ft bgs. TBM-1 was plugged with approximately 58.8 ft<sup>3</sup> of neat cement grout from 124.0 (total depth) to 2.0 ft bgs. The final surface completion activities were conducted on February 20, 2013. The volume and type of abandonment materials used to abandon TBM-1 are presented in Table 3.4-1. The final borehole configuration is shown in Figure 3.4-1.

#### *TBM-2*

Plugging and abandonment activities at TBM-2 occurred on February 20, 2013, using a CME-75 auger rig and ancillary equipment. The 4-in.-I.D. PVC casing and backfill were overdrilled with 7.25-in. augers to 39.0 ft bgs. TBM-2 was plugged with approximately 20.1 ft<sup>3</sup> of neat cement grout from 39.0 (total depth) to 2.0 ft bgs. The final surface completion activities were conducted the same afternoon. The volume and type of abandonment materials used to abandon TBM-2 are presented in Table 3.4-2. The final borehole configuration is shown in Figure 3.4-2.

### 3.5 Layne Western Well

Plugging and abandonment activities at the Layne Western well occurred between February 27 and February 28, 2013. The 9-in.-I.D. outer surface casing (approximately 0.5-ft length) was removed by hand. An attempt was made to remove the 8-in.-I.D. well casing from the borehole using hydraulic casing jacks powered by a pump hoist rig (used to power the jacks only). The pump hoist was placed a safe distance from the borehole because of the presence of overhead powerlines, and the tower was not raised. The 8-in.-I.D. well casing parted at 10.2 ft bgs at a casing joint during the attempt to remove the well casing. Approximately 10.4 ft of well casing was removed from the borehole after neat cement grout was emplaced from TD to 10.0 ft bgs. Approximately 49.5 ft<sup>3</sup> of neat cement grout was placed from 106.8 (total depth) to 7.5 ft bgs.

A large void was encountered from 4 to 7.5 ft bgs. Approximately 7.4 ft<sup>3</sup> of 3/8-in. hydrated bentonite chips were used to plug the void from 7.5 to 4.0 ft bgs. The remaining borehole was plugged with 0.8 ft<sup>3</sup> of neat cement grout from 4.0 to 2.0 ft bgs. The final surface completion activities were conducted on February 28, 2013. The volume and type of abandonment materials used to abandon the Layne Western well are presented in Table 3.5-1. The final borehole configuration is shown in Figure 3.5-1.

## 4.0 SURFACE COMPLETION

The boreholes, coreholes, test holes, and well were cement-grouted to approximately 2 ft bgs. Concrete surface plugs were mounded slightly abovegrade and were slightly larger than the borehole diameter at TH-4, TBM-1, TBM-2, and the Layne Western well. Concrete surface plugs were installed at boreholes 49-10046, 49-10047, 49-10048 and at CH-1, CH-3, and CH-4. Aluminum survey markers were installed in the plugs and were surveyed in accordance with Section IX.B.2.f of the Consent Order.

#### **4.1 Geodetic Survey**

Geodetic surveys were conducted on the surface completions (Table 4.1-1) with a Topcon GRS-1 GPS using an external antenna. The survey data collected conform to Laboratory Information Architecture project standards IA-CB02, "GIS Horizontal Spatial Reference System," and IA-D802, "Geospatial Positioning Accuracy Standard for A/E/C and Facility Management." All coordinates are expressed relative to the New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed relative to feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. The survey point was the aluminum pin placed in the concrete pad/plug.

### **5.0 POST-ABANDONMENT ACTIVITIES**

Post-abandonment activities are described below.

#### **5.1 Site Restoration**

Plugging and abandonment activities at the boreholes, coreholes, test holes, and wells required only minimal restoration efforts to return the sites to preplugging and preabandonment conditions.

#### **5.2 Waste Management**

Waste generated from the plugging and abandonment project included drill cuttings and contact waste. All waste streams produced during plugging and abandonment activities were sampled in accordance with "Waste Characterization Strategy Form for Plug and Abandonment (P&A) of LANL Wells" (LANL 2008, 103916). Cuttings produced during drilling will be disposed of as industrial or low-level waste at an authorized facility after a review of associated analytical results per the waste characterization strategy form and EP-DIR-SOP-10012, Characterization of Environmental Programs Waste. Characterization of contact waste will be based upon acceptable knowledge from historical site data per Laboratory Procedure P930-1, LANL Waste Acceptance Criteria.

### **6.0 DEVIATIONS FROM PLANNED ACTIVITIES**

#### *TH-4*

The 4-in. PVC surface casing at TH-4 was to be removed from the borehole. Instead, the casing was cut off at the ground surface and removed so as not to disturb the NES Inventory Isolation System.

#### *TBM-2*

The plan at TBM-2 was to fill the PVC casing with cement from 40 to 20 ft bgs, then overdrill the PVC casing and backfill from surface to 20 ft bgs. However, the PVC casing was found to be filled with silica sand backfill to just below the ground surface. The PVC casing and sand backfill were overdrilled to approximately 40 ft bgs, and the borehole was plugged from 40 ft bgs to the surface.

The plugging and abandoning of the remaining wells was performed as specified in the scope of work and the field implementation plan.

## 7.0 SUMMARY

Boreholes 49-10046, 49-10047, 49-10048, CH-1, CH-3, CH-4, TH-4, TBM-1, TBM-2, and the Layne Western well were plugged and abandoned in accordance with the NMED-approved work plans. Before abandonment activities, all above- and belowground appurtenances were removed.

Boreholes 49-10046, 49-10047, 49-10048, CH-1, CH-3, CH-4, and TH-4 were plugged and abandoned without the use of an auger rig or pump hoist. The boreholes and coreholes were plugged with Portland Type I/II cement and municipal water. TH-4 was plugged with hydrated bentonite chips and Portland Type I/II cement and municipal water.

A CME-75 auger rig and ancillary equipment were used during plugging and abandonment activities at TBM-1 and TBM-2. TBM-1 and TBM-2 were reamed to remove PVC casing and well-construction materials. The boreholes were plugged with Portland Type I/II cement and municipal water.

A pump hoist rig was used during plugging and abandonment activities at the Layne Western well. The partial casing string was removed from the well during plugging and abandonment with hydrated bentonite chips and Portland Type I/II cement and municipal water.

## 8.0 REFERENCES AND MAP DATA SOURCES

### 8.1 References

*The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.*

*Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.*

LANL (Los Alamos National Laboratory), January 2008. "Investigation Work Plan for Sites at Technical Area 49 Outside the Nuclear Environmental Site Boundary, Revision 1," Los Alamos National Laboratory document LA-UR-08-0449, Los Alamos, New Mexico. (LANL 2008, 102215)

LANL (Los Alamos National Laboratory), October 2008. "Waste Characterization Strategy Form for the R 38, R-41, R-44, R-45, and R-46 Regional Groundwater Well Installation and Corehole Drilling," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2008, 103916)

LANL (Los Alamos National Laboratory), November 2010. "Work Plans to Plug and Abandon Wells and Boreholes at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-10-6972, Los Alamos, New Mexico. (LANL 2010, 111131)

NMED (New Mexico Environment Department), March 9, 2011. "Notice of Approval with Modifications, Work Plans to Plug and Abandon Wells and Boreholes at Los Alamos National Laboratory," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 201231)

Purtymun, W.D., January 1995. "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, 045344)

Purtymun, W.D., and A.S. Swanton, February 5, 1998. "Engineering, Geology, and Construction Data of Twenty-Five Test Holes and Test Wells on and Adjacent to the Pajarito Plateau," draft, Los Alamos National Laboratory, Los Alamos, New Mexico. (Purtymun and Swanton 1998, 099096)

TerranearPMC, December 2012. "Field Implementation Plan to Plug and Abandon Boreholes 49-10046, 49-10047, 49-10048, Coreholes CH-1, CH-3, CH-4, Test Hole TH-4, TBM-1, TBM-2, and Layne Western Well," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2012, 238466)

## **8.2 Map Data Sources for Plugging and Abandonment Report Location Map**

Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109; 12 April 2010.

Hypsography, 100 and 20 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Surface Drainages, 1991; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0591; 1:24,000 Scale Data; Unknown publication date.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 4 December 2009.



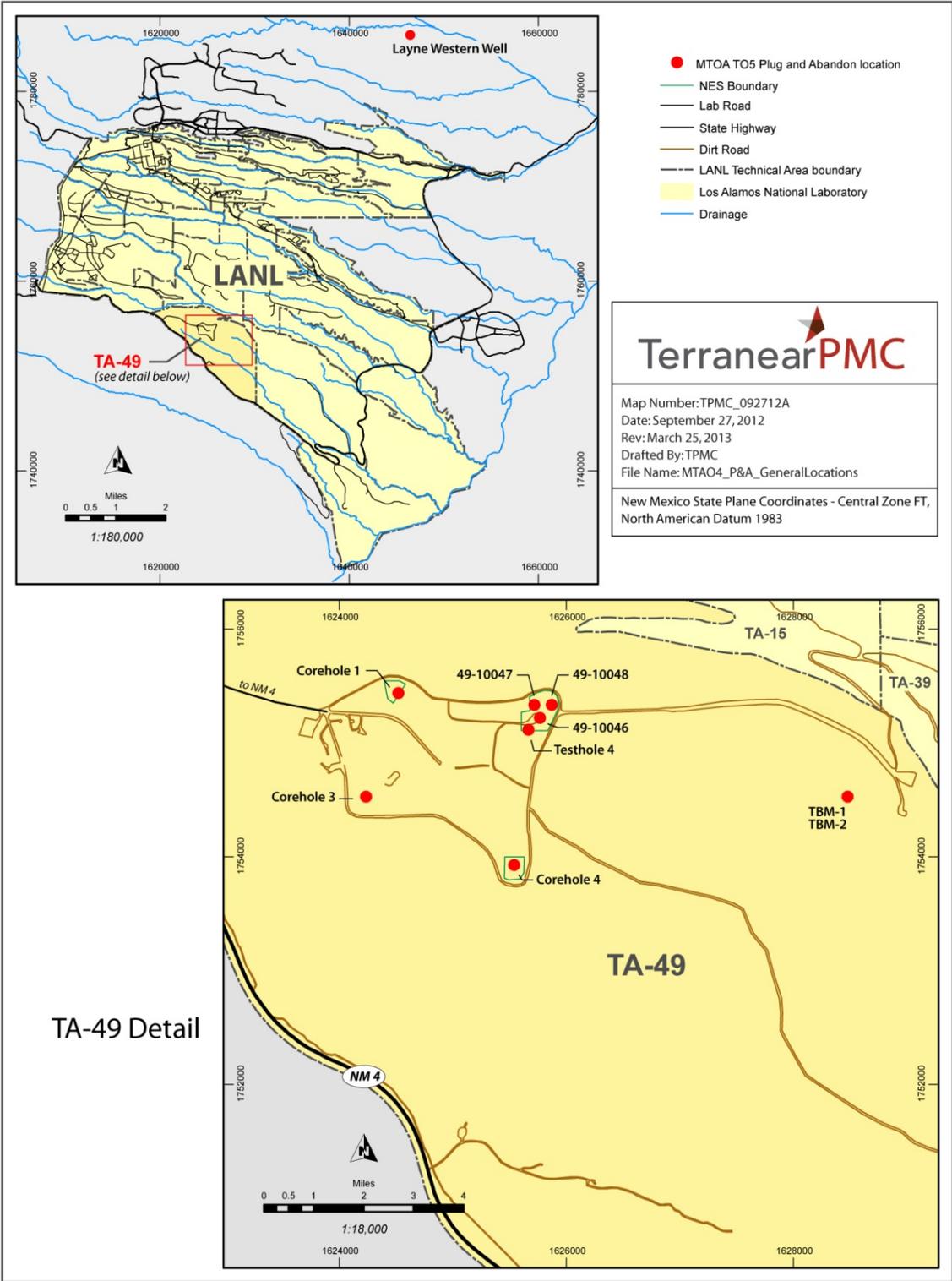


Figure 1.0-1 Location of plugged and abandoned boreholes 49-10046, 49-10047, 49-10048, coreholes CH-1, CH-3, CH-4, test holes TH-4, TBM-1, TBM-2, and the Layne Western well

