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Ms. Dilan Roe
Alameda County Health Care Services Agency
Department of Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

RECEIVED
By Alameda County Environmental Health 9:13 am, Feb 21, 2017

Re: 1233 Bockman Road – Acknowledgement Statement
San Lorenzo, California
ACEH Case No. 3217

Dear Ms. Roe:

PaulsCorp, LLC, has retained the environmental consultant referenced on the attached report for the project referenced above. The attached report is being submitted on PaulsCorp's, LLC, behalf.

I have read and acknowledge the content, recommendations and/or conclusions contained in the attached document or report submitted on my behalf to ACDEH's FTP server and the State Water Resources Control Board's GeoTracker website.

Sincerely,

Scott Schoeman
Development Associate

February 13, 2017

Scott Schoeman
PaulsCorp, LLC
100 Saint Paul Street
Denver, Colorado 80206

Re: **VIMS Basis of Design Report**
Bockman Road Property
1233 Bockman Road
San Lorenzo, California 94577
ACDEH Case # RO00003217

Dear Mr. Lavaux:

On behalf of PaulsCorp, LLC, PANGEA Environmental Services, Inc. (PANGEA) is pleased to present this *Vapor Intrusion Mitigation System Basis of Design Report, Construction Quality Assurance Plan, and Operations & Maintenance Plan – Buildings 5 – 8* ("Design Basis Report") prepared for the project at 1233 Bockman Road, San Lorenzo, California ("the Site"). The overall development project includes the planned construction of 53 two–story residential units within 10 buildings at the property. This Design Basis Report for Building 5 & 8 is similar to the prior Design Basis Report for Buildings 1 through 4, but this report incorporates a subslab engineered vapor barrier. This plan was prepared at the request of the Alameda County Department of Environmental Health (ACDEH) during a meeting on February 2, 2017. If you have any questions or comments, please call me at (510) 435-8664 or email briddell@pangeaenv.com.

Sincerely,
PANGEA Environmental Services, Inc.

Bob Clark-Riddell, P.E.
Principal Engineer

Attachment: *Vapor Intrusion Mitigation System Basis of Design Report, Construction Quality Assurance Plan, and Operations & Maintenance Plan – Buildings 5 & 8*

VAPOR INTRUSION MITIGATION SYSTEM BASIS OF DESIGN REPORT, CONSTRUCTION QUALITY ASSURANCE PLAN, AND OPERATIONS & MAINTENANCE PLAN – BUILDINGS 5 & 8

1233 Bockman Road
San Lorenzo, CA 94577

February 13, 2017

Prepared for:

PaulsCorp, LLC
100 Saint Paul Street
Denver, Colorado 80206

Prepared by:

PANGEA Environmental Services, Inc.
1710 Franklin Street, Suite 200
Oakland, California 94612

Written by:

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Table of Contents

1.0 INTRODUCTION **1**

1.1 Document Purpose and Scope 2

2.0 PROJECT AND MITIGATION OBJECTIVES **3**

2.1 Design Objectives and Basis 3
2.2 Mitigation Objectives 3
2.2.1 Soil Gas *3*
2.2.2 Indoor Air *4*

3.0 VAPOR MITIGATION SYSTEM DESIGN **4**

3.1 Key Design Parameters 5
3.2 Sub-Slab Ventilation (SSV) System 5
3.2.1 Maximum Allowable Design Flow Rate *6*
3.2.2 Permeable Base *8*
3.2.3 Vapor Collection Piping *8*
3.2.4 Vapor Collection Risers *9*
3.2.5 Wind-Driven Turbine Fan *9*
3.2.6 SSV System Layout *9*
3.3 Sub-slab Engineered Vapor Barrier System 9
3.4 Slab Penetration Sealing 9
3.5 Closure of Potential Preferential Pathways 10
3.6 Contingent Active SSV System 10

4.0 VIMS IMPLEMENTATION **11**

4.1 Preconstruction Activities 11
4.2 VIMS Installation 11
4.2.1 Mobilization and Site Preparation *11*
4.2.2 Environmental Controls for Storm Water and Dust *11*
4.2.3 Waste Management *12*
4.2.4 Site Restoration, Project Closeout, and Demobilization *12*
4.2.5 Survey *12*

5.0 CONSTRUCTION QUALITY AND ASSURANCE PLAN **12**

5.1 Construction Quality Assurance Roles and Coordination 12
5.2 Quality Control for VIMS Installation 13
5.2.1 VIMS Materials Quality Control *13*
5.2.2 VIMS Construction Quality Control *13*

6.0 OPERATIONS AND MAINTENANCE PLAN **14**

6.1 VIMS Performance Monitoring 14
6.1.1 Vent Riser Sampling *14*
6.1.2 Vent Flow Rate Adjustment *15*
6.1.3 Monitoring for Contingent Active SSV System Operation *15*
6.1.4 Indoor Air Sampling *15*
6.2 VIMS Maintenance 15
6.2.1 Normal Operation of System *16*
6.2.2 Monitoring and Regular Maintenance *16*
6.2.3 Recordkeeping and Reporting *16*
6.2.4 System Disruptions, Alterations, Repairs, and Improvements *17*

6.2.5 Annual Review *17*
6.2.6 Measures for the Termination of Long Term O&M *17*
6.2.7 Event Response *18*

7.0 REPORTING AND SCHEDULE **18**

7.1 DOCUMENTATION AND REPORTING 18
7.2 PRELIMINARY SCHEDULING 19

8.0 REFERENCES **20**

ATTACHMENTS

Figure 1 Vicinity Map
Figure 2 Site Map
Figure 3 Stie Vapor Mitigation Summary

Appendix A Development Plans
Appendix B VIMS Design Drawings
Appendix C Wind Turbine Fan and Active Blower Specifications
Appendix D RetroCoat™ Vapor Barrier Information
Appendix E Estimating VOC Emissions for VMS Systems

1.0 INTRODUCTION

On behalf of PaulsCorp, LLC, Pangea Environmental Services, Inc. is pleased to present this *Vapor Intrusion Mitigation System Basis of Design Report, Construction Quality Assurance Plan, and Operations & Maintenance Plan – Buildings 5 &8* ("Design Basis Report") prepared for the project at 1233 Bockman Road, San Lorenzo, California ("the Site")(Figure 1). The overall development project includes the planned construction of 53 two–story residential units within 10 buildings at the property. This Design Basis Report for Building 5 & 8 is similar to the prior Design Basis Report for Buildings 1 through 4, but this report incorporates a subslab engineered vapor barrier. This plan was prepared at the request of the Alameda County Department of Environmental Health (ACDEH) during a meeting on February 2, 2017.

Subsurface investigations previously performed at the Site by others have identified several volatile organic compounds (VOCs), including benzene, ethylbenzene, and tetrachloroethylene (PCE), in soil gas at the Site at concentrations that *may* pose a potential risk to indoor air quality for future residential users at the Site. The VOC presence within the *western* portion of the Site beneath planned Buildings 1 through 4 is likely associated with historic releases at the former *automotive repair facility* at 1415 Bockman. VOCs presence within the *eastern* portion of the Site beneath planned Buildings 5 through 10 may be associated with historic releases at the former historic *dry cleaner* at 1269 Bockman Road, former unknown sources at the subject site, and former offsite sources at 1210 Bockman (former Impulse Motors fueling station/offsite auto repair facility). PaulsCorp, LLC recently initiated site surveying to split the parcel into two legal entities, one for the western area of Buildings 1-4 and one for the eastern are of Buildings 5 – 10. A site map is provided as Figure 2. The locations planned Buildings 5 & 8 are shown on Figure 2 and in Appendix A.

Available data indicates that VOC concentrations in soil gas beneath Buildings 5 & 8 exceed conservative environmental screening levels (ESLs) at select locations. The ethylbenzene impact in soil gas exceeding ESLs is present beneath a portion of planned Building 5. The PCE impact in soil gas exceeding ESLs is present between the planned foot print for Buildings 5 & 8, but has the potential to impact the planned building area via soil gas plume migration or via PCE migration within subsurface preferential pathways. Absent longer-term data, ACDEH is requiring initial vapor intrusion mitigation measures with contingent measures based on subsequent data at Buildings 5 & 8.

To mitigate potential risk and protect indoor air quality, ACDEH has approved the following vapor mitigation approach for the eastern portion of the site for Buildings 5 & 8:

- Installation of a subslab ventilation system (SSV) beneath each building slab;
- Installation of a sub-slab engineered vapor barrier system (e.g., GeoSeal™ by Land Science®) beneath the entire building foundation;

- Subslab gas monitoring from vent riser sampling ports after slab construction and before occupancy; and
- SSV system design for conversion from passive to active operation, if merited by gas monitoring.

A summary of vapor mitigation systems (VMS) for the whole site is shown on Figure 3. This includes the previously approved VMS for Buildings 1-4, the requested VMS for Buildings 5&8, and the anticipated VMS for Buildings 6,7,9&10.

A detailed description of the project background and the nature and extent of VOCs in the subsurface is provided in the October 7, 2016 *Draft Corrective Action Plan* (Pangea, 2016a), the October 26, 2016 *Interim Remediation Report* (Pangea, 2016b), November 16, 2016 *Data Gap Investigation Report, Buildings 3 & 4* (Pangea, 2016c), and February 17, 2017 *Pilot Study Report* (Pangea, 2017).

This Design Basis Report describes the construction of a vapor intrusion mitigation system (VIMS) comprised of the SSV piping and the sub-slab engineered vapor barrier (e.g., GeoSeal™ by Land Science®). This VIMS is consistent with the Draft CAP and agency requirements. Subslab gas monitoring is described below in Section 6.1. A construction quality assurance plan is presented in Section 5. A long-term O&M plan is described in Section 6.

A separate Design Basis Report will be prepared for future VIMS for the other planned development (Buildings 6, 7, 9 & 10) at the Site. The locations planned Buildings 6, 7, 9 & 10 are shown on Figure 2 and in Appendix A.

A Post-Construction Site Management Plan (SMP) will be prepared following completion of VIMS installation, construction, and testing. The Post-Construction SMP will include a Record Report of Construction (As-Builts for VIMS, trench plugs, etc), final O&M plans, tenant notifications (Proposition 65), and deed restriction (if required).

1.1 Document Purpose and Scope

This document has been prepared to establish the basis for the detailed engineering design of the proposed VIMS at the Site, present key design components of the proposed VIMS, provide specific procedures for VIMS construction quality assurance (CQA), and present a long-term operation and maintenance (O&M) plan. Per the CQA procedures, the VIMS Design Engineer will be present on site during construction of the VIMS to observe and certify that the implementation is consistent with the construction documents. The O&M procedures presented herein are to be implemented by the Owner or a Responsible Party designated by the Owner.

2.0 PROJECT AND MITIGATION OBJECTIVES

2.1 Design Objectives and Basis

The objectives of the VIMS are as follows:

- Mitigate the potential for soil vapor beneath future building slabs to contribute to unacceptable risk in indoor air by installing vapor collection piping below the new building slab to passively vent sub-slab vapors above the roofline, and by installing a sub-slab engineered vapor barrier.
- Maintain vapor concentrations within the buildings below long-term air quality objectives for chemical of concern (COC) that include benzene, ethylbenzene, and PCE and its breakdown products.
- Provide a mitigation system that is passive and requires minimal operation and maintenance.
- Design a system that could be converted from a passive system to an active system, if needed.

The October 2011 *Vapor Intrusion Mitigation Advisory, Revision 1, Final* (VIMA) issued by the California Department of Toxic Substances Control (DTSC, 2011) and the methane mitigation standards established by the Los Angeles Department of Building and Safety (LADBS) provide general requirements for the design, implementation, and long term O&M of designed sub-slab mitigation systems. These agency guidance documents were used to guide the design of the proposed VIMS described herein.

2.2 Mitigation Objectives

The VIMS mitigation objectives are based on the ESLs for soil gas and indoor air (Regional Water Board, 2013), for residential land use. As described by the Regional Water Board, ESLs are conservative screening levels that correspond to an acceptable risk level; concentrations of constituents below their respective ESLs can be considered to pose no significant risk, within noted limits. Concentrations of constituents above their respective ESLs do not necessarily indicate a risk is present, but rather suggest that additional evaluation is warranted.

2.2.1 Soil Gas

The objective of the VIMS is to maintain concentrations of COCs at concentrations below their respective ESLs in subslab/soil gas beneath the future site buildings (Table SG-1, Regional Water Board, 2016). The specific treatment objectives for the primary COCs in subslab/soil gas are based on the lowest residential endpoint in Table SG-1 as shown below on Table A. Should the indoor air ESLs be updated, the effectiveness of the corrective action will be assessed relative to whatever ESLs are current at the time.

2.2.2 Indoor Air

The objective of the VIMS is to maintain concentrations of COCs at concentrations below their respective indoor air ESLs in indoor air within the future site buildings (Table IA-1, Regional Water Board, 2016). The specific treatment objectives for the primary COCs in indoor air based on the lowest residential endpoint in Table IA-1 as shown below on Table A.

Table A – Residential Screening Levels for Soil Gas and Indoor Air

Chemical	Soil Gas Tier 1 ESL (ug/m3)	Indoor Air Tier 1 ESL (ug/m3)
PCE	240	0.48
Benzene	48	0.097
Ethylbenzene	560	1.1

Should the indoor air ESLs be updated, the effectiveness of the corrective action will be assessed relative to whatever ESLs are current at the time.

3.0 VAPOR MITIGATION SYSTEM DESIGN

Consistent with the Draft CAP and agency requirements, the proposed VIMS includes a venting system and an engineered sub-slab vapor barrier system. The VIMS will be installed within the proposed residential buildings during construction and before occupancy of these buildings. The venting system will provide a route for the VOC-affected soil gas that would otherwise collect beneath the building slab and barrier system to vent directly to the atmosphere outside the building while also providing a slight negative pressure beneath the building. The barrier system is intended to sufficiently retard the migration of VOC-affected soil gas into the onsite building such that VOCs in soil gas do not represent an unacceptable risk to future residential users of the Site. The sub-slab venting system is designed for conversion to an active sub-slab depressurization/venting system if performance monitoring results indicate the passive venting system is not providing sufficient mitigation of VOC vapors.

The VIMS includes the following elements:

- Installation of a sub-slab ventilation (SSV) system beneath each building slab;
- Installation of a sub-slab engineered vapor barrier above the SSV system (e.g., GeoSeal™ by Land Science®);

- Sealing of slab penetrations and cracks using Retro-Coat™ Caulk and Retro-Coat™ Gel or comparable polyurethane material;
- Closure of potential preferential pathways (e.g., trench plugs for utilities);
- Sub-slab gas monitoring after slab construction and before occupancy; and
- SSV system design for conversion from passive to active operation, if merited by gas monitoring.

The elements of the venting system and contingent engineered barrier system are depicted in the *Vapor Intrusion Mitigation System (VIMS) Design Drawings* dated January 20, 2017, included as Appendix B.

3.1 Key Design Parameters

The following key parameters were used for the design of the vapor collection system and contingent vapor mitigation barrier:

- Types of soil vapor contaminants and concentrations.
- Commercially available vapor mitigation systems (membranes and/or venting) and their expected performance.
- Current extent of soil vapor plumes.
- Proposed building foundation design.
- Building footprint area.
- Collection piping head losses.
- Wind-turbine fan manufacturer specifications.
- Regulatory permitting.
- Regulatory advisories; the VIMS will be installed in general accordance with the recommendations outlined in the *Vapor Intrusion Mitigation Advisory* published by the California Department of Toxic Substances Control (DTSC, 2011).

3.2 Sub-Slab Ventilation (SSV) System

A passive sub-slab venting (SSV) system will be installed beneath each building slab. The SSV system is intended to be passive and long lasting, and to require minimal operations and maintenance activities. The SSV system consists of a trench, a layer of permeable material, horizontal vapor collection piping within the permeable material layer, vent risers attached to the vapor collection pipes that run to the roof, with the potential for a wind-driven turbine fans installed at the top of the vent risers. The purpose of the SSV is to provide protection by extracting soil vapor that may accumulate in the subsurface. A description of the selected flow rate for the SSV system and a description of each component are presented below.

Sub-slab components of the venting system include a network of a 3-inch diameter perforated Schedule 40 PVC piping embedded within a four-inch thick permeable layer of crushed rock (100% passing 1-inch; 90% passing ¾-inch; 10% maximum passing #4) directly beneath the building slab. The vent piping network includes fresh air inlet vent piping as wells as outlet vent piping that will be connected to vent risers that trend through the building interior or exterior, conveying the collected soil gas to the roof level for discharge to the atmosphere. The design includes one vent riser pipe for approximately every 4,000 to 6,000 square feet depending on the building layout (LADBS). The vent risers will be three-inch diameter, solid, ductile iron pipe (DIP) or cast iron pipe (CIP) to protect the pipe from potential future damage. Vent risers will be labeled "CONTAINS VAPORS: DO NOT BREAK OR CUT." The engineered vent material will be installed in accordance will the applicable manufacturer recommendations and specifications.

The passive venting system is designed with appropriate features to allow future modification to an active system, if deemed necessary. The venting system can be converted to an active system with the addition of a blower connected to the VIMS riser piping either within the attic space or at the roof. The blower would mechanically move VOC-affected soil gas through the venting system and provide active sub-slab depressurization. A fan (RP 140 Radon Fan or equivalent) would be installed at each riser location. Manufacturer cut sheets for the proposed blowers are included as Appendix C.

3.2.1 Maximum Allowable Design Flow Rate

SSV systems generally do not require abatement for the vapors being vented to the atmosphere due the relatively low concentrations and flow rates and, therefore, low mass loading. Furthermore, passive venting systems often operate at very low pressures such that addition of abatement equipment can have a significant effect on the system's venting performance. Regulatory requirements set forth by the Bay Area Air Quality Management District (BAAQMD) exempt passive soil vapor extraction operations with operations with total emission of less than one pound per day VOCs per BAAQMD Regulation 8, Rule,47, Section 8-47-113 (BAAQMD, 2005). Because this emission limit applies to the entire property, our calculations herein incorporate estimated concentrations for all planned buildings.

To maintain the intent of the VIMS objectives of a passive system that requires minimal maintenance, the VIMS will be designed to operate below the threshold requiring abatement. The methodology used to estimate the maximum allowable design flow rate is described below.

The maximum allowable design flow rate for the SSV system was determined based on the historical soil vapor concentrations and estimated future VOC concentrations. The use of the estimated soil vapor concentrations for the SSV influent (as opposed to the maximum detected soil vapor concentrations to estimate the maximum flow rate through the vents) is representative of expected subsurface soil vapor concentrations and is *conservative* based on the following: 1) soil vapor concentrations are expended to reduce given the recent removal of select source material, 2) contaminant concentrations are expected to attenuate as soil vapor travels from subgrade soils to the soil vapor collection system; and 3) soil vapor concentrations are expected to diminish due to mixing with cleaner air during venting and ambient air intake within the soil vapor collection system.

For PCE and ethylbenzene impact areas targeted for remediation, Pangea assumes the remediation will reduction the impact to maximum concentrations of 500 µg/m^3 PCE and 1,000 µg/m^3 ethylbenzene. The estimated future VOC concentrations shown below in Table B for all site buildings were used to calculate the maximum allowable flow rate per vent to meet BAAQMD 8-47-113 exemption. Pangea estimates a minimum 50% reduction in VOC concentration as soil vapor travels from subgrade soils into the vapor collection system. Pangea also estimates a minimum 90% further reduction in VOC concentration as ambient air mixes within the soil vapor collection system. A 90% VOC reduction is very conservative based on an approximate average 99.7% reduction rate calculated for similar VMS systems, as documented in equation (5) on page 5 of the enclosed technical documentation in Appendix E (Reinis, 2008).

Table B – Average VOC Concentrations in Soil Gas

Chemical	**Building 5**	**Building 8**	Buildings 1-4	Buildings 6,7,9,10
	Average Concentration (micrograms per cubic meter, µg/m^3)			
PCE	<13	112	<18	80
Benzene	36	<3	<17	40
Ethylbenzene	<170	<7	<7	315
Total VOCs	<220	<122	<42	150
50% Reduction into subslab zone	<100	<61	<21	75
90% Reduction in collection system	<10	<6	<2	8
Estimated Max VOCs in Riser	<10	<6	<2	8
Estimated Quantity of Risers	2	2	8	8

Based on the estimated max VOCs in each building riser, the estimated total average soil vapor concentrations in each riser is <6 µg/m^3 (<0.006 µg/L). As shown below, the maximum allowable flow rate calculated for each of the 20 vents is 92,600 cubic feet per minute (ft^3/min) vents to remain under the pound per day emission limit per BAAQMD Regulation 8, Rule 47, Section 8-47-11. The maximum allowable vent flow rate calculation is as follows:

Mass Removal Calculation:

_ X _µg/L x _Y_ cfm x 0.00009 (conversion to yield lbs/day) = 1 lbs/day (BAAQMD limit)

0.006 µg/L x _Y_ cfm x 0.00009 (conversion to yield lbs/day) = 1 lbs/day (BAAQMD limit)

Y = 1,850,000 CFM

Y = 1,850,000 CFM / 20 Riser Vents = 92,600 CFM/Riser Vent

The above calculation will be revised if the number of SSV systems and risers changes. The calculation of VOC emissions from each building can be calculated in the future to establish a VOC emission rate for each building for VOC emissions for the whole site to remain under the 1 pound per day emission limit per BAAQMD Regulation 8, Rule 47, Section 8-47-11.

Note that observed flow rates from passive risers for systems similar to the planned VMS was measures to be approximately 13 CFM (Reinis, 2008). Port of Oakland Buildings 1 & 2 have a similar VMS system consisting of a gravel subgrade layer with piping for extraction and air inlet, as documented on Table 1 (page 4) of the enclosed technical documentation in Appendix E (Reinis, 2008). This information suggests that VOC emissions should be well below the calculated maximum riser flow rate of 92,6000 CFM, and that no adjustment will be necessary.

Performance monitoring and system controls for measuring and adjusting the system flow rate and contingency plans are provided below.

3.2.2 Permeable Base

The permeable base layer will consist of a minimum of 4 inches of gravel or crushed rock placed continuously around the VIMS piping below grade. The permeable material will surround the vapor mitigation piping. The permeable base will provide a continuous, highly permeable zone that allows advective flow of soil vapor to the collection piping.

3.2.3 Vapor Collection Piping

The vapor collection piping will be 3" diameter perforated Schedule 40 PVC pipe. The 3" piping is chosen to be large enough to allow vapor flow. The slotted pipe will connect to a 3" diameter cast-iron pipe (CIP) prior to grade. The layout for the vapor collection piping was designed to cover the entire area under each building. The layout of the vapor collection piping is presented in Appendix B.