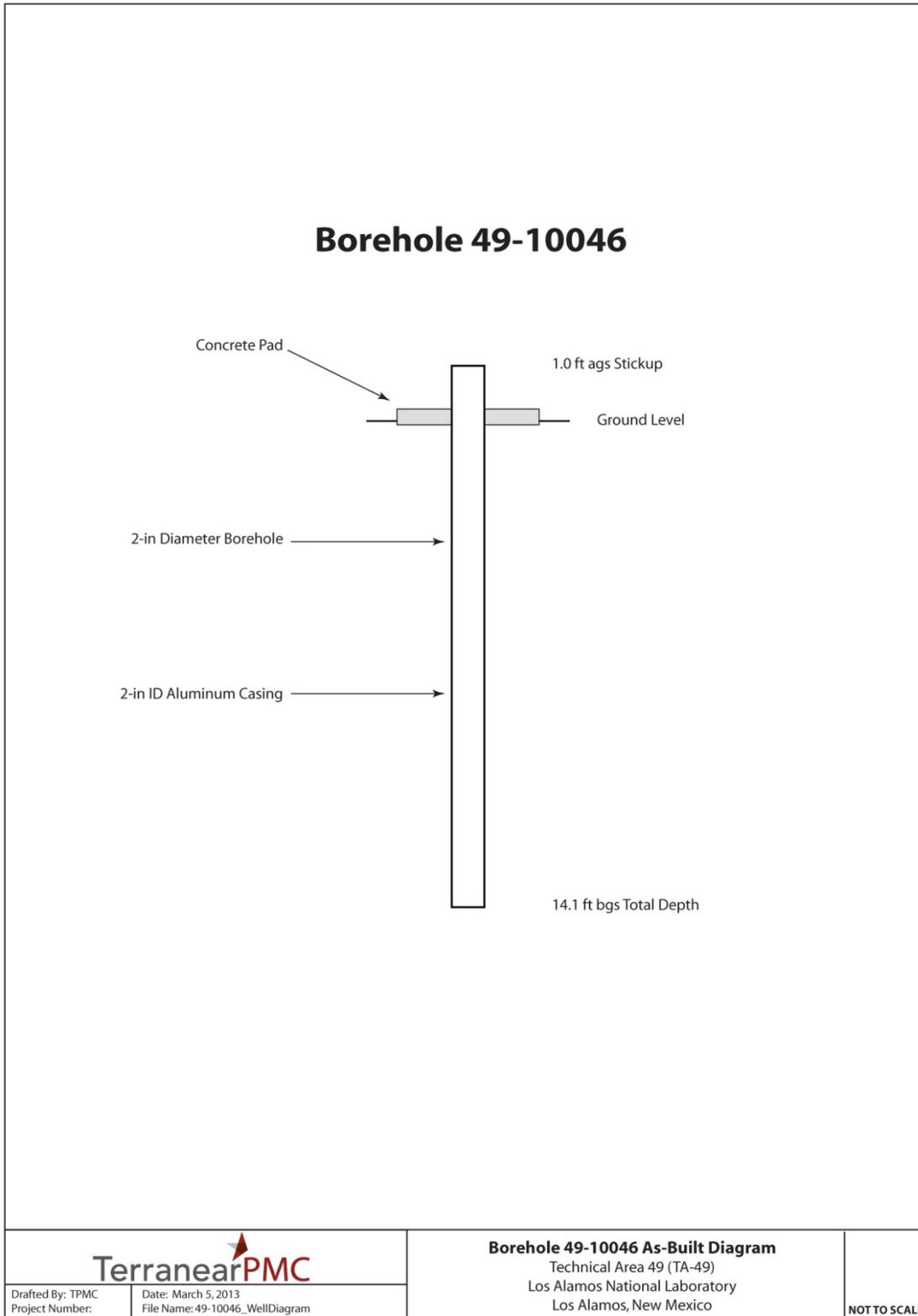


Figure 2.1-1 Borehole 49-10046 construction diagram

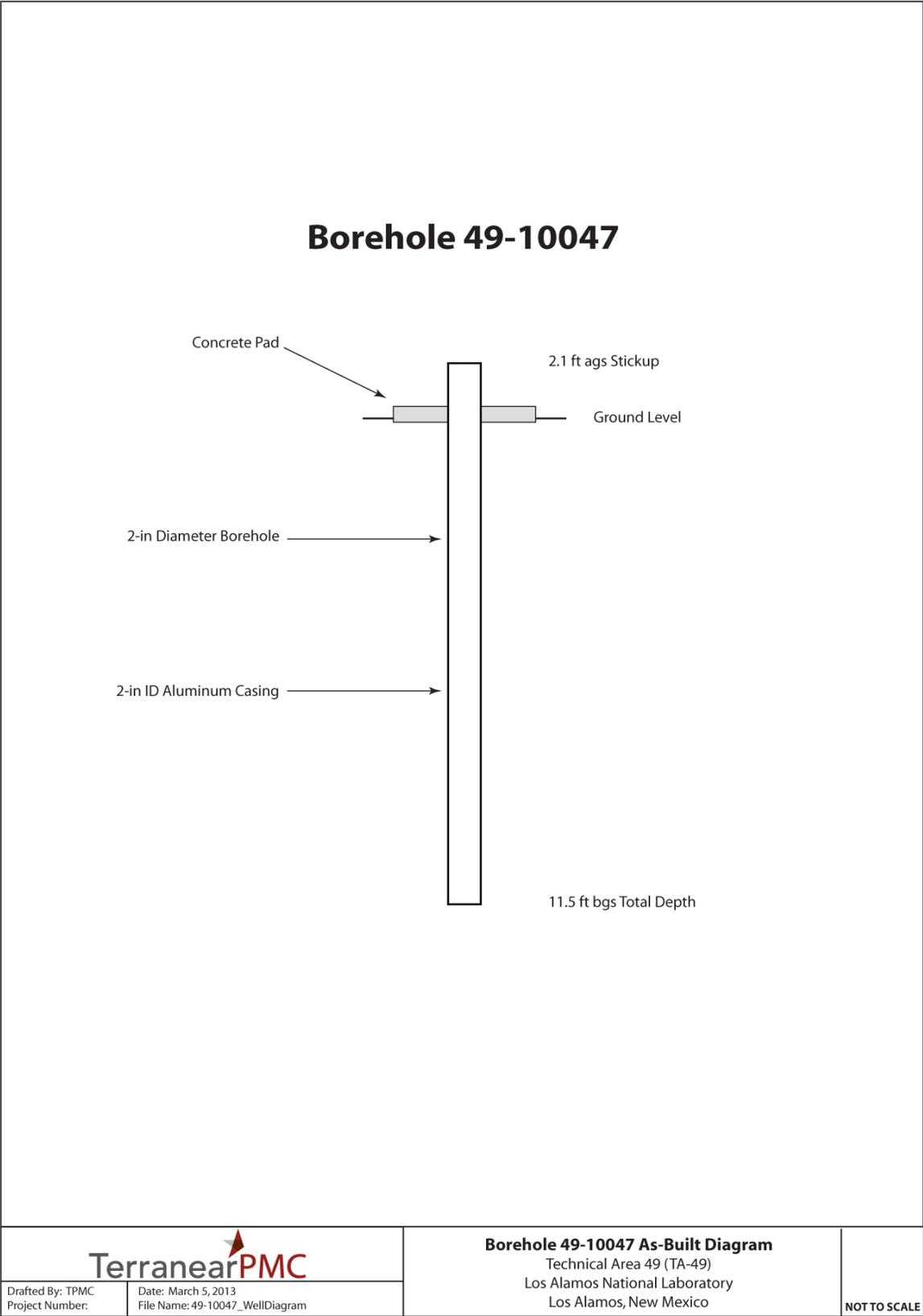
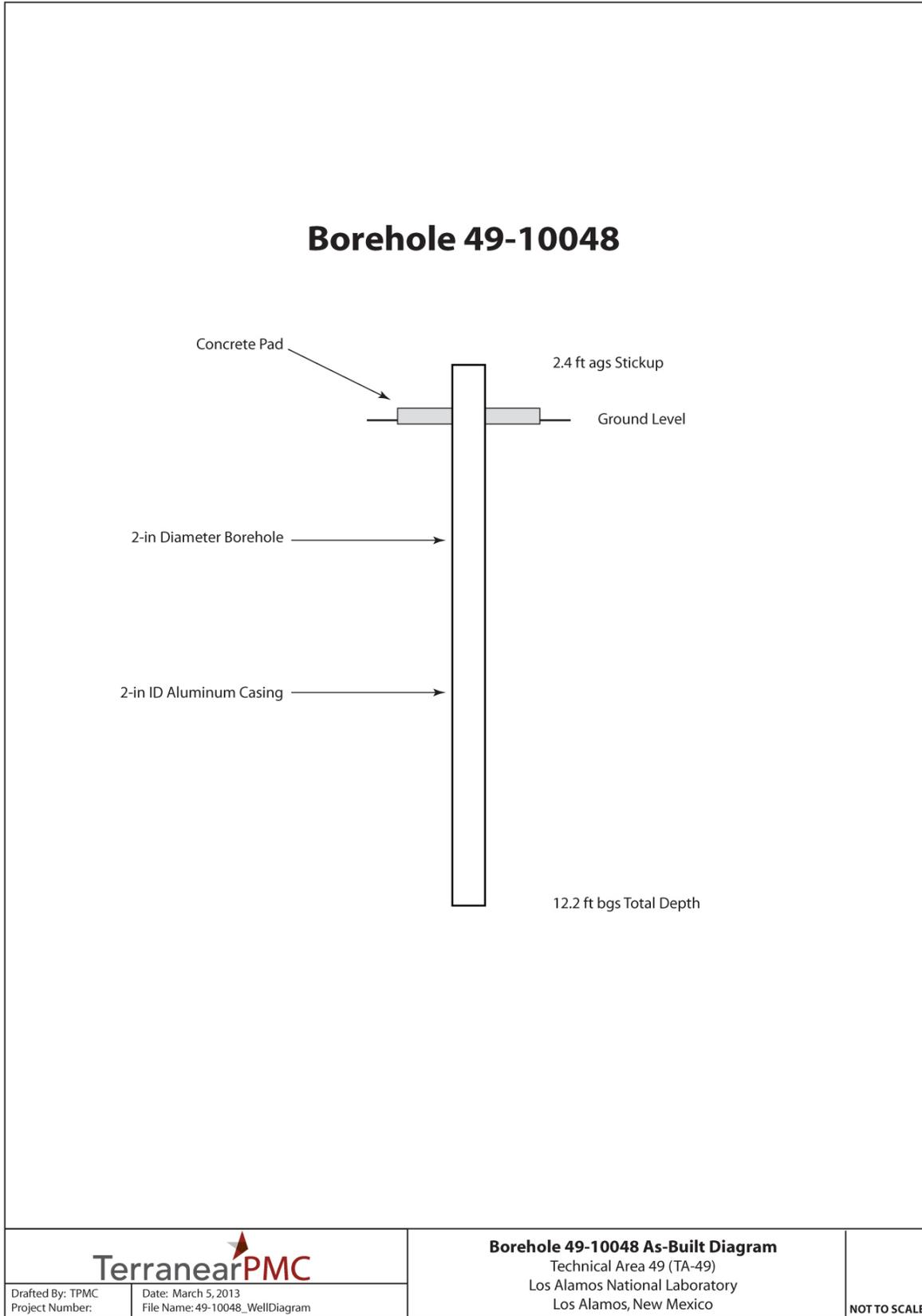
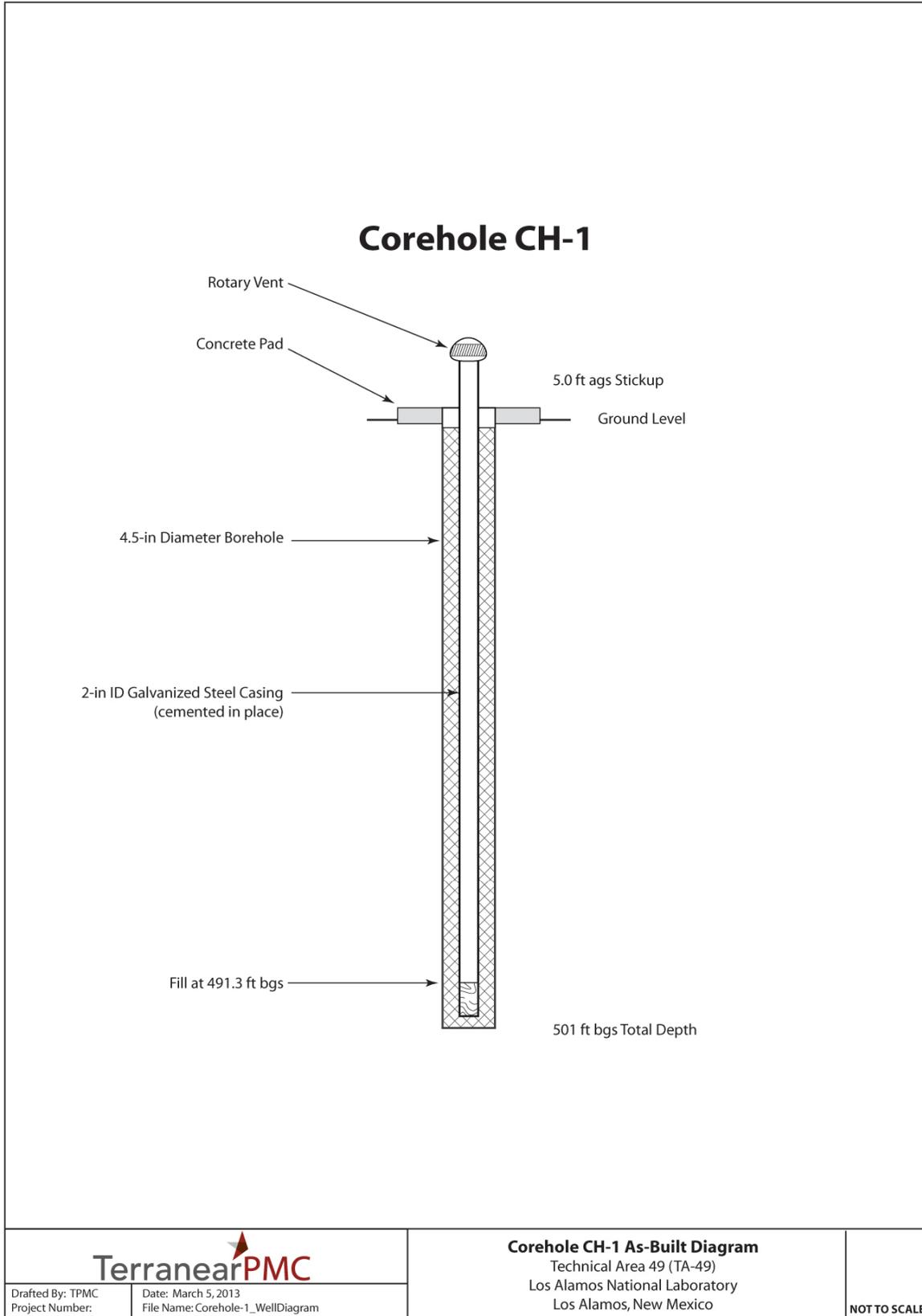