3.2.4 Vapor Collection Risers

The horizontal vapor collection piping will be connected to vertical vent riser piping, a 3" diameter CIP. The piping will be installed at a minimum of 10' from the property line, as shown on the drawings in Appendix B. The 3" diameter CIP will be mounted to the building as shown on the drawings. The vent will continue past the roof and terminate approximately 1 foot above the roof.

The selected 3-inch vent piping is capable of conveying in excess of 650 ft^3/min of air with minimal pressure drop and has more than sufficient capacity to convey the design flow rate of the wind-driven turbine fan.

A single 3-inch vent is capable of servicing a vapor mitigation membrane that covers an area ranging from 4,000 to 6,000 square feet (ft^2)(LADBS).

3.2.5 Wind-Driven Turbine Fan

A wind-driven turbine fan will be installed at the top of the riser vent to provide wind siphoning flow from the vent. The selected wind-driven turbine fan creates a vacuum that draws air out from the VIMS. The air flow for the 12" diameter fan (McMaster-Carr Catalog# 1992K48 or equivalent) is 440 cfm at 4 mph wind. The fan requires no power to operate. Performance monitoring described below will determine if the fan flow rate requires reduction, or if fan removal is required to allow passive ventilation without a fan.

3.2.6 SSV System Layout

The layout of the soil vapor collection system is design to vent vapors from beneath the entire slab of reach building.

3.3 Sub-slab Engineered Vapor Barrier System

A sub-slab engineered vapor barrier system will be installed beneath the concrete building slab. The vapor barrier design by Langan Engineering of San Francisco, California is included in Appendix ___. The vapor barrier will be a minimum 60-mils thickness composite membrane system. The composite membrane system consists of a spray applied material within underlying and overlying high density polyethylene (HDPE) carrier fabric (e.g., GeoSeal™ by Land Science®). The vapor barrier system included procedures for sealing the barrier around the foundation and sealing penetrations. The engineered vapor barrier complies with State VIMA guidance from DTSC for an engineered vapor barrier system.

3.4 Slab Penetration Sealing

Potential preferential pathways (such as cracks, imperfection to the slab, or other penetrations) will be sealed using Retro-Coat™ Caulk and Retro-Coat™ Gel or equivalent, as appropriate.

3.5 Closure of Potential Preferential Pathways

Utility line backfill will be sealed at or near the building perimeter and between designated VIMS sectors using a sand/cement slurry or controlled density fill (CDF) plug to limit vapor migration within the utility trench. Mechanical and electrical conduits originating from beneath the building floor slabs will also be sealed with a conduit seal to prevent migration of VOC-affected soil gas into the building. VIMS drawings in Appendix B include typical details for conduit seals and trench plugs. The utility system plan is included in Appendix A. A site plan showing locations of trench plugs will be included in the completion report record drawing set. Unused site utilities, if any, will be abandoned and sealed where appropriate.

3.6 Contingent Active SSV System

The passive venting system is designed with appropriate features to allow future modification to an active system. If needed, the venting system can be converted to an active system with the addition of a blower connected to the VIMS riser piping either within the attic space or at the roof. The blower would mechanically move VOC-affected soil gas through the venting system and provide active sub-slab depressurization. A fan (RP 140 Radon Fan or equivalent) would be installed at each riser location. Manufacturer cut sheets for the proposed blowers are included as Appendix C.

The procedure for evaluating the need for the contingent active SSV system operation involves sub-slab gas monitoring described below in Section 6.1.

4.0 VIMS IMPLEMENTATION

The following sections describe the activities associated with the construction of the VIMS, including preconstruction activities and installation.

4.1 Preconstruction Activities

A preconstruction meeting with property owner or representatives are required for the installation of the VIMS. VIMS installation will be performed by an appropriately licensed contractor. Prior to initiating field activities, the following tasks will be conducted:

- Obtain authorization from ACDEH and City of San Lorenzo, as necessary.
- Pre-mark any excavation area with white paint and notify Underground Service Alert (USA) of the excavation activities at least 48 hours before work begins;
- Prepare a Site-specific health and safety plan to educate personnel and minimize their exposure to potential hazards related to Site activities; and
- Coordinate with involved parties.

4.2 VIMS Installation

The following sections describe the major activities required for the installation of the VIMS.

4.2.1 Mobilization and Site Preparation

Site preparation will include identification of layout of the VIMS, and locate any and all utilities near work zone. Establish exclusion zone.

4.2.2 Environmental Controls for Storm Water and Dust

All nearby storm drains will be protected from sediment. Minimal visible dust generation is expected during SSV system installation. As necessary, general construction dust controls, including spraying/misting with water during grading, minimizing material drop height during placement, and protection of material stockpiles, will be implemented during installation of the VIMS. These controls are a subset of the Storm Water Pollution Prevention Plan and the Air and Dust Monitoring Plans prepared for this Site.

4.2.3 Waste Management

Grading and waste material will be managed during general construction activities.

4.2.4 Site Restoration, Project Closeout, and Demobilization

After VIMS installation, the contractor will demobilize from the site after receiving approval by the owner and VIMS engineer. As necessary, contractors may be required to return to the site to address deficiencies identified at startup/commissioning of the VIMS. General project closeout procedures will include owner and project engineer inspections and approvals of the installations. Closeout documents will include as-built markups of design drawings, documentation of installed materials and equipment, available operation and maintenance manuals, and written warranties (as applicable) for work and installed products. Project recordkeeping and documentation is detailed below in Sections 6.2.3 and 7.1.

4.2.5 Survey

As-built alignments of installed horizontal piping and locations of the vent riser slab penetrations shall be clearly marked on the design drawings. The As-built drawings will not be performed by a licensed surveyor.

5.0 CONSTRUCTION QUALITY AND ASSURANCE PLAN

This section presents the construction quality assurance (CQA) plans for the VIMS installation.

5.1 Construction Quality Assurance Roles and Coordination

The CQA coordination will include a *preconstruction meeting* between the owner, VIMS design engineer, construction quality manager (CQM), and contractor. The pre-construction meeting will serve to introduce all parties and establish the chain of command and lines of communications for the project. This and other meetings will include other trades that may be affected by the installation of the systems or must know to protect the systems during the performance of their activities. For the VIMS construction, the contractors will be required to document installation prior to backfilling and finishing the job.

During the construction of the VIMS, the owner will be regularly updated on progress and variances of the VIMS design and schedule. CQA roles are presented in Table C.

Table C – Construction Quality Assurance Roles

Role	Firm	Person(s)
Owner	PaulsCorp, LLC	Scott Schoeman
Environmental Consultant	Pangea Environmental	Bob Clark-Riddell, PE
VIMS Design Engineer	Langan Treadwell Rollo	Sigrida Reinis, PE; Hayley Baker
Construction Quality Manager (CQM)	DCI Construction	Michael Gonzales, Caleb Cooper
Engineered Vapor Barrier Contractor	TBD	TBD
Contractors	TBD	TBD

5.2 Quality Control for VIMS Installation

The VIMS Design Engineer will be present on site during construction of the VIMS to observe that the implementation is consistent with the intent of the design and the design documents. In addition, the construction quality assurance and quality control (QA/QC) protocol specified herein will be implemented during the installation.

5.2.1 VIMS Materials Quality Control

The contractor will inspect all material prior to installation. The CQM will oversee the material inspection. All materials used shall be free of defects and damages. The manufacturer will provide certification-testing documentation that the materials specified meet or exceed the minimum design requirements.

5.2.2 VIMS Construction Quality Control

Construction of the subsurface piping will be performed by an appropriately qualified licensed contractor. Regularly scheduled visual inspections will be performed by the CQM during construction of the VIMS to verify conformance with design drawings and specifications. Prior to completion of the vent risers at roof levels, the vent setback and clearance will be verified for conformance with the requirements. Testing will be conducted to ensure the venting system operates as designed. The testing will include, but may not be limited to, monitoring and/or sampling of soil gas in the vent riser piping.

If the contingent post-slab engineered vapor barrier is required, the vapor barrier will be installed by appropriately qualified and manufacturer-certified contractors. They will have appropriate experience for installing the specified engineered barrier and related products. Testing procedures will ensure that the applied barrier system has been installed in accordance with the design and manufacturer recommendations and without defects. These tests may include, but are not limited to, visual inspection and verification of application thickness, and a smoke test.

Upon completion of the final VIMS, a report will be prepared documenting that the installation was performed in accordance with the design and manufacturer specifications and that the specific construction QA/QC procedures were performed and yielded satisfactory results. The report will also include a signed and stamped record drawing set documenting the 'as-built' construction of the VIMS, including necessary field changes to the design.

6.0 OPERATIONS AND MAINTENANCE PLAN

Operations, maintenance, and monitoring (O&M) activities will support the objectives of the VIMS design. The VIMS constitutes a long-term, passive approach to remediating and mitigating risks to indoor air. Routine operations and maintenance activities are generally not required. Non-routine maintenance activities may be required if unexpected maintenance needs are observed during routine performance monitoring. Monitoring of the VIMS will be conducted to verify that it is functioning as intended at the time of installation.

A performance monitoring phase will occur shortly after installation to verify that each mitigation measure is functioning as intended. Following installation of the VIMS, the owner will retain the services to performance monitoring, operations, and maintenance. The Primary Operator will be responsible for performing site inspection, sampling, and data evaluation. The Primary Operator, to be established by the Owner, will be an environmental consultant, VIMS design engineer, or other owner representative.

6.1 VIMS Performance Monitoring

Performance monitoring will be conducted to confirm the efficacy of the installed VIMS and to demonstrate that VOC concentrations are below established screening levels. The performance of the VIMS will be evaluated by sampling soil gas in the vent riser piping as specified below.

6.1.1 Vent Riser Sampling

Vent riser performance monitoring will consist of three *monthly sampling events* following installation of the VIMS and the concrete slab to confirm stable and acceptable VOC concentrations in subslab gas. The vent riser monitoring will commence approximately one month after slab installation. The monitoring frequency may be revised in order to comply with any monitoring requirements of ACDEH or BAAQMD. The owner will notify ACDEH of any proposed changes to the monitoring or sampling schedule.

Vent riser performance monitoring will involve collection of flow rate data and samples of vented soil vapor from the riser by the environmental consultant or VIMS design engineer. The flow rate data and vapor samples will be collected from the sampling port installed within each riser pipe. The riser pipes are located within the exterior walls to facilitate sampling within minimal disruption to building residents. The vented soil vapor sample collected in 1-liter Summa canisters will be sent for state-certified laboratory analysis for the presence of site-specific chemicals of concern by EPA Method SIM TO-15. Flow rate and vented soil vapor concentrations will be used to calculate the emissions from each vent riser. Additional monitoring may be performed using a photo-ionization detector (PID) to further evaluate VOC concentrations trends in vented soil gas.

6.1.2 Vent Flow Rate Adjustment

Adjustments to the vent riser flow rate will be performed as necessary to maintain total combined emissions (aggregate of all vents) to less than 1 pound per day as required by BAAQMD regulations for unabated sources (BAAQMD, 2005). A valve or restriction can be provided to reduce vapor flow as merited. Or the wind-driven turbine fan can be replaced with a rain guard to allow passive venting.