Figure 2.1-2 Borehole 49-10047 construction diagram



**Figure 2.1-3 Borehole 49-10048 construction diagram**



**Figure 2.2-1 CH-1 construction diagram**

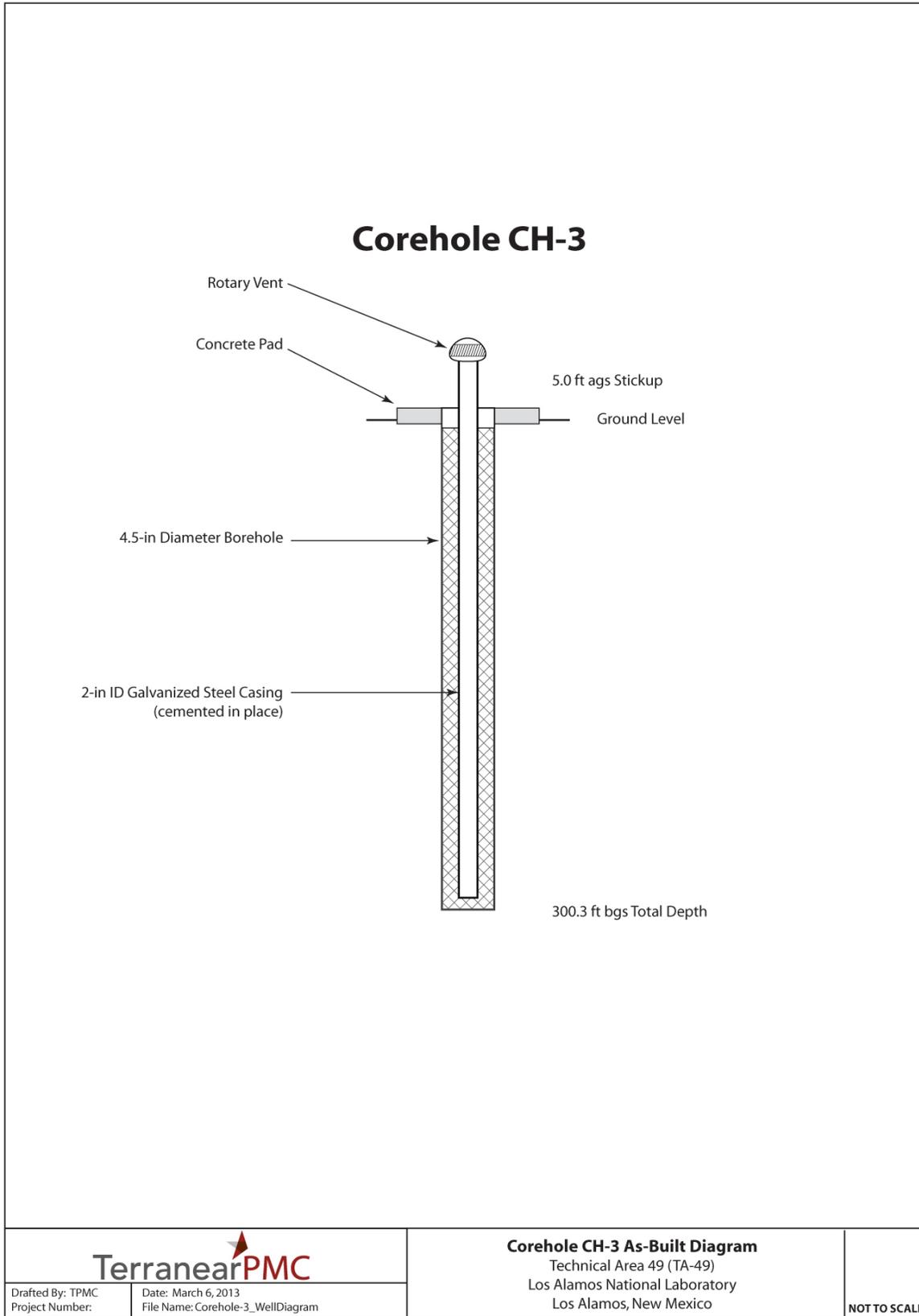
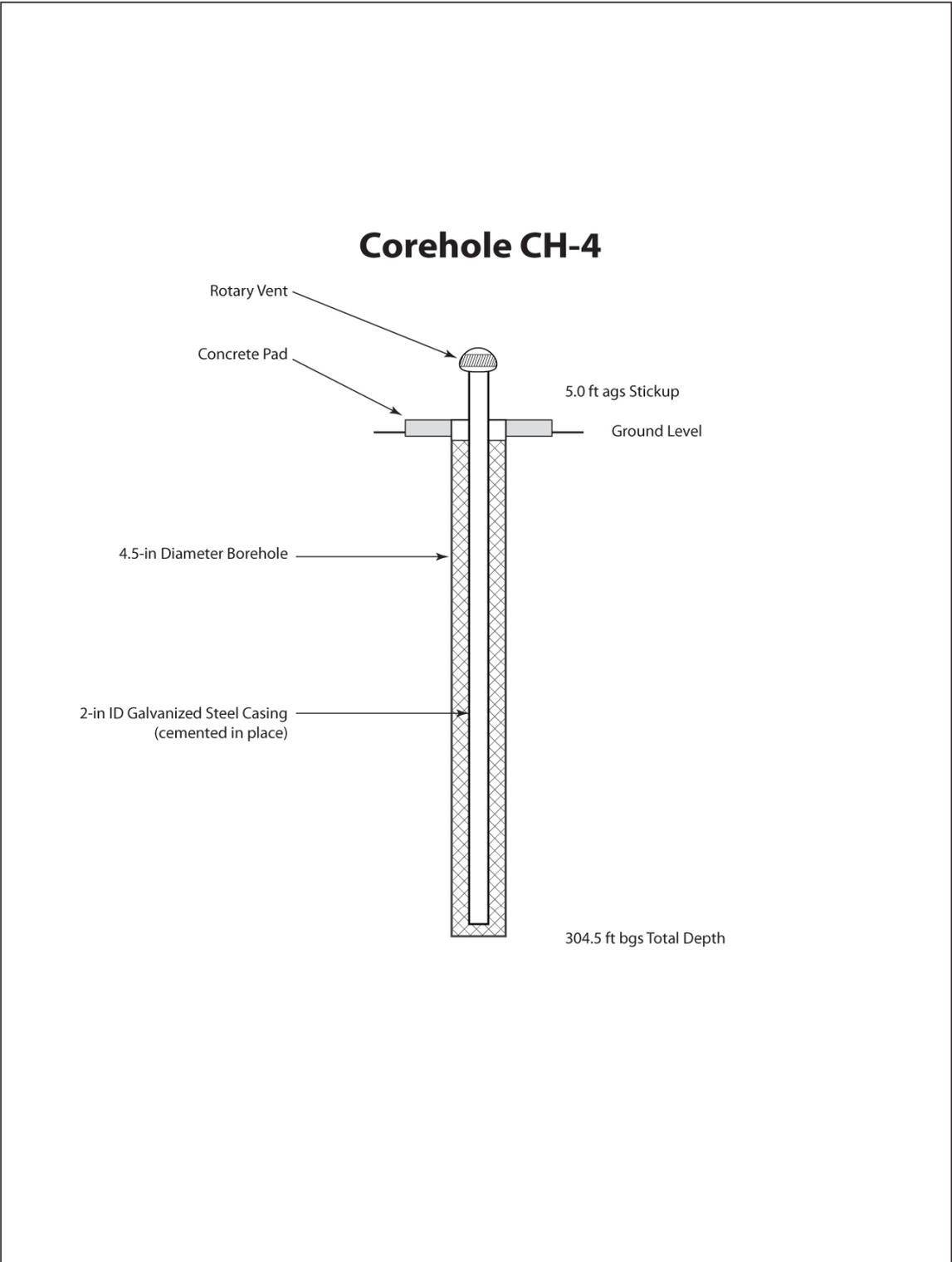


Figure 2.2-2 CH-3 construction diagram



		<b>Corehole CH-4 As-Built Diagram</b> Technical Area 49 (TA-49) Los Alamos National Laboratory Los Alamos, New Mexico	<b>NOT TO SCALE</b>
Drafted By: TPMC Project Number:	Date: March 6, 2013 File Name: Corehole-4_WellDiagram		