6.1.3 Monitoring for Contingent Active SSV System Operation

If VOC concentrations in the vent risers exceed the applicable environmental screening levels established by the San Francisco Bay Regional Water Quality Control Board, the SSV system will be converted from passive operation to active operation. Conversion to active sub-slab depressurization can be performed at any time. Conversion would involve installation of a powered fan and routing of electrical service via the contingent electrical conduit. The powered fan would be installed of in the attic or on the roof level.

6.1.4 Indoor Air Sampling

If sub-slab soil gas concentrations in the vent riser piping indicates presences of VOCs above the applicable ESLs after the first few months of SSV operation, indoor air sampling within the constructed building will be conducted to further confirm proper performance of the VIMS. Indoor air monitoring can be performed before and/or during building occupancy. Additional mitigation measures may be implemented to comply with ACDEH requirements if indoor air concentrations of site-specific compounds exceed ESLs.

6.2 VIMS Maintenance

Because the VIMS is an engineered protection for the building, proper O&M is required to ensure that the system is not damaged and remains operational over the life of the building, or until soil gas concentrations have been reduced to below levels of concern. This long-term O&M plan has been prepared for this purpose.

Long-term O&M of the VIMS will be the responsibility of Owner or Designated Responsible Party. The Owner or Designated Responsible Party shall be responsible for ensuring that the VIMS is maintained by Site personnel who have reviewed the record drawings and this plan, and are thereby familiar with the system operations.

6.2.1 Normal Operation of System

There are no mechanized components to the passive SSV. VOC-affected soil gas is passively vented to the outdoor ambient air due to temperature and pressure gradients, the roof vents are open to allow the passive VIMS to operate continuously. Note that if the system is made active, emissions monitoring and a Bay Area Air Quality Management District (BAAQMD) permit may be necessary and this O&M Plan will be updated.

6.2.2 Monitoring and Regular Maintenance

At a minimum, system inspection will be conducted on a quarterly basis. The system components will be repaired or replaced for operational reliability as the need of repair or replacement is identified during each scheduled monitoring period. No major replacement or troubleshooting should be performed without the help of a Professional Engineer registered in the State of California and specializing in the design of VIMS.

6.2.3 Recordkeeping and Reporting

During the operation and maintenance of the VIMS, the monitoring and maintenance tasks discussed above will be performed and recorded in a monitoring and maintenance logbook. The logbook pages will be numbered to avoid loss of entry or to control unnecessary extraneous entry. The logbook shall include:

- Copies of completed inspection forms for each inspection event.
- Copies of any pictures taken during inspection events, repair activities, etc.
- Copies of any approvals, work plans, design drawings and specifications, and/or other necessary engineering design documents prepared for any major alteration to the VIMS.
- Information/entries recording emergencies, unusual events, or activities that may have affected the VIMS.
- Information/entries recording any adjustments, changes, or repairs to the VIMS.

It is the duty of the Owner or Designated Responsible Party to ensure that the proper records are maintained. In addition, the Owner or Designated Responsible Party will prepare an annual summary of its inspections, which will include copies of the entries made in the log book, for submittal to the ACDEH. The annual summary will include an evaluation of the VIMS effectiveness, any deficiencies noted, and proposed repairs in the case deficiencies are observed.

6.2.4 System Disruptions, Alterations, Repairs, and Improvements

If future building improvement plans include cutting or drilling through the floor slab and possibly disturbing the SSV system or breaching the vapor barrier (if installed), repairs should be implemented to properly seal the barrier breach and, if necessary, repair cut or damaged sections of sub-slab components of the venting system or post-slab vapor barrier. An appropriately qualified and manufacturer-certified contractor must conduct the repair to the post-slab engineered vapor barrier.

A Site-Specific Health and Safety Plan (SSHSP) must be prepared for any such work. The SSHSP must include appropriate provisions for monitoring of indoor air for VOCs, for adequate ventilation of the work area, and any other necessary safety measures. The SSHSP should be provided to the Owner or Designated Responsible Party for review and approval prior to the work. All breaches or significant modifications to the VIMS must be approved in writing by the Owner or Designated Responsible Party. Approvals shall be kept in the log book.

A Professional Engineer registered in the State of California and specializing in the design of such systems shall be retained to provide a work plan, design drawings and specifications, and/or other necessary engineering design documents for any extensive repairs or significant alterations to the VIMS. The record drawings will be revised to reflect changes in the VIMS and kept in the logbook.

6.2.5 Annual Review

As noted above, the Owner or Designated Responsible Party will prepare an annual summary of its inspections for submittal to the ACDEH. The annual summary will include an evaluation of the VIMS effectiveness, any deficiencies noted, and proposed repairs in the case deficiencies are observed. The annual summary will also include a recommendation for continued O&M or cessation of the VIMS operation, as appropriate. The annual summary will be provided to the ACDEH no later than February 15 of the calendar year following the reporting period.

6.2.6 Measures for the Termination of Long Term O&M

At any time, the termination of long term O&M requirements can be proposed as warranted by the operational data. At a minimum, every five years the need for long term O&M will be reviewed. Justification for ceasing long term O&M requirements may include:

- Collecting representative soil gas samples showing that COPC concentrations have been reduced to levels below levels of concern.
- Documentation that the inspections and performance measures have not shown a reduction in operational performance of the VIMS and that notification procedures are sufficient.

6.2.7 Event Response

In the event of a fire, earthquake, or other occurrence with the potential to damage the VIMS, the VIMS shall be inspected for damage and evaluated for necessary repairs.

7.0 REPORTING AND SCHEDULE

This section presents a preliminary schedule and a description of the documentation and reporting of the VIMS installation and associated activities.

7.1 Documentation and Reporting

Project documentation involves recordkeeping and reporting associated with the VIMS installation and sub-slab gas monitoring for contingency actions. During installation of the SSV piping and moisture vapor barrier, Pangea and/or the VIMS Design Engineer will inspect and document installation.

Following certification of the SSV system, performance monitoring/vent riser sampling will commence for the VIMS. After soil gas testing of the SSV riser piping, Pangea will prepare brief reports documenting sampling procedures and results.

A Post-Construction Site Management Plan (SMP) will be prepared following completion of VIMS installation, construction, and testing. The Post-Construction SMP will include a Record Report of Construction (As-Builts for VIMS, trench plugs, etc), final O&M plans, tenant notifications (Proposition 65), and deed restriction (if required). The SMP will also include a certification from the CQM manager and VIMS Design Engineer that the completed project conforms to the construction documents. The schedule for project documentation is shown below in Table D.

7.2 Preliminary Scheduling

The anticipated schedule for the activities described in this Design Basis Report is presented below in Table D. This schedule is approximate, and the actual dates will depend on the timing and acquisition of agency approval, applicable permits, subcontractor availability, and field conditions.

Table D – Tentative VIMS Schedule for Buildings 5 & 8

Date	Action	Responsible Entity
February 14, 2017	Design Basis Report and VIMS Design Drawing Submittal	Pangea/VIMS Design Engineer
February 14, 2017	Pilot Study Report Submittal	Pangea
February 14, 2017	Detailed Schedule Submittal	Owner
February 2017	Commence Grading after City/County Approval	Owner, Contractor
April 14, 2017	Agency Comment/Approval of Design Basis/VMS Report (60 days after submittal)	ACDEH
TBD	SSV and Vapor Barrier Installation and CQA	Contractor, VIMS Engineer
TBD	Pour Building Slabs	Contractor
TBD	Building Construction	Contractor
TBD	1st Monthly SSV Riser Gas Sampling/Report	Pangea
TBD	2nd Monthly SSV Riser Gas Sampling/Report	Pangea
TBD	3rd Monthly SSV Riser Gas Sampling/Report	Pangea
TBD	Building Ready for Sale	Owner
TBD	Indoor Air Sampling (if merited)	Pangea
TBD	Convert SSV to Active (if needed)	Contractor
TBD	Post-Construction SMP, VIMS Record Report of Construction and Certification, Final O&M Plan	VIMS Engineer
TBD	No Further Action Letter or Case Closure Letter	ACDEH
TBD	O&M Implementation, if Needed (Indoor Air Sample and Contingent Active SSD)	Owner, Pangea

8.0 REFERENCES

The regulatory record for this Site can be found on the State of California GeoTracker Website at http://geotracker.waterboards.ca.gov/profile_report.asp?global_id=T10000009292

DTSC, 2011. *Vapor Intrusion Mitigation Advisory (VIMA), Revision 1, Final.* October. https://dtsc.ca.gov/SiteCleanup/upload/VIMA_Final_Oct_20111.pdf

Los Angeles Department of Building and Safety (LADBS). Methane Mitigation Standards. http://ladbs.org/services/core-services/plan-check-permit/methane-mitigation-standards

PANGEA, 2016a, *Draft Corrective Action Plan*. October 7.

PANGEA, 2016b. *Interim Remediation Report*. October 26.

PANGEA, 2016c. *Data Gap Investigation Report, Buildings 3 & 4.* November 16.

PANGEA, 2017. *Pilot Study Report.* February 17.

Reinis, 2008. *Estimated VOC Emissions in Vapor Mitigation System for Air Permitting.* Presented at Battelle Sixth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California. May 2008

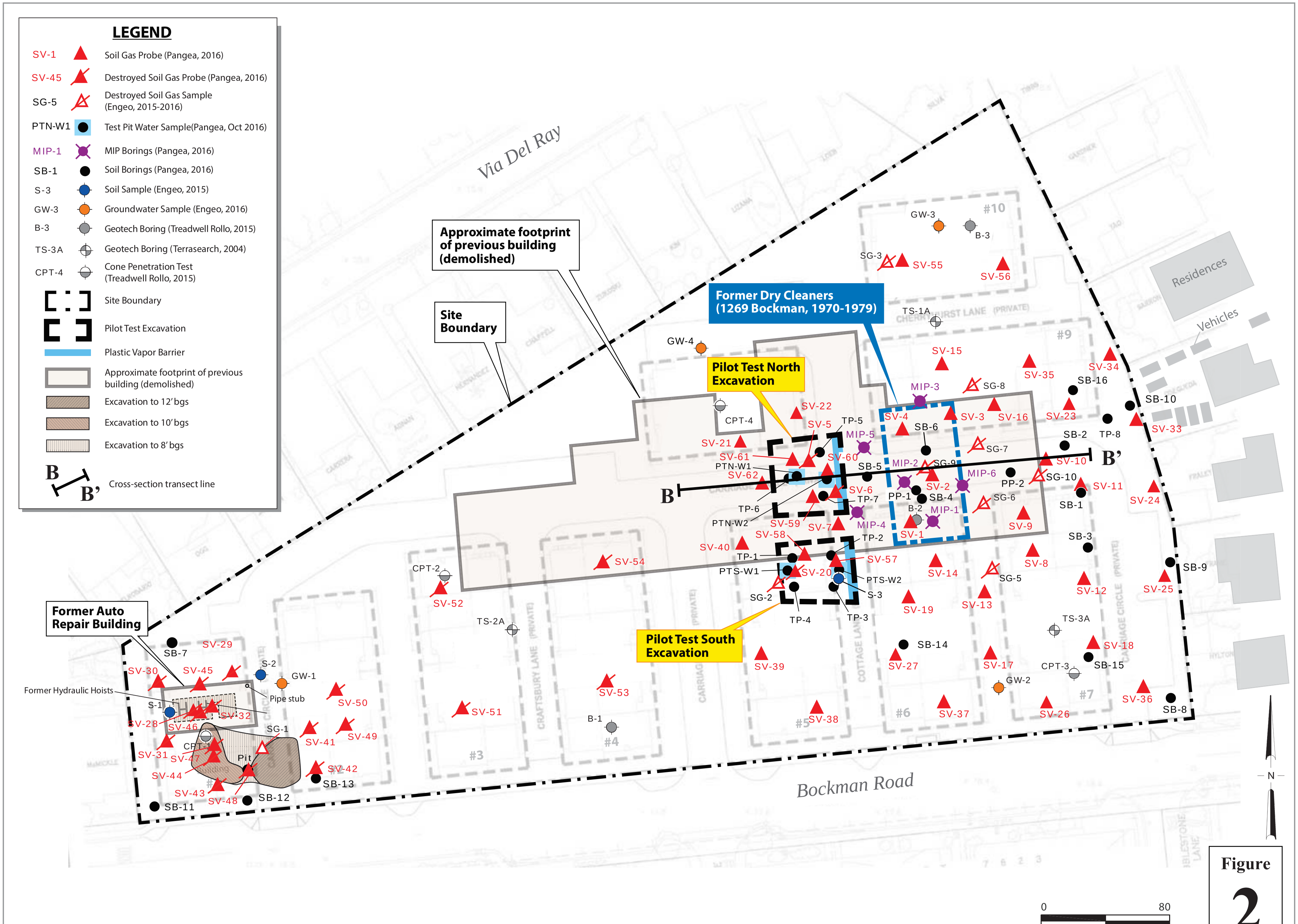
SFRWQCB, 2016. San Francisco Bay Regional Water Quality Control Board, *Environmental Screening Levels,* February 22, (Revision 3, May)