Figure 2.2-3 CH-4 construction diagram

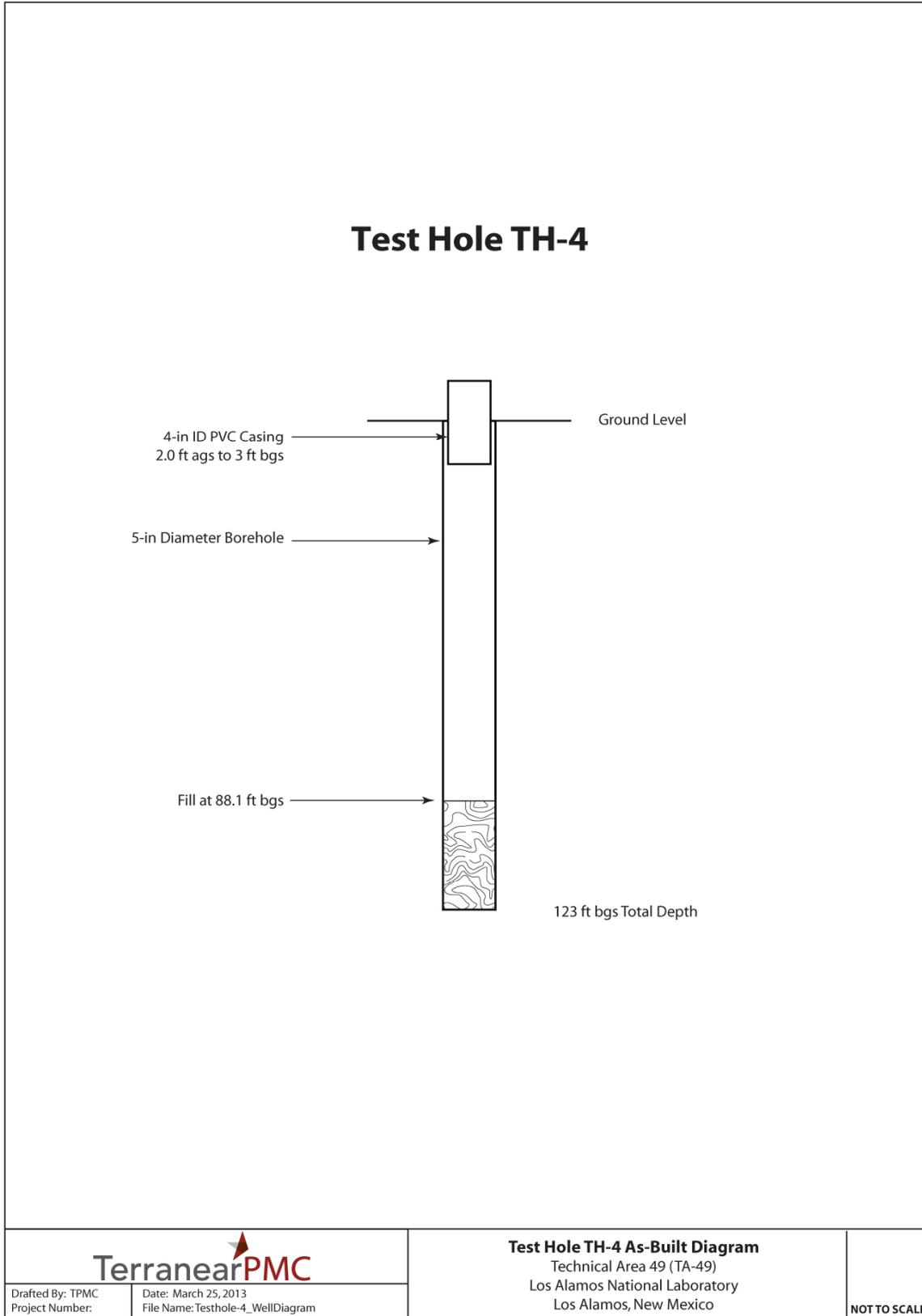


Figure 2.3-1 TH-4 construction diagram

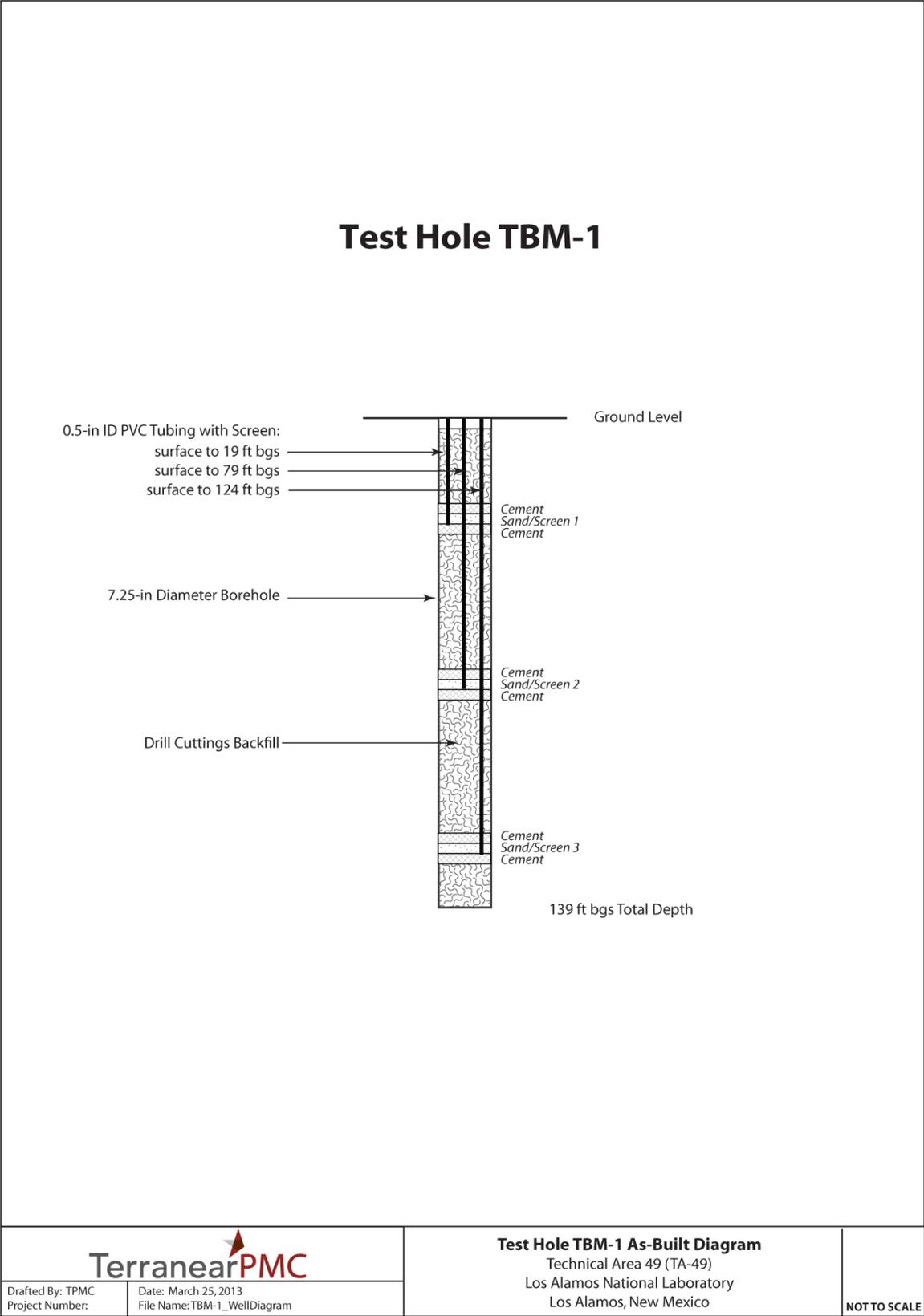
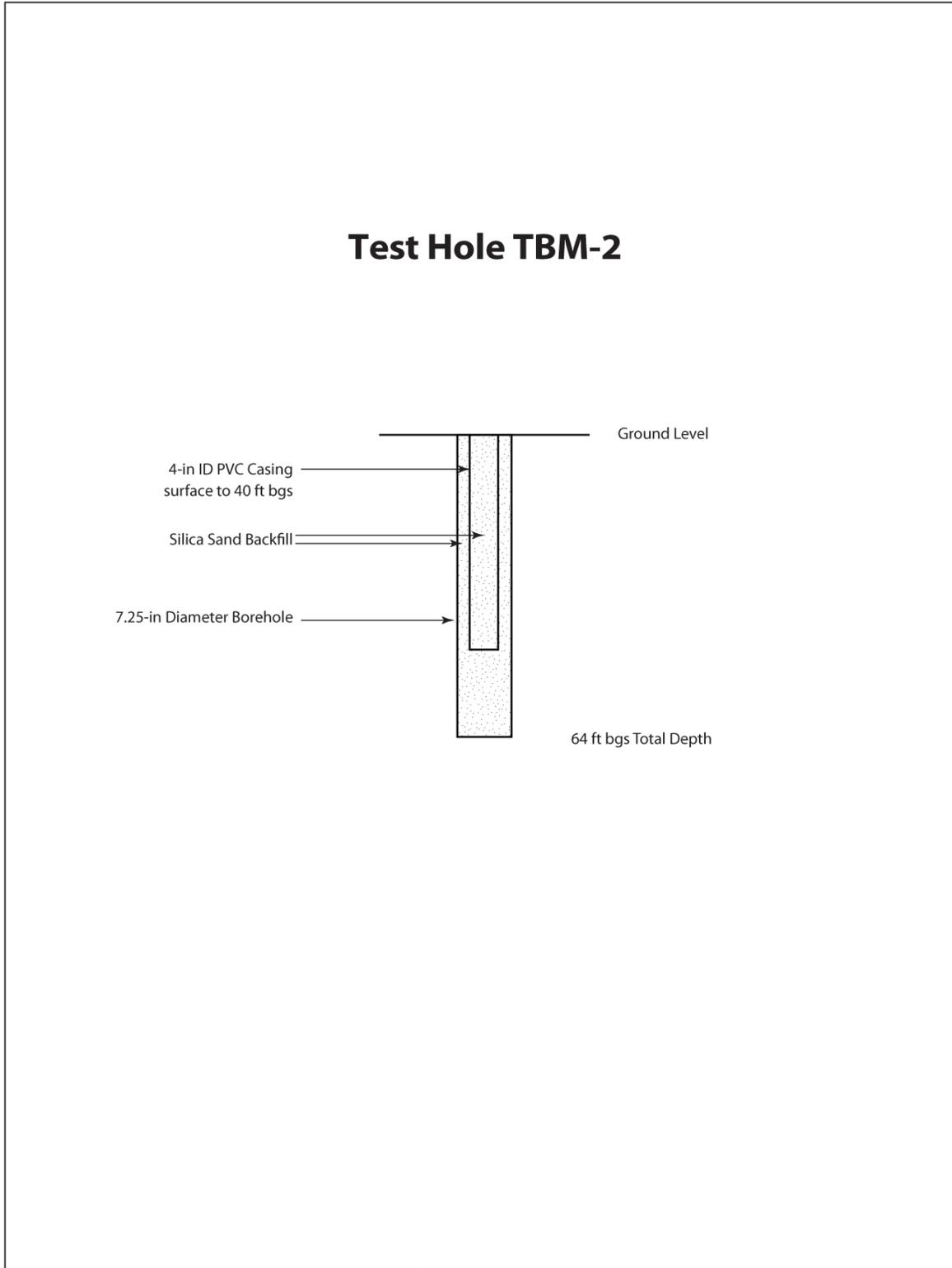
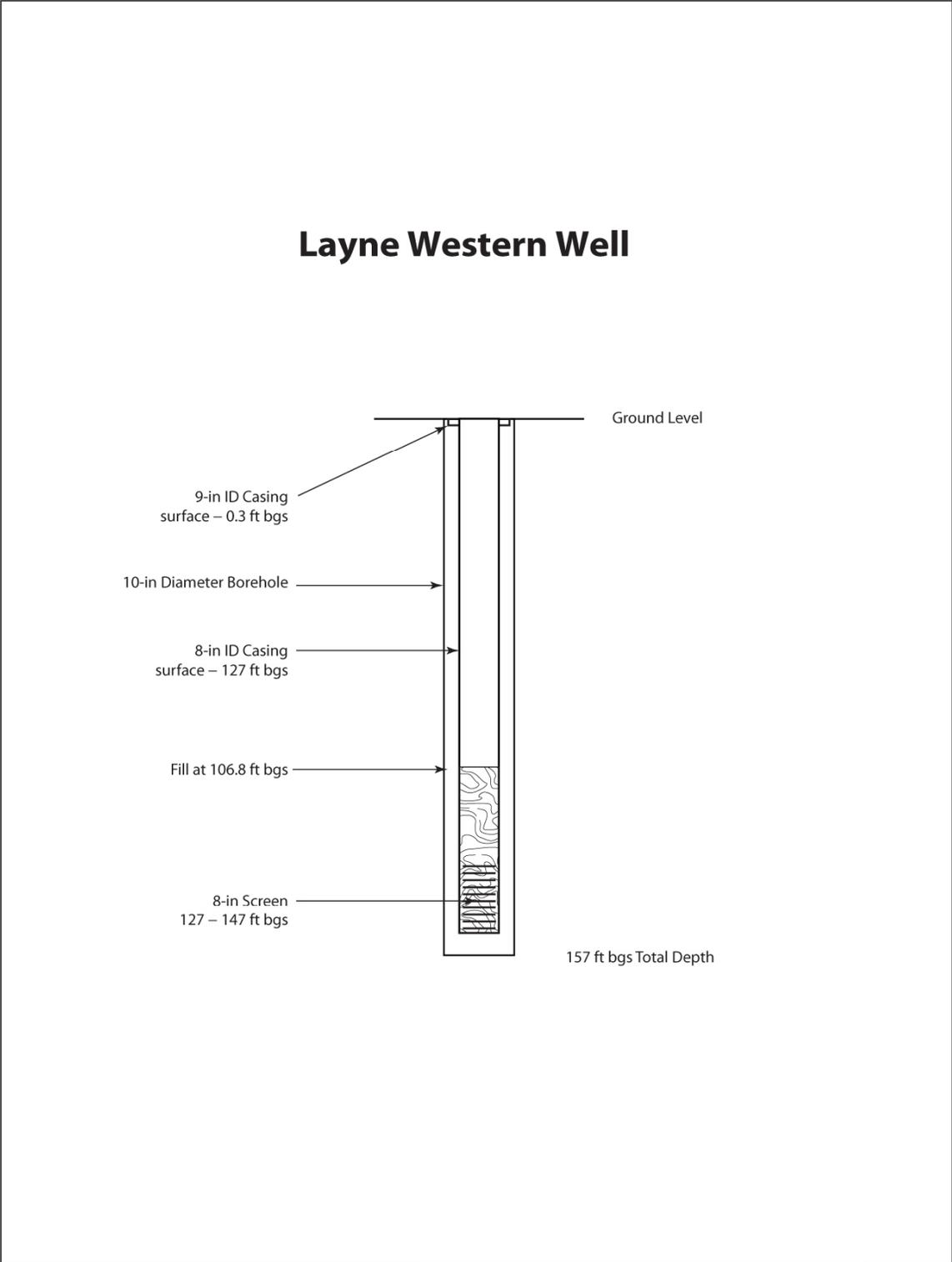


Figure 2.4-1 TBM-1 construction diagram



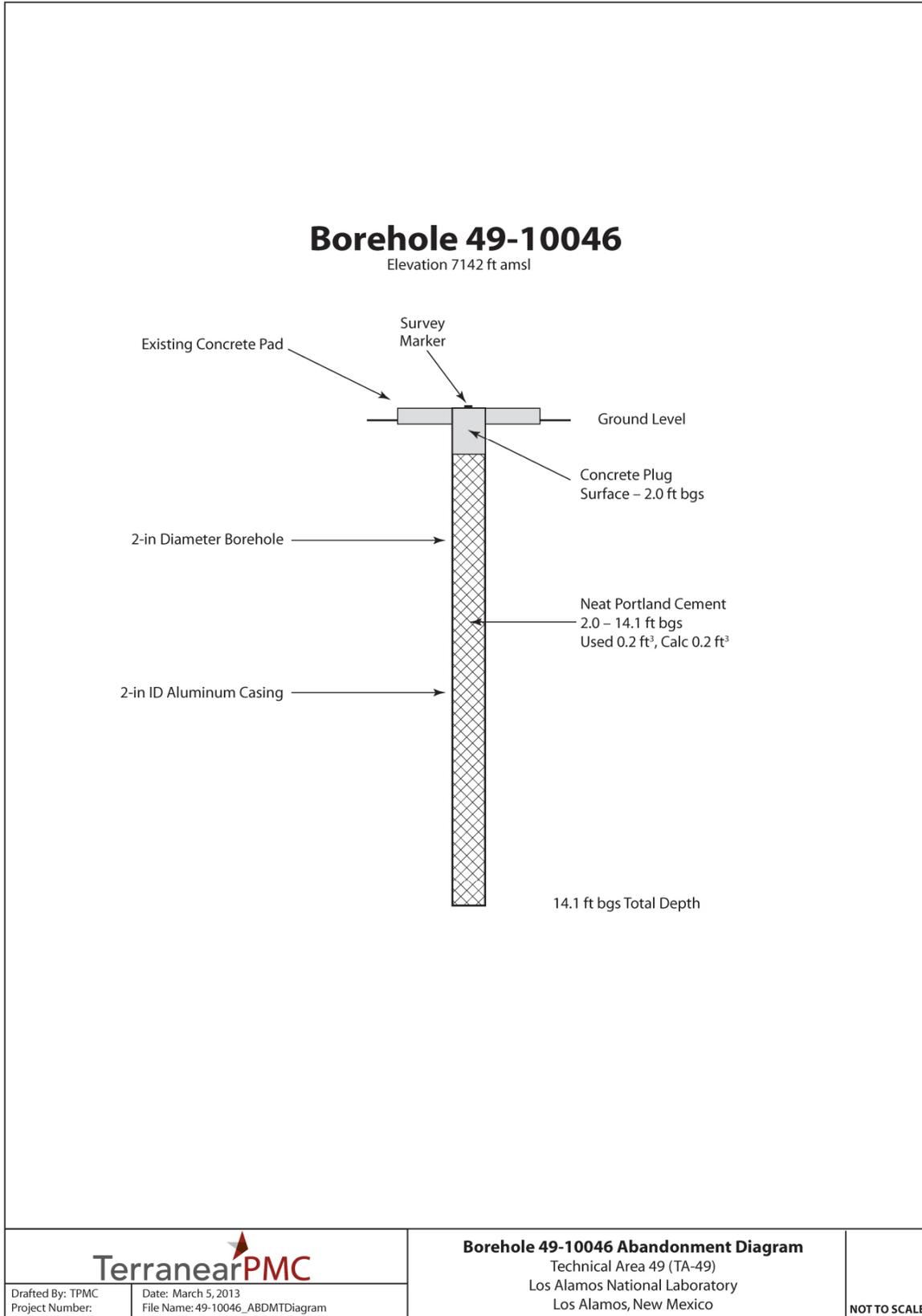
		<b>Test Hole TBM-2 As-Built Diagram</b> Technical Area 49 (TA-49) Los Alamos National Laboratory Los Alamos, New Mexico	<b>NOT TO SCALE</b>
Drafted By: TPMC Project Number:	Date: March 25, 2013 File Name: TBM-2_WellDiagram		

Figure 2.4-2 TBM-2 construction diagram



		<b>Layne Western Well As-Built Diagram</b> Lower Guaje Canyon Los Alamos National Laboratory Los Alamos, New Mexico	NOT TO SCALE
Drafted By: TPMC Project Number:	Date: March 12, 2013 File Name: LayneWestern_WellDiagram		