Figure
1

1233 Bockman Road
San Lorenzo, California

PANGEA

Vicinity Map



Map courtesy of ENGEO Incorporated. Base map derived from a electronic file titled "ACAD2010-151072-BASE.dwg," received on 09/15/15, and "Bockman Road," by Tetra Tech dated 06/11/15.

Figure 2

Site Map

1233 Bockman Road
San Lorenzo, California

PANGEA

Map courtesy of ENGEO Incorporated. Base map derived from a electronic file titled "ACAD2010-151072-BASE.dwg," received on 09/15/15, and "Bockman Road," by Tetra Tech dated 06/11/15.

1233 Bockman Road
San Lorenzo, California

PANGEA

Vapor Mitigation System
Site Summary

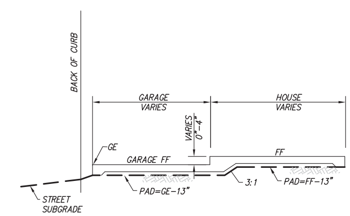
Appendix A

Development Plans

0 30 60 90
(IN FEET)
1 inch = 30 ft.

NOTES:

1. REMEDIAL GRADING LIMITS OF OVEREXCAVATION OR LIME TREATMENT FOR BUILDING PAD SUBGRADE IS 5 FEET MINIMUM BEYOND PERIMETER OF BUILDING FOOTPRINT.
2. FOR THE OVEREXCAVATION OPTION, OVEREXCAVATE 24 INCHES BELOW THE BUILDING PAD AND GARAGE PAD ELEVATIONS AND REPLACE WITH SELECT FILL. SEE NOTE 4.
3. FOR THE LIME TREATMENT OPTION, LIME TREAT THE UPPER 18 INCHES BELOW THE BUILDING PAD AND GARAGE PAD ELEVATIONS. SEE NOTE 4.
4. FOR ADDITIONAL RECOMMENDATIONS REGARDING THE PREPARATION OF THE SUBGRADE FOR THE PROPOSED BUILDING PADS AND GARAGE PADS, REFER TO THE SOIL REPORT TITLED "GEOTECHNICAL INVESTIGATION, 1233 BOCKMAN ROAD, SAN LORENZO, CALIFORNIA", DATED 1 OCTOBER 2015, PREPARED BY LANGAN TREADWELL ROLLO.
5. ALL REMEDIAL GRADING INFORMATION SHOWN ON THIS PLAN IS PROVIDED AND REVIEWED BY LANGAN TREADWELL ROLLO (THE PROJECT GEOTECHNICAL ENGINEER).



TYPICAL PAD GRADING SECTION

NOT TO SCALE

REVIEWED BY:

FOR ALAMEDA COUNTY PUBLIC WORKS AGENCY

RJA
RUGGERI-JENSEN-AZAR
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PHONE: (925) 227-9100 FAX: (925) 227-9300

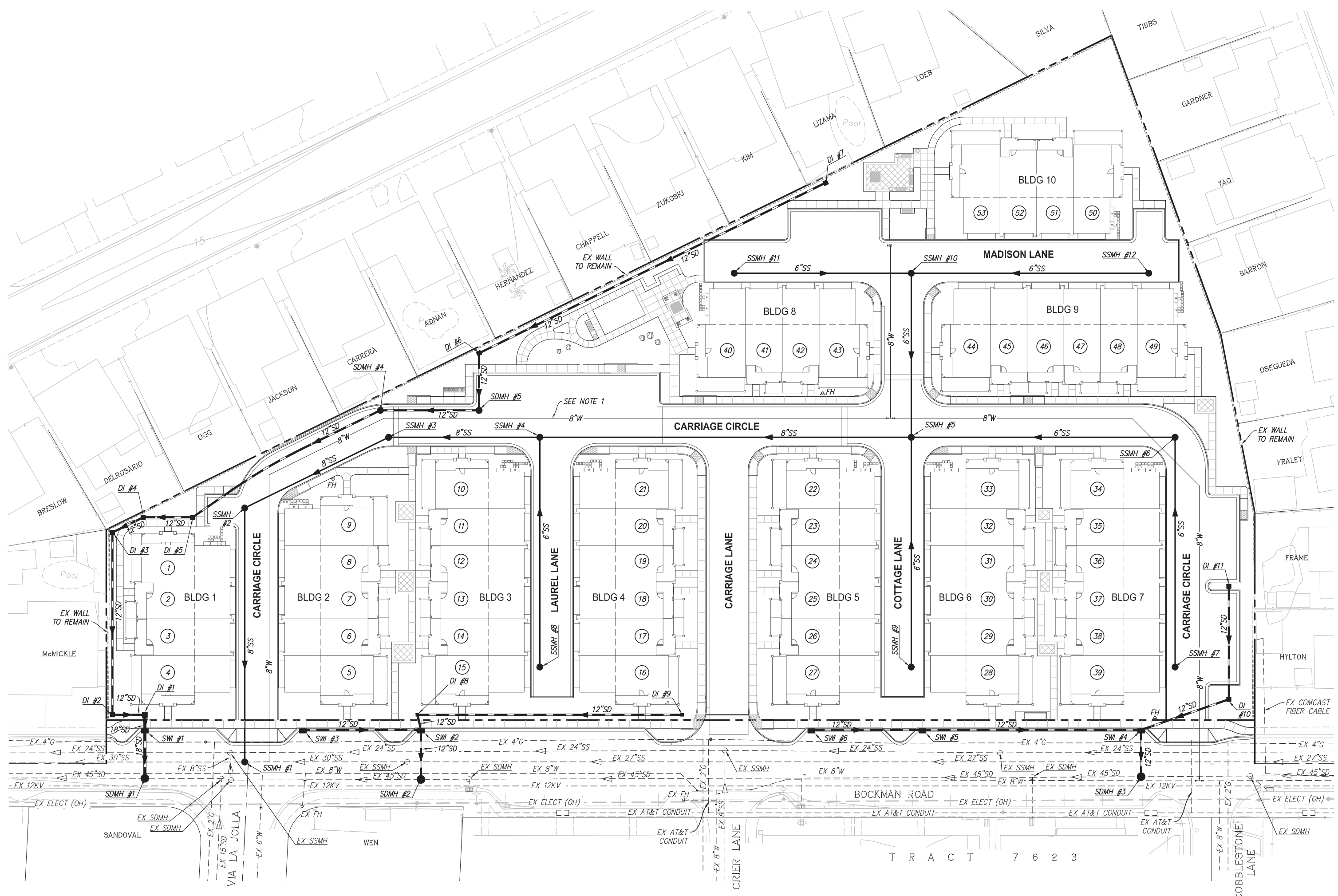
REGISTERED PROFESSIONAL ENGINEER
MARK A. FALGOUT
No. C 63394
CIVIL
STATE OF CALIFORNIA

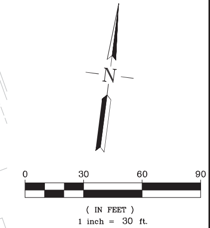
IMPROVEMENT PLANS
TRACT 8284 - THE BUNGALOWS
REMEDIAL GRADING PLAN
SAN LORENZO, ALAMEDA COUNTY, CALIFORNIA
FOR: SAN LORENZO RES, LLC

SCALE	DATE	DRAWN	CHECKED	PROJ. MGR.
NTS	1-13-2016	AL/APW/TH	JA	MF

DATE	MK	SHEET REVISIONS	BY	CK	CITY

SHEET NO.
C6.1
23 OF 33 SHEETS
JOB NO.
151072





STORM DRAIN STRUCTURE SCHEDULE	
STRUCTURE NO.	STRUCTURE
SWI #1, 2, 3, 4, 5, 6	DROP INLET WITHOUT TAPER PER COUNTY STD DETAIL SD-420
SDMH #1, 2	SHALLOW MANHOLE PER DETAIL 1/C2.5
SDMH #3	MANHOLE TYPE II WITH MANHOLE FRAME AND COVER PER DETAILS SD-401 & SD-407
DI #1	OLDCASTLE PRECAST DROP INLET MODEL 2K (24"x24") WITH PEDESTRIAN FRAME & GRATE PER DETAIL 4/C2.4
DI #2, 3, 4, 5, 6, 7, 8, 9, 10, 11	OLDCASTLE PRECAST DROP INLET MODEL CK (18"x18") WITH PEDESTRIAN FRAME & GRATE PER DETAIL 4/C2.4

NOTES:

1. 8"W MAIN AND FIRE HYDRANT (FH) ARE SHOWN FOR REFERENCE ONLY. SEE EBMUD PLANS FOR EXACT LOCATIONS AND DESIGN INFORMATION.
2. ONLY SD PIPES 12" AND LARGER ARE SHOWN.