Figure 2.5-1 Layne Western well construction diagram



**Figure 3.1-1 Borehole 49-10046 abandonment diagram**

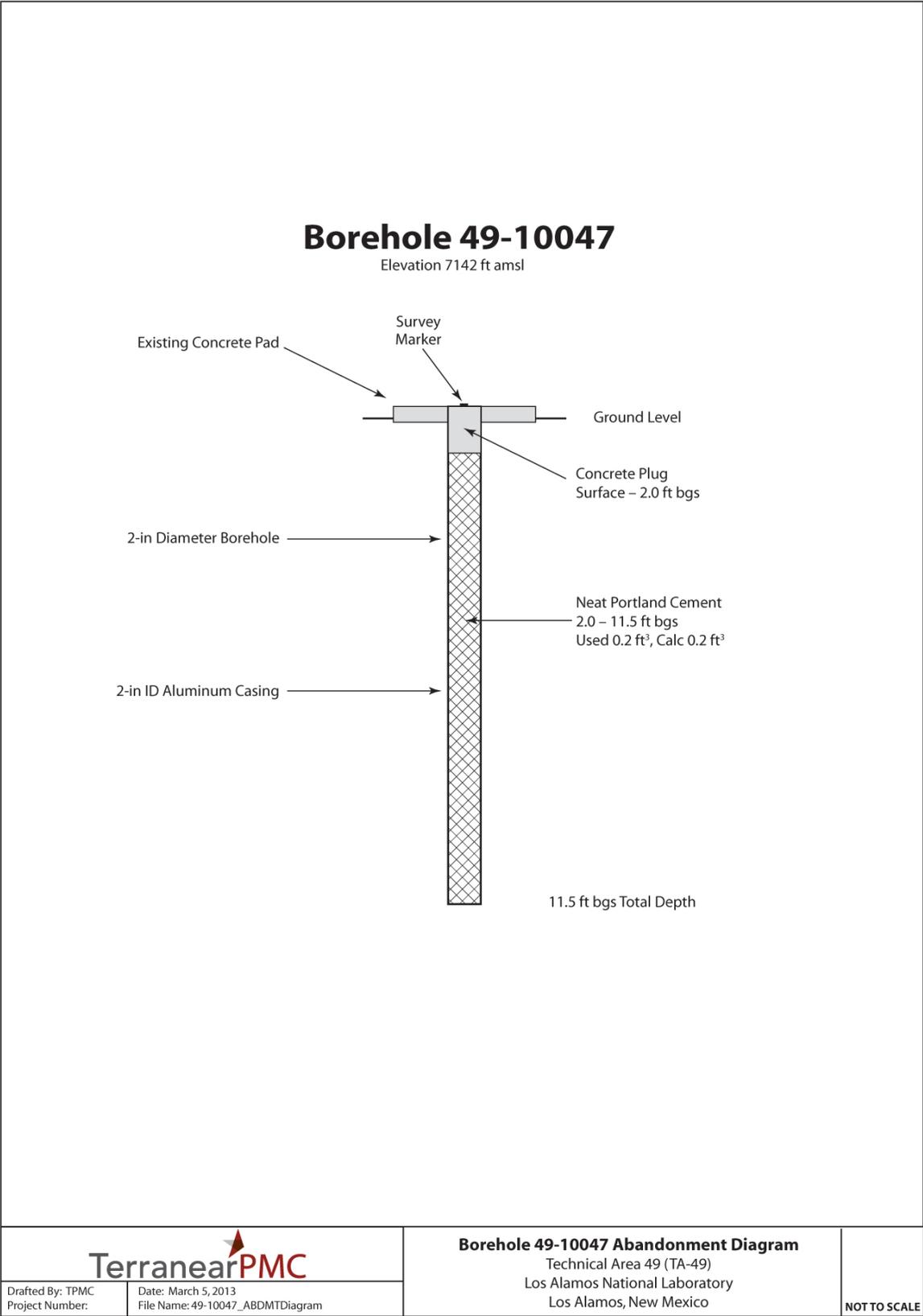


Figure 3.1-2 Borehole 49-10047 abandonment diagram

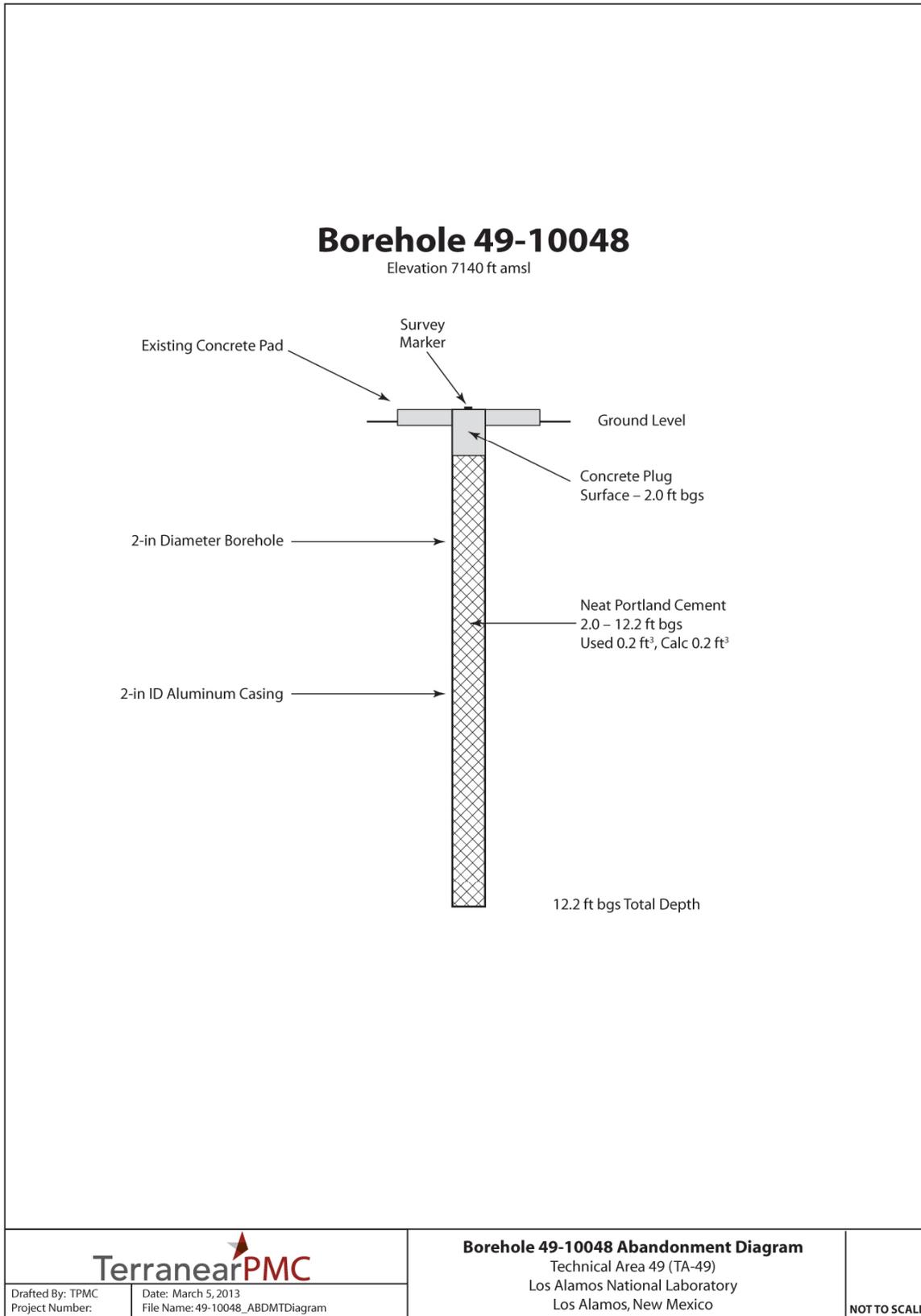
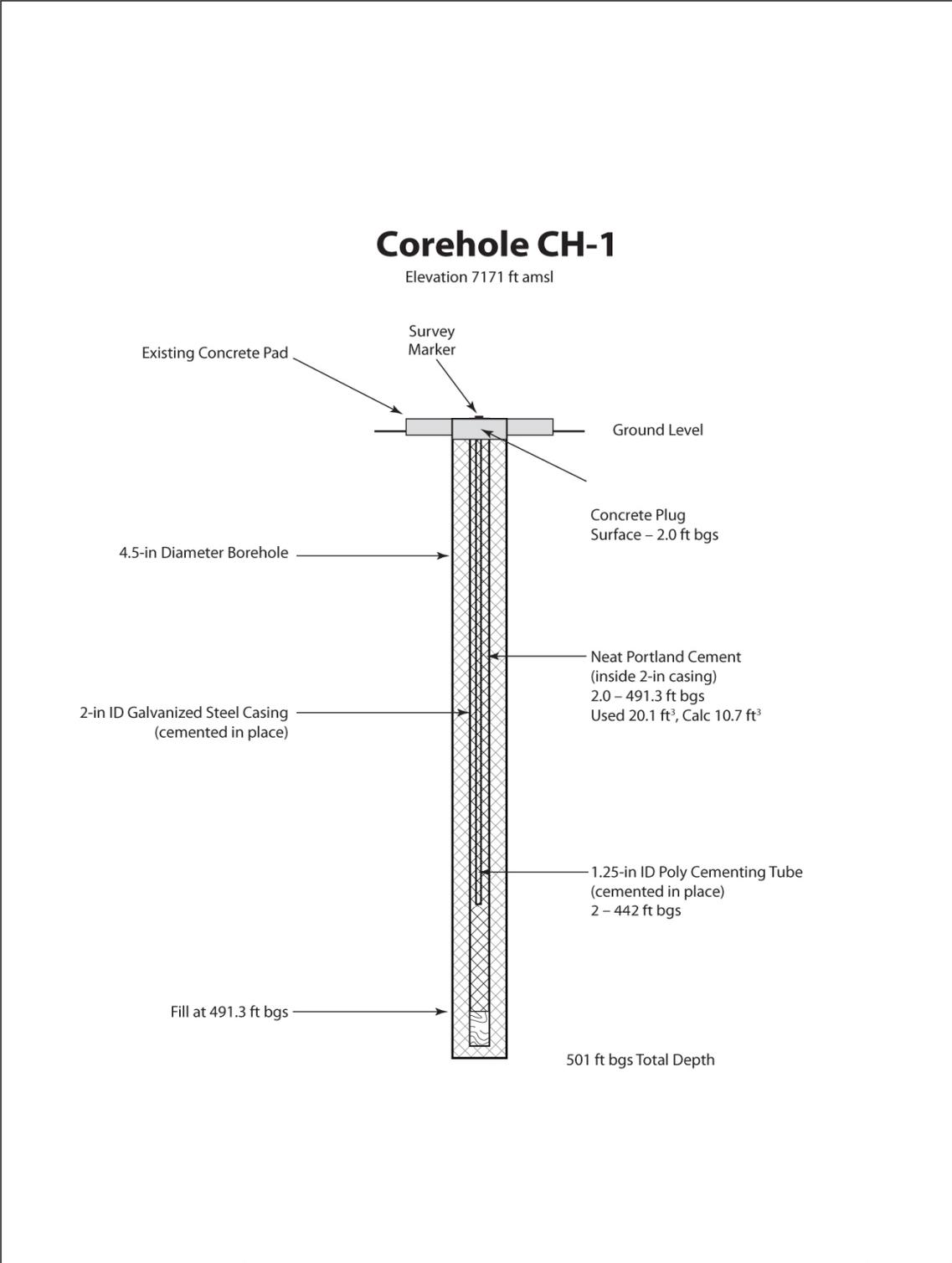


Figure 3.1-3 Borehole 49-10048 abandonment diagram



		<b>Corehole CH-1 Abandonment Diagram</b> Technical Area 49 (TA-49) Los Alamos National Laboratory Los Alamos, New Mexico	NOT TO SCALE
Drafted By: TPMC Project Number:	Date: March 25, 2013 File Name: Corehole-1_ABDMTDiagram		