REVIEWED BY:

FOR ALAMEDA COUNTY PUBLIC WORKS AGENCY

RUGGERI-JENSEN-AZAR

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REGISTERED PROFESSIONAL ENGINEER MARK A. FALGOUT No. C 63394 CIVIL STATE OF CALIFORNIA

IMPROVEMENT PLANS
TRACT 8284 - THE BUNGALOWS
UTILITY SYSTEM MAP
SAN LORENZO, ALAMEDA COUNTY, CALIFORNIA

FOR: SAN LORENZO RES, LLC

SCALE NTS
DATE 1-13-2016
DRAWN AL/APW/TH
CHECKED JA
PROJ. MGR. MF

DATE	MK	SHEET REVISIONS	BY	CK	CITY

SHEET NO. **C3.2**

10 OF 33 SHEETS

JOB NO. 151072

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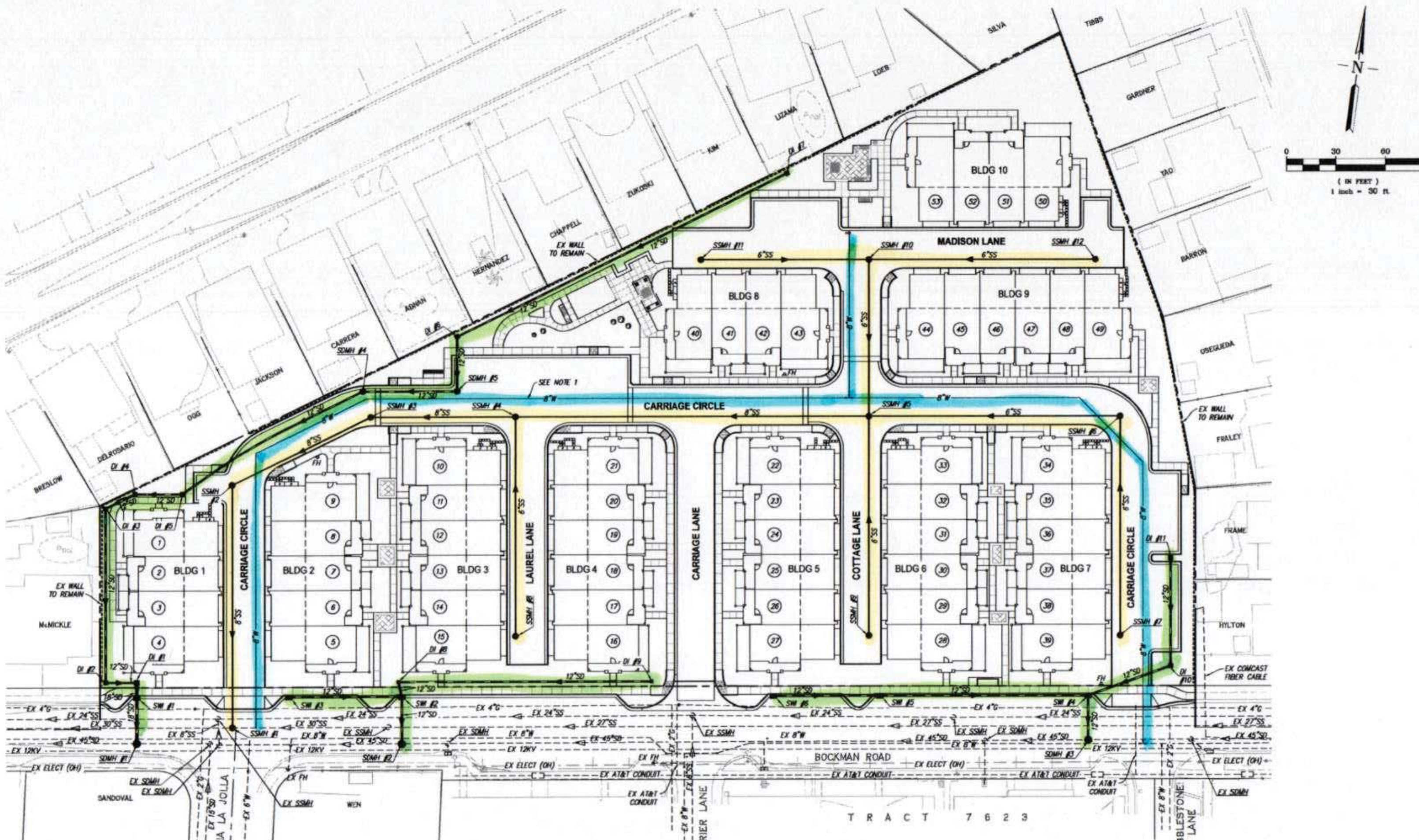

STORM DRAIN STRUCTURE SCHEDULE	
STRUCTURE NO.	STRUCTURE
SWI #1, 2, 3, 4, 5, 6	DROP INLET WITHOUT TAPER PER COUNTY STD DETAIL SD-420
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DI #2, 3, 4, 5, 6, 7, 8, 9, 10, 11	OLDCASTLE PRECAST DROP INLET MODEL CK (18"x18") WITH PEDESTRIAN FRAME & GRATE PER DETAIL 4/C2.4

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2. ONLY SD PIPES 12" AND LARGER ARE SHOWN.

SANITARY SEWER (SS)
WATER (W)
STORM DRAIN (SD)

REVIEWED BY:
FOR ALAMEDA COUNTY PUBLIC WORKS AGENCY

IMPROVEMENT PLANS
TRACT 8284 - THE BUNGALOWS
UTILITY SYSTEM MAP
SAN LORENZO, ALAMEDA COUNTY, CALIFORNIA
FOR: SAN LORENZO RES, LLC

SCALE NTS
DATE 1-13-2016
DRAWN AL/APN/TH
CHECKED JA
PROJ. MGR. MF

DATE | MK | SHEET REVISIONS | BY | CK | CITY

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SHEET NO. C3.2

JOB NO. 151072

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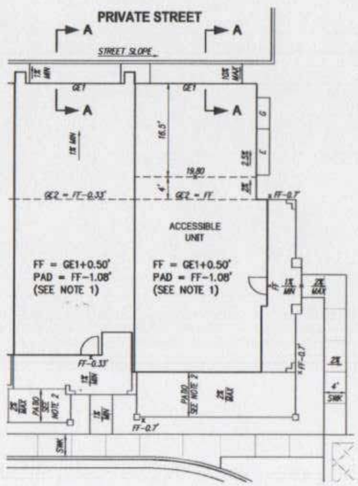
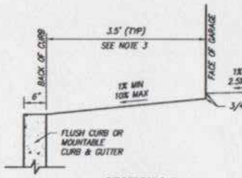
REGISTERED PROFESSIONAL ENGINEER — MARK A. FALGOUT — No. C 53384 — CIVIL — STATE OF CALIFORNIA

IMPROVEMENT PLANS
TRACT 8284 - THE BUNGALOWS
DETAILS
SAN LORENZO, ALAMEDA COUNTY, CALIFORNIA
FOR: SAN LORENZO RES, LLC

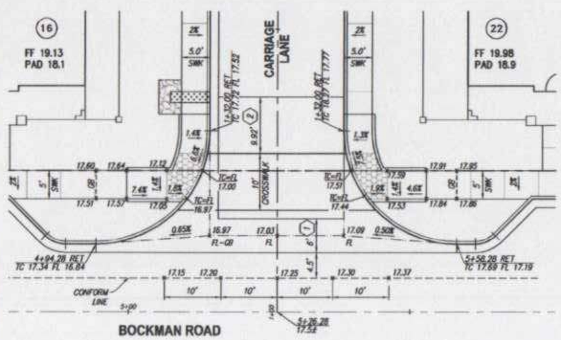




SECTION A-A
NOT TO SCALE

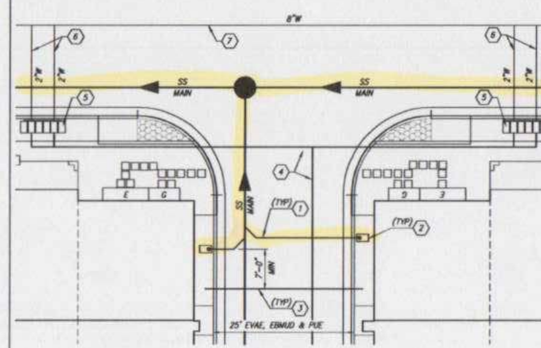
NOTES:
1. PAD IS ROUNDED TO ONE DECIMAL PLACE.
2. SEE ARCHITECTURAL PLANS FOR PATIO WIDTH.
3. DRIVEWAY LENGTH IS 3.0' FOR ALL UNITS OF BUILDING 1.
4. FOR SLOPE ACROSS PORCH AND PATIO, MIN SLOPE IS 1% AND MAX SLOPE IS 2%.

NOT TO SCALE
1 TYPICAL GRADING AT BUILDING UNITS



GRADING DETAIL KEY SYMBOL:
1. 6" WIDE VALLEY GUTTER PER COUNTY STD DETAIL SD-303
2. PERMEABLE VEHICULAR PAVER PER DETAIL 12/C2.2

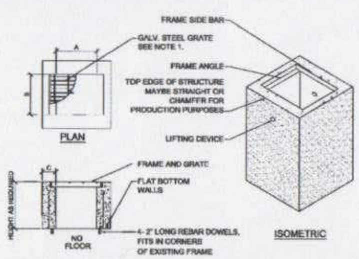
SCALE: 1"=10'
2 GRADING DETAIL AT INTERSECTION OF BOCKMAN RD & CARRIAGE LANE



UTILITY KEY SYMBOL:
1. INSTALL 4" SANITARY SEWER LATERAL. SEE PLAN AND PROFILE SHEETS FOR STATION AND INVERT AT SSCO.
2. INSTALL SSCO PER DETAIL 5 ON THIS SHEET. SEE PLAN AND PROFILE SHEETS FOR STATION AND INVERT AT SSCO.
3. PLUG END DOMESTIC AND FIRE SERVICE 1.5' FROM BACK OF CURB. SEE PLAN AND PROFILE SHEETS FOR STATIONING.
4. 24" WIDE DOMESTIC AND FIRE SERVICE TRENCH. SEE DETAIL 3 ON THIS SHEET.
5. GANGED WATER METERS TO BE INSTALLED PER EBMUD PLANS.
6. WATER LATERAL TO BE INSTALLED PER EBMUD PLANS.
7. WATER MAIN TO BE INSTALLED PER EBMUD PLANS.

NOT TO SCALE
3 TYPICAL UTILITY SERVICES FOR EACH BUILDING UNIT

Oldcastle Precast — Water — Top Extension Drop Inlet — Model: DROPIN TOPEXT

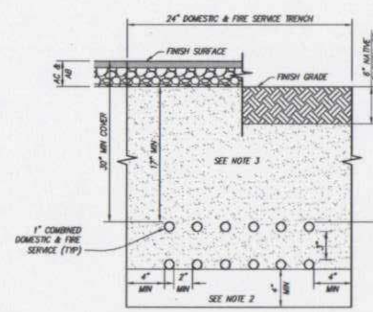


TOP EXTENSION TABLE
ADD 'TOP EXTENSION' AFTER MODEL NUMBER OR PURCHASE ORDER

MODEL No.	CPC MODEL NAME	A IN	A MM	B IN	B MM	C IN	C MM
CB212TE	EK	12	300	12	300	4	100
CB1818TE	CK	18	450	18	450	5	125
CB1824TE	1K"	18	450	24	600	5	125
CB2424TE	2K	24	600	24	600	5	125
CB2430TE	3K	24	600	30	750	5	125
CB3030TE	5K	30	750	30	750	6	150
CB2436TE	1L	24	600	36	900	6	150
CB3636TE	1M	36	900	36	900	6	150
CB2448TE	3L	24	600	48	1200	6	150
CB3648TE	3M	36	900	48	1200	6	150
CB4848TE	1R	48	1200	48	1200	6	150

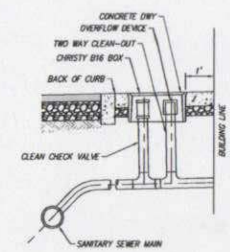
NOTES:
1. FRAMES AND GRATES MAY BE SPECIFIED FOR PEDESTRIAN OR TRAFFIC LOADING. ALL GRATES ARE BICYCLE PROOF. OPTIONAL GRATE LOCKING DEVICE AVAILABLE ON REQUEST SEE DRAWING ON PAGE 1-7. CLOSED MESH GRATES OR CAST IRON FRAME AND GRATES ARE AVAILABLE ON REQUEST.
2. [illegible] AND DISCHARGE OPTIONS AVAILABLE SEE DRAWING ON PAGE 1-[illegible], 1-6 AND 1-6.
3. FRAMES AND GRATES DETAILS SEE PAGES 1-9, 1-9, AND 1-10.
4. WALL THICKNESSES ON ALL D.I.S. CAN BE CHANGED UPON REQUEST.
5. [illegible] D.I.S REPLACE THE OLD "[illegible]" [illegible] & 1K.
6. ADA AND HEEL PROOF FRAME AND GRATES ARE AVAILABLE ON REQUEST.