Figure 3.2-1 CH-1 abandonment diagram

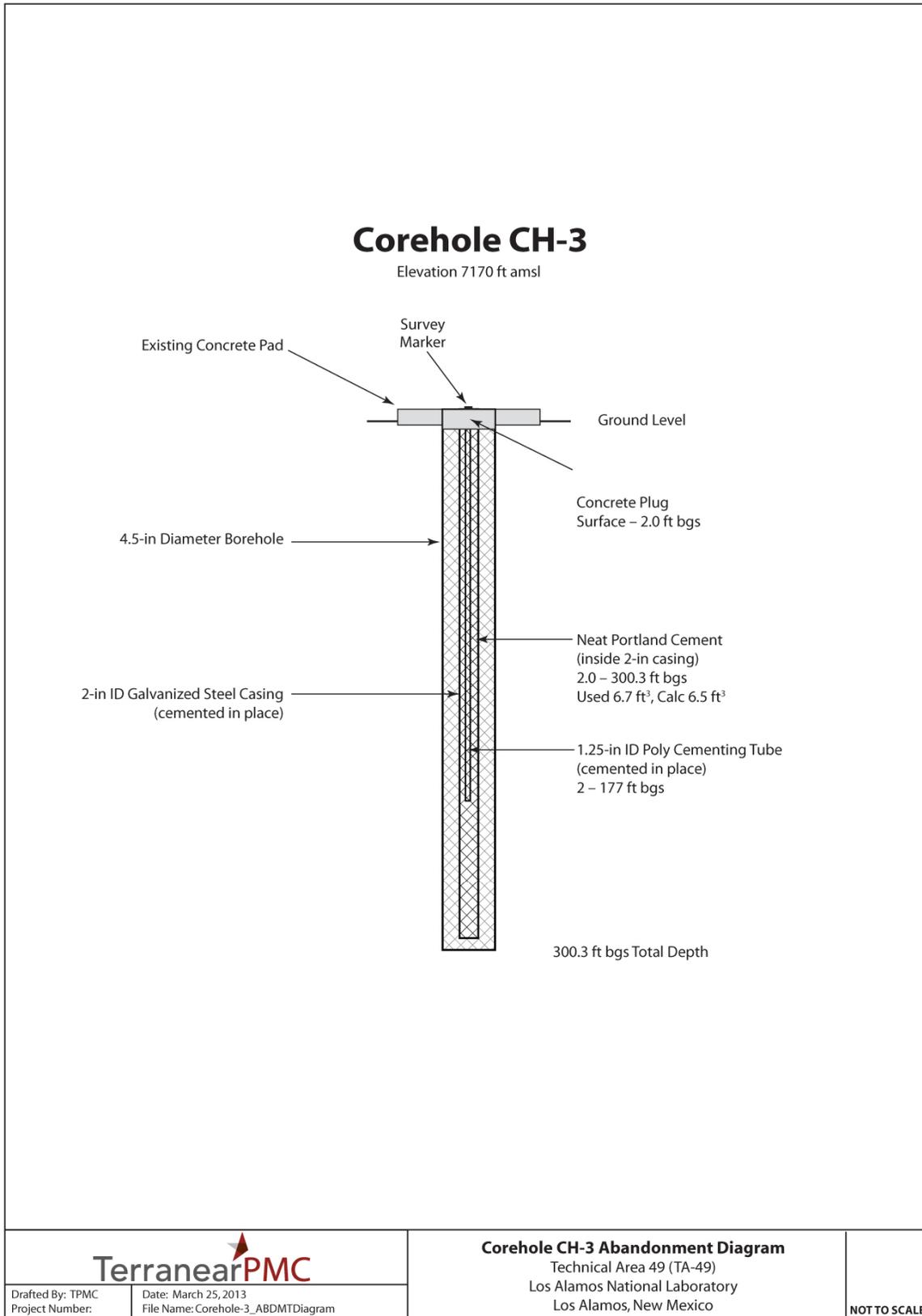
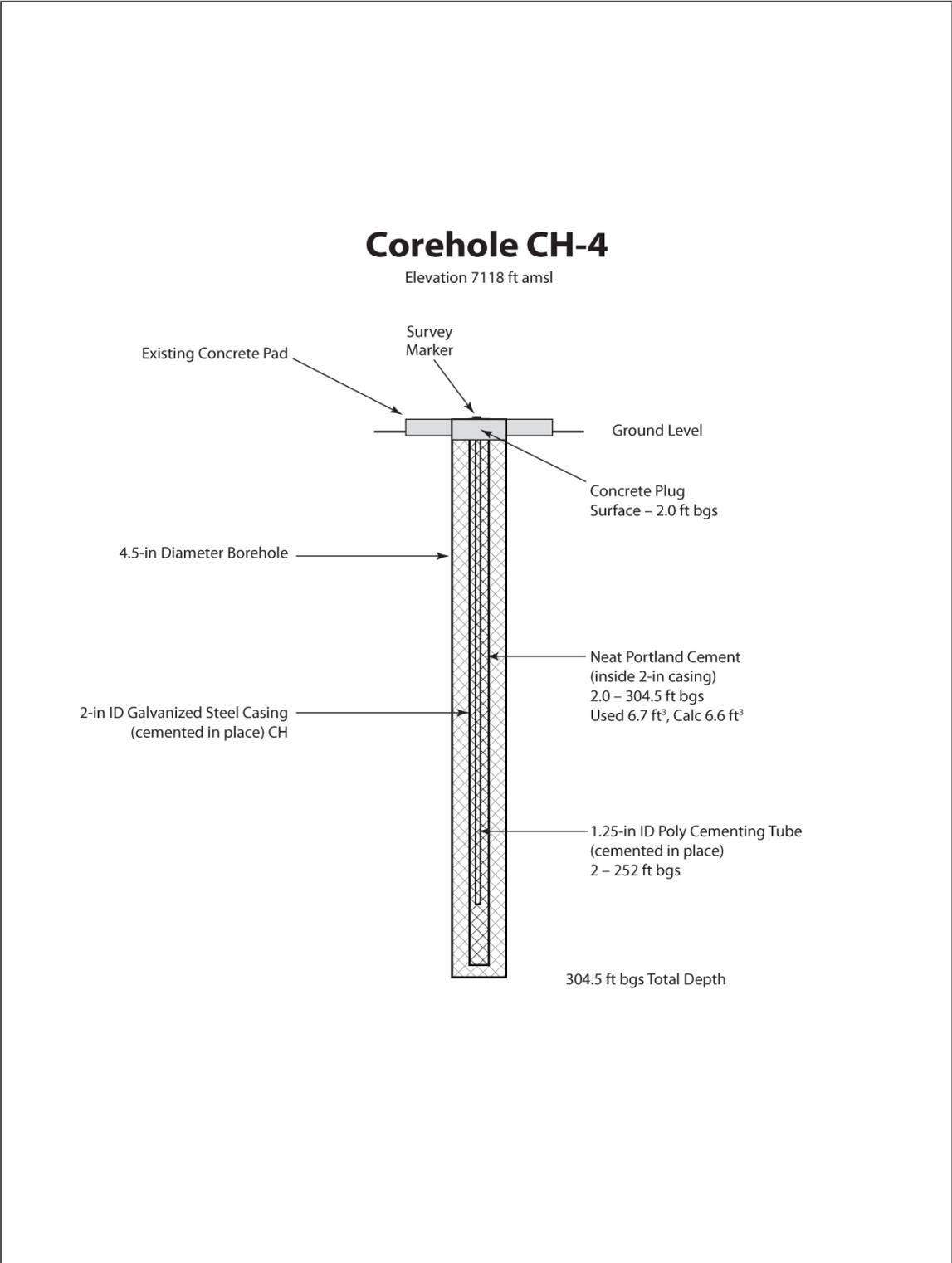
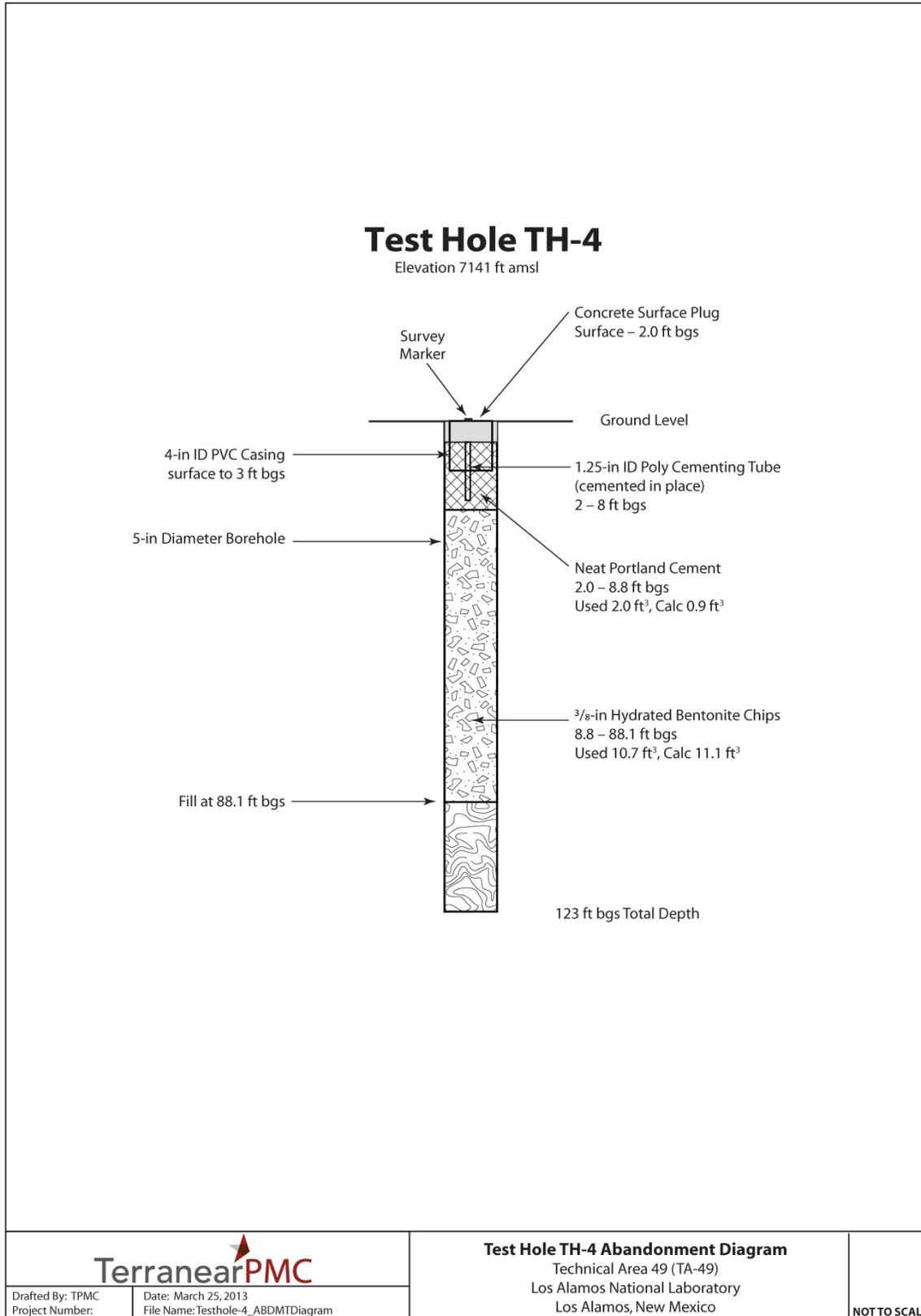


Figure 3.2-2 CH-3 abandonment diagram

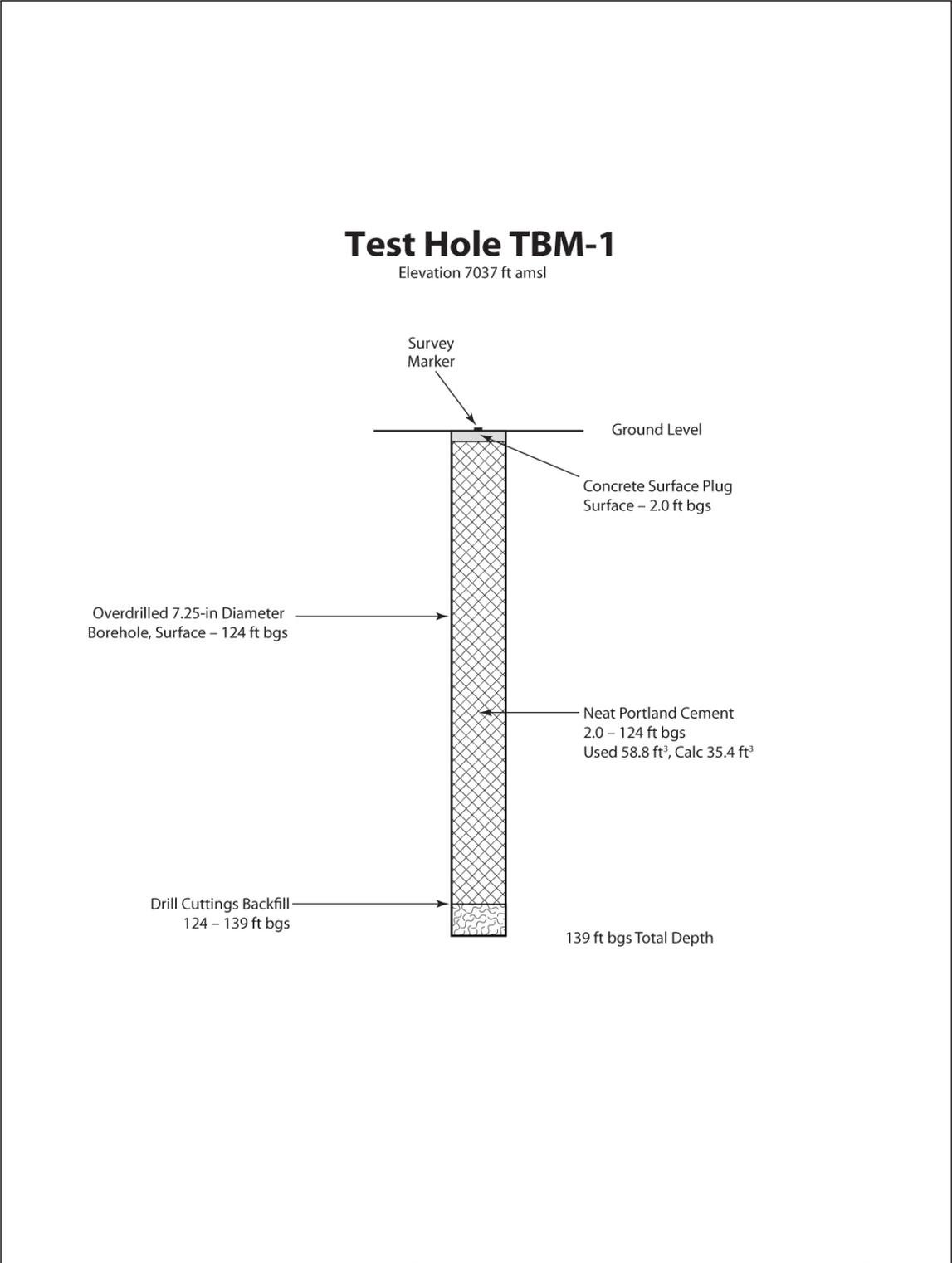


		<b>Corehole CH-4 Abandonment Diagram</b> Technical Area 49 (TA-49) Los Alamos National Laboratory Los Alamos, New Mexico	<b>NOT TO SCALE</b>
Drafted By: TPMC Project Number:	Date: March 25, 2013 File Name: Corehole-4_ABDMTDiagram		