NOT TO SCALE
4 DROP INLET



NOTES:
1. SEE EBMUD STD DETAIL 1992-A FOR COMPACTION REQUIREMENTS
2. CLASS 2 ASB, QUARRY FINES OR DRAIN ROCK
3. CLASS 2 ASB OR QUARRY FINES

NOT TO SCALE
5 WATER SERVICE TRENCH



NOTES:
SEE ORO LOMA SANITARY DISTRICT STD DETAILS SD-11 AND SD-15 FOR ADDITIONAL INFORMATION.

NOT TO SCALE
6 SANITARY CLEANOUT AND OVERFLOW

REVIEWED BY:
FOR ALAMEDA COUNTY PUBLIC WORKS AGENCY

SCALE	DATE	DRAWN	CHECKED	PROJ. MGR.
NTS	1-12-2016	AL/NPW/TH	JA	MF

DATE	MK	SHEET REVISIONS	BY	CK	CITY

SHEET NO. **C2.4**

JOB NO. 151072

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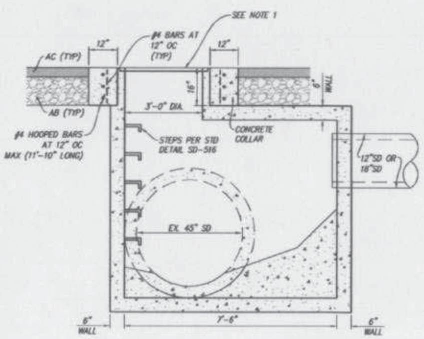
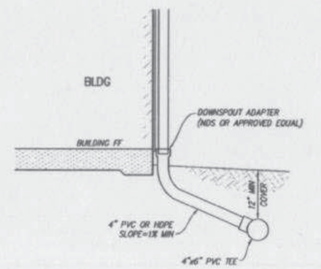


NOTES:
1. MODIFIED MANHOLE FRAME AND COVER TYPE I PER STD DETAIL SD-407. REPLACE DISTRICT "ACFC & WCD" INSET WITH "STORM DRAIN" INSET.

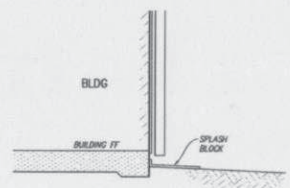
NOT TO SCALE

1 SHALLOW STORM DRAIN MANHOLE



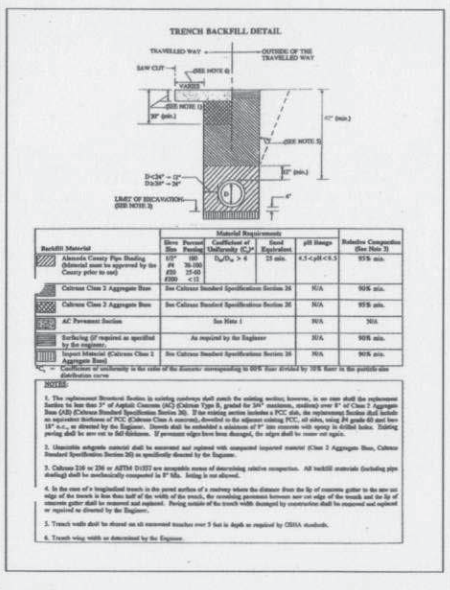
NOT TO SCALE

2 DOWNSPOUT CONNECTION TO AREA DRAIN LATERAL



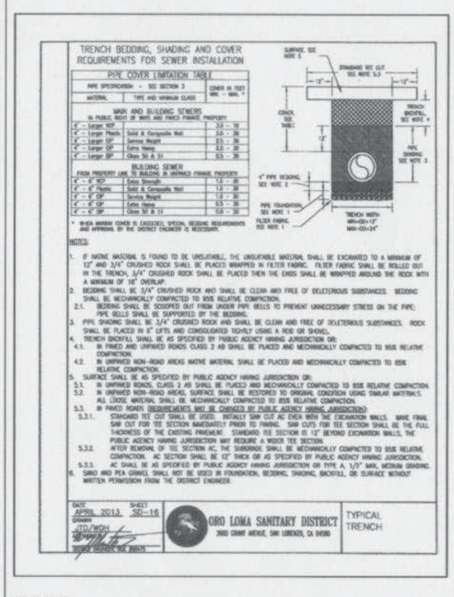
NOT TO SCALE

3 DOWNSPOUT WITH SPLASH BLOCK



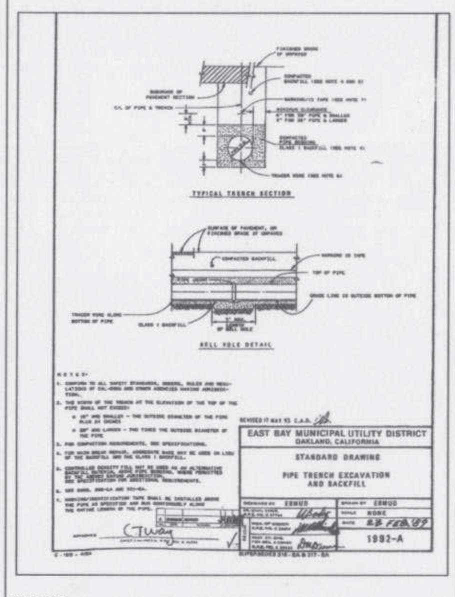
NOT TO SCALE

4 STORM DRAIN TRENCH BACKFILL DETAIL



NOT TO SCALE

5 SANITARY SEWER TRENCH BACKFILL DETAIL



NOT TO SCALE

6 WATER TRENCH BACKFILL DETAIL

RUGGERI-JENSEN-AZAR
ENGINEERS • PLANNERS • SURVEYORS
4690 CHABOT DRIVE, SUITE 200 PLEASANTON, CA 94588
PHONE: (925) 227-9100 FAX: (925) 227-9300

REGISTERED PROFESSIONAL ENGINEER
MARK A. FALGOUT
No. C 63391
CIVIL
STATE OF CALIFORNIA

IMPROVEMENT PLANS
TRACT 8284 - THE BUNGALOWS

DETAILS

SAN LORENZO, ALAMEDA COUNTY, CALIFORNIA

FOR: SAN LORENZO RES, LLC

SCALE	DATE	DRAWN	CHECKED	PROJ. MGR.
NTS	1-11-2016	AL/MW/HI	JA	MF

DATE	MK	SHEET REVISIONS	BY	CK	CITY

REVIEWED BY:

FOR ALAMEDA COUNTY PUBLIC WORKS AGENCY

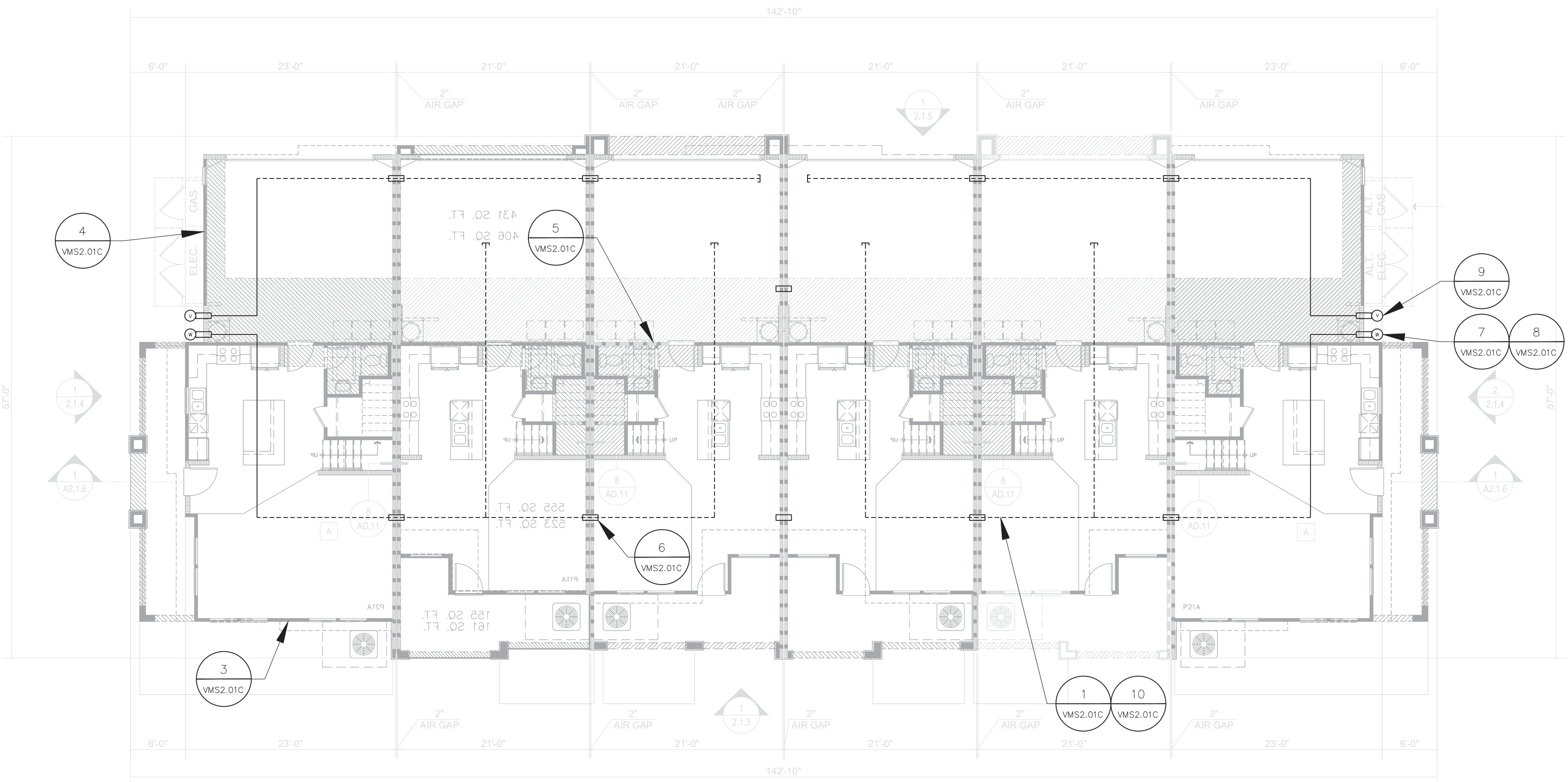
SHEET NO. **C2.5**

8 OF 33 SHEETS

JOB NO. 151072

Appendix B

Vapor Intrusion Mitigation System (VIMS)
Design Drawings



SYMBOLS LEGEND

- 3" DIAMETER PERFORATED SCH. 40 PVC PIPE BELOW SLAB (SEE DETAILS ON SHEET VMS2.01C)
- 3" DIAMETER PVC PIPE END CAP
- 3" DIAMETER SOLID SCH. 40 PVC PIPE BELOW SLAB
- 4" DIAMETER SOLID PVC PIPE SLEEVE
- PERIMETER INLET VENT (SEE DETAILS ON SHEET VMS2.01C)
- CIP OR DIP RISER PIPE TO ROOF (SEE DETAILS ON SHEET VMS2.01C)
- SEE DETAIL 1, SHEET VMS2.01C