Figure 3.2-3 CH-4 abandonment diagram

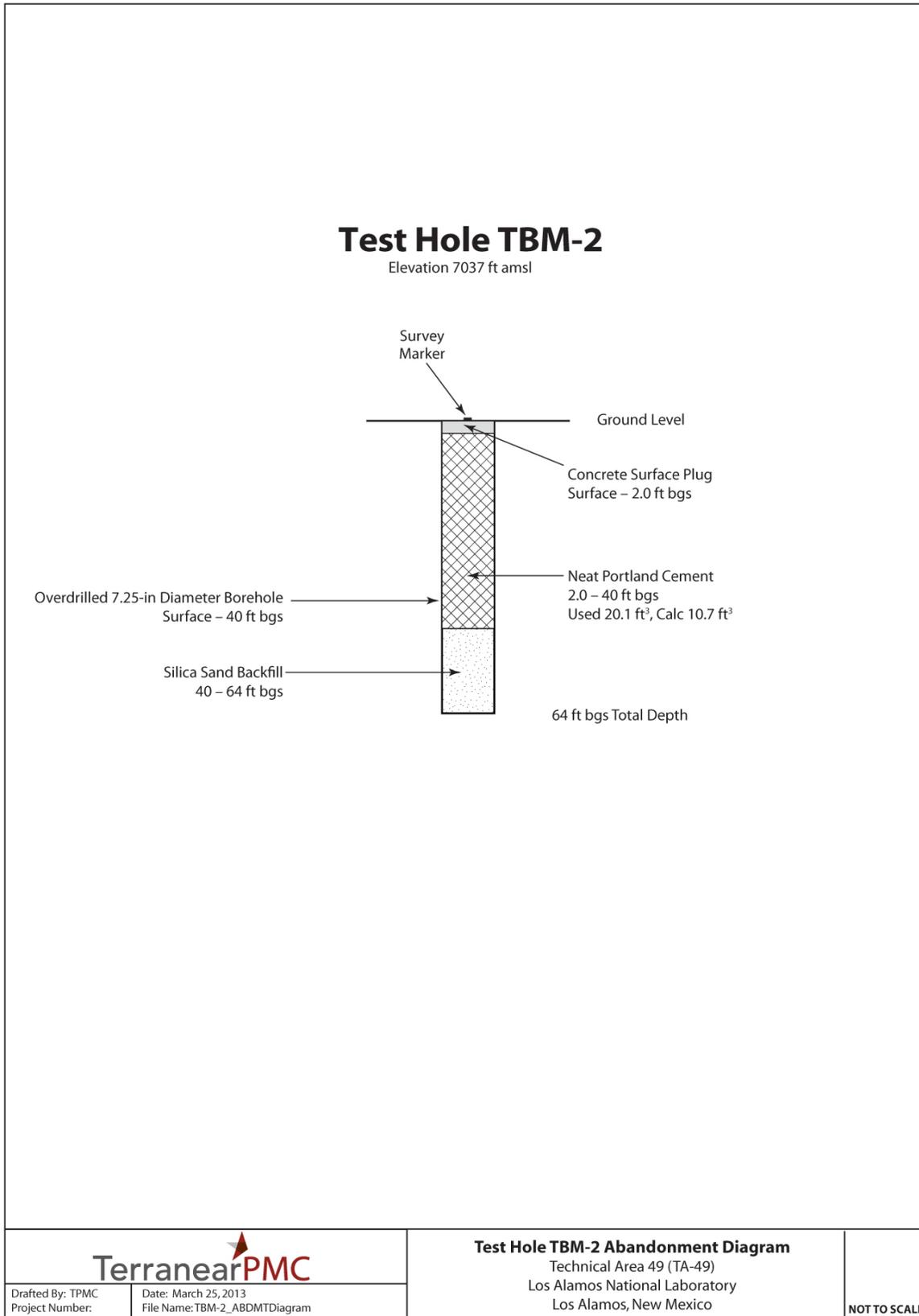


**Figure 3.3-1 TH-4 abandonment diagram**



		<b>Test Hole TBM-1 Abandonment Diagram</b> Technical Area 49 (TA-49) Los Alamos National Laboratory Los Alamos, New Mexico	<b>NOT TO SCALE</b>
Drafted By: TPMC Project Number:	Date: March 25, 2013 File Name: TBM-1_ABDMTDiagram		

Figure 3.4-1 TBM-1 abandonment diagram



**Figure 3.4-2 TBM-2 abandonment diagram**

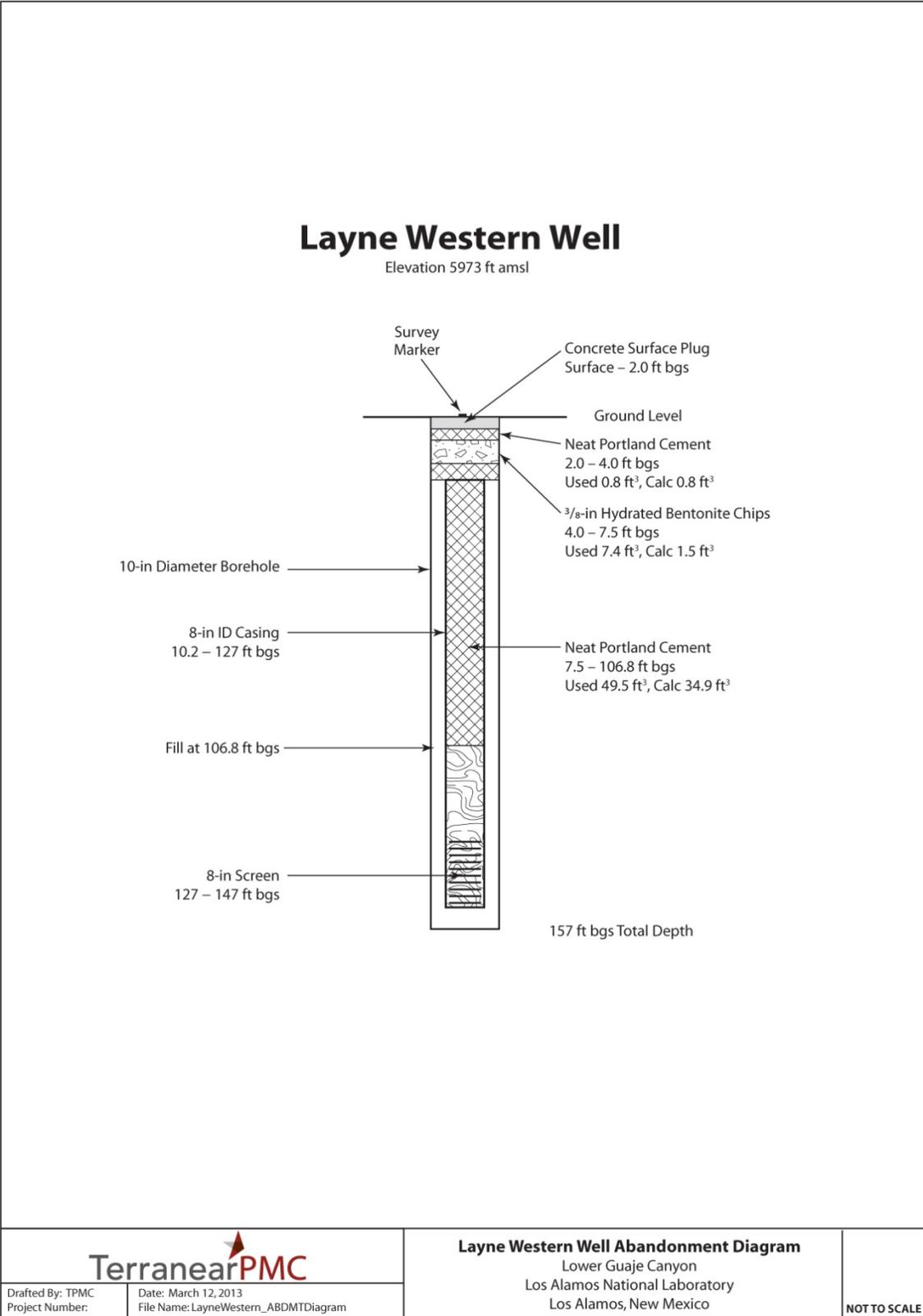


Figure 3.5-1 Layne Western Well abandonment diagram



**Table 3.1-1  
Quantity and Materials Used to Plug and Abandon Borehole 49-10046**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/19/13	14.1–2.0	16	1	0	0.2	0.2
<b>Total</b>		<b>16</b>	<b>1</b>	<b>0</b>	<b>0.2</b>	<b>0.2</b>

**Table 3.1-2  
Quantity and Materials Used to Plug and Abandon Borehole 49-10047**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/19/13	11.5–2.0	16	1	0	0.2	0.2
<b>Total</b>		<b>16</b>	<b>1</b>	<b>0</b>	<b>0.2</b>	<b>0.2</b>

**Table 3.1-3  
Quantity and Materials Used to Plug and Abandon Borehole 49-10048**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/19/13	12.2–2.0	16	1	0	0.2	0.2
<b>Total</b>		<b>16</b>	<b>1</b>	<b>0</b>	<b>0.2</b>	<b>0.2</b>

**Table 3.2-1  
Quantity and Materials Used to Plug and Abandon CH-1**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/15/13	491.3–2.0	1504	110	0	10.7	20.1
<b>Total</b>		<b>1504</b>	<b>110</b>	<b>0</b>	<b>10.7</b>	<b>20.1</b>

**Table 3.2-2  
Quantity and Materials Used to Plug and Abandon CH-3**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/14/13	300.3–2.0	517	35	0	6.5	6.7
<b>Total</b>		<b>517</b>	<b>35</b>	<b>0</b>	<b>6.5</b>	<b>6.7</b>

**Table 3.2-3  
Quantity and Materials Used to Plug and Abandon CH-4**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/15/13	304.5–2.0	517	35	0	6.6	6.7
<b>Total</b>		<b>517</b>	<b>35</b>	<b>0</b>	<b>6.6</b>	<b>6.7</b>

**Table 3.3-1  
Quantity and Materials Used to Plug and Abandon Test Hole TH-4**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/19/13	88.1–8.8	0	200	800	11.1	10.7
2/19/13	8.8–2.0	141	9	0	0.9	2.0
<b>Total</b>		<b>141</b>	<b>209</b>	<b>800</b>	<b>12.0</b>	<b>12.7</b>

**Table 3.4-1  
Quantity and Materials Used to Plug and Abandon TBM-1**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/20/13	124.0–2.0	2820	270	0	35.4	58.8
<b>Total</b>		<b>2820</b>	<b>270</b>	<b>0</b>	<b>35.4</b>	<b>58.8</b>

**Table 3.4-2  
Quantity and Materials Used to Plug and Abandon TBM-2**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/20/13	39.0–2.0	846	81	0	10.7	20.1
<b>Total</b>		<b>846</b>	<b>81</b>	<b>0</b>	<b>10.7</b>	<b>20.1</b>

**Table 3.5-1  
Quantity and Materials Used to Plug and Abandon Layne Western Well**

Date	Depth Interval (ft bgs bottom to top)	Quantity Portland Type I/II Used (lb)	Quantity Municipal Water Used (gal.)	Quantity 3/8-in. Bentonite Used (lb)	Calculated Volume (ft <sup>3</sup> )	Actual Volume (ft <sup>3</sup> )
2/28/13	106.8–7.5	3478	222	0	34.9	49.5
2/28/13	7.5–4.0	0	20	550	1.5	7.4
2/28/13	4.0–2.0	12	4	0	0.8	0.8
<b>Total</b>		<b>3490</b>	<b>246</b>	<b>550</b>	<b>37.2</b>	<b>57.7</b>

**Table 4.1-1  
Survey Coordinates of Aluminum Pin Embedded in Surface Pad**

Identification	Northing	Easting	Elevation
49-10046	1755325.26	1625807.59	7142.5
49-10047	1755366.99	1625796.41	7142.8
49-10048	1755353.57	1625877.65	7140.4
CH-1	1755475.98	1624472.71	7171.9
CH-3	1754490.72	1624197.38	7170.7
CH-4	1753894.94	1625536.40	7118.2
TH-4	1755171.61	1625667.06	7141.4
TBM-1	1754595.57	1628546.59	7037.9
TBM-2	1754596.89	1628553.39	7037.2
Layne Western Well	1783496.26	1656285.62	5973.9



## **Appendix A**

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*Video Log of Layne Western Well  
(on DVD included with this document)*



## **Appendix B**

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*Gamma Log of Layne Western Well  
(on CD included with this document)*