GENERAL NOTES

1. SYMBOLS NOT TO SCALE.

GRAPHIC SCALE

0 5 10 Feet

Date	Description	No.
1/20/17	SUBMITTAL TO ALAMEDA COUNTY	1

REVISIONS

SIGNATURE — DATE SIGNED

PROFESSIONAL ENGINEER STATE LIC. No. 69777

LANGAN

Project: THE BUNGALOWS

BOCKMAN DRIVE

SAN LORENZO — CALIFORNIA

Drawing Title: VAPOR MITIGATION PLAN BUILDING TYPE A

Project No. 770625803

Date 01/20/17

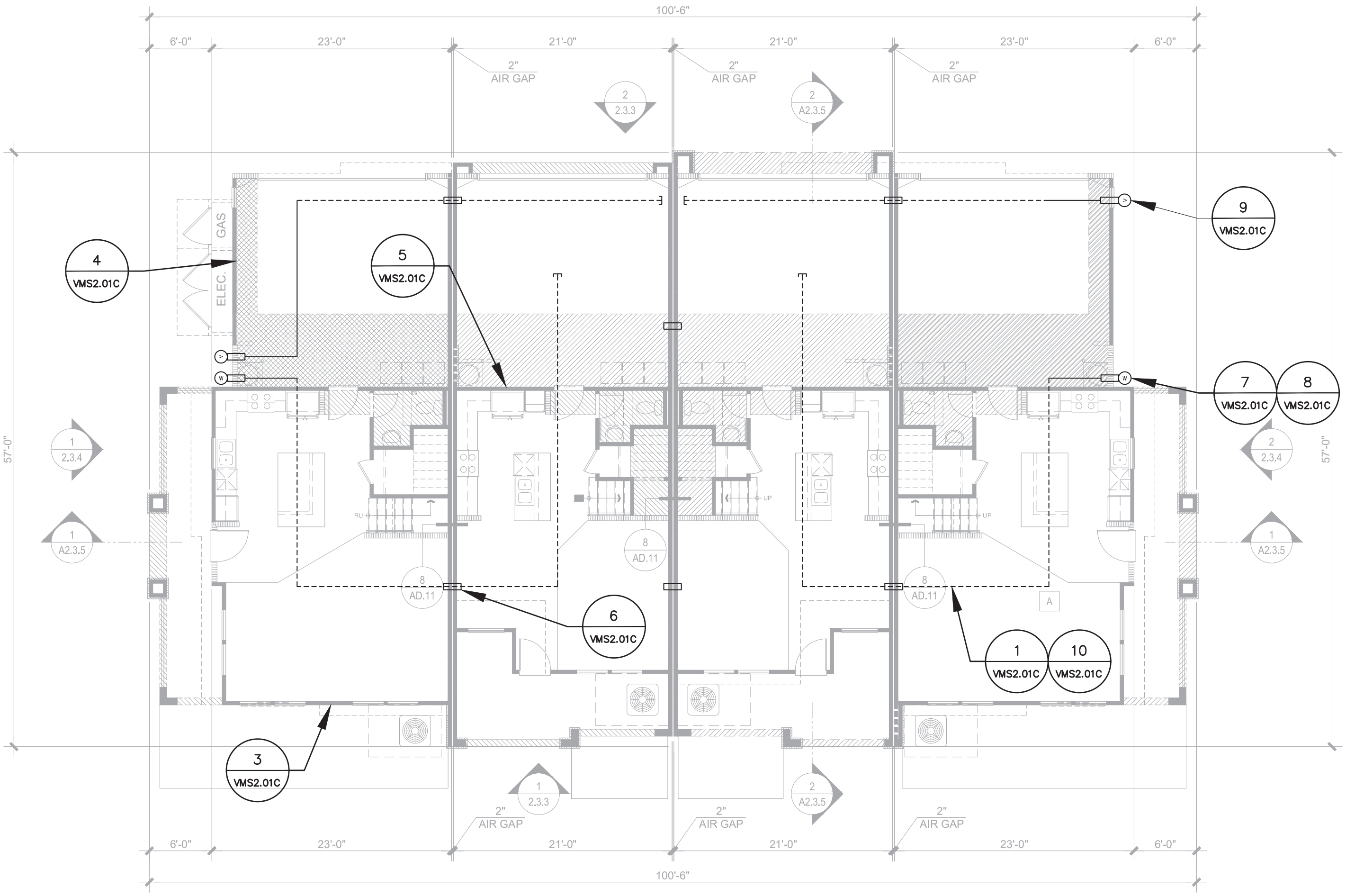
Scale Not to Scale

Drawn By HB — Checked By SR

Submission Date 01/20/17

Drawing No. VMS1.01

Sheet 1 of 3



SYMBOLS LEGEND

- 3" DIAMETER PERFORATED SCH. 40 PVC PIPE BELOW SLAB (SEE DETAILS ON SHEET VMS2.01C)
- 3" DIAMETER PVC PIPE END CAP
- 3" DIAMETER SOLID SCH. 40 PVC PIPE BELOW SLAB
- 4" DIAMETER SOLID PVC PIPE SLEEVE
- PERIMETER INLET VENT (SEE DETAILS ON SHEET VMS2.01C)
- CIP OR DIP RISER PIPE TO ROOF (SEE DETAILS ON SHEET VMS2.01C)
- SEE DETAIL 1, SHEET VMS2.01C

GENERAL NOTES

1. SYMBOLS NOT TO SCALE.

GRAPHIC SCALE

0 5 10 Feet

Date	Description	No.
1/20/17	SUBMITTAL TO ALAMEDA COUNTY	1

REVISIONS

SIGNATURE — PROFESSIONAL ENGINEER STATE LIC. No. 69777 — DATE SIGNED

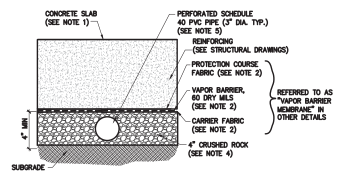
LANGAN

Project: THE BUNGALOWS

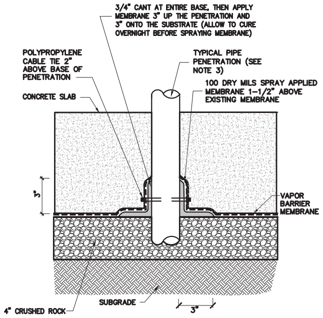
BOCKMAN DRIVE, SAN LORENZO, CALIFORNIA

Drawing Title: VAPOR MITIGATION PLAN BUILDING TYPE C

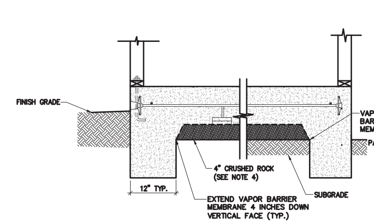
Project No.	770625803
Date	1/20/17
Scale	Not to Scale
Drawn By	HB
Checked By	SR
Submission Date	1/20/17
Drawing No.	VMS1.02
Sheet	2 of 3



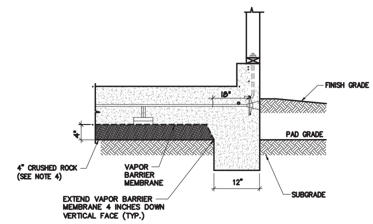
1 TYPICAL VAPOR MITIGATION SYSTEM CROSS-SECTION
NOT TO SCALE



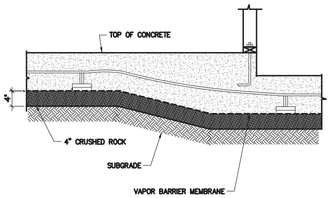
2 TYPICAL SEALING OF ALL PENETRATIONS THROUGH CONCRETE SLAB
NOT TO SCALE



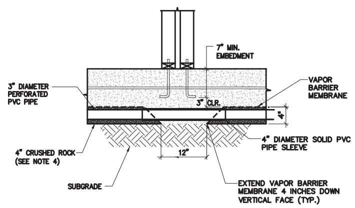
3 TYPICAL MEMBRANE AT THICKENED SLAB EDGE
NOT TO SCALE



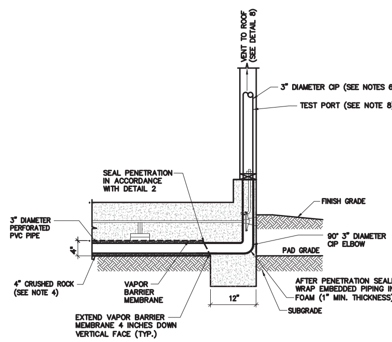
4 TYPICAL MEMBRANE AT THICKENED SLAB
NOT TO SCALE



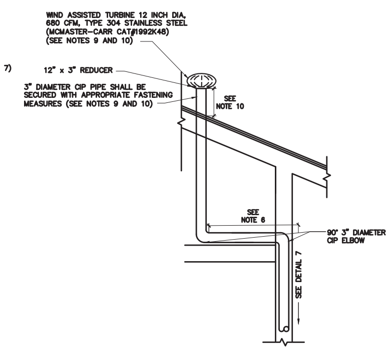
5 TYPICAL MEMBRANE AT STEP IN SLAB
NOT TO SCALE



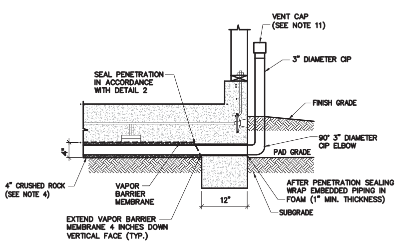
6 TYPICAL MEMBRANE AT AT BRG/SHEAR WALL
NOT TO SCALE



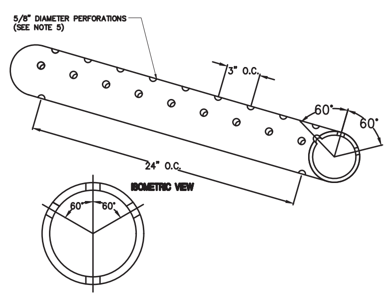
7 HORIZONTAL-TO-VERITICAL RISER TRANSITION AT EXTERIOR WALL
NOT TO SCALE



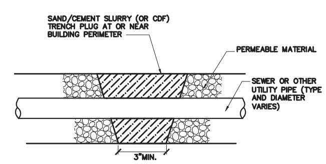
8 RISER TRANSITION INTO ATTIC AT EXTERIOR WALL AND VENT TO ROOF
NOT TO SCALE



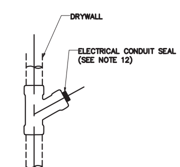
9 TYPICAL PERIMETER INLET VENT
NOT TO SCALE



10 DETAIL OF PERFORATED PIPE PATTERN
NOT TO SCALE



11 TYPICAL SOIL GAS CUT-OFF BARRIER IN UTILITY TRENCH
NOT TO SCALE



12 TYPICAL INTERIOR AND EXTERIOR CONDUIT SEAL
NOT TO SCALE

NOTES:

1. ALL LOCATIONS AND DIMENSIONS OF BUILDING SLABS, FOOTINGS, SHEAR WALLS, AND GRADE BEAMS TO BE CONFIRMED WITH STRUCTURAL DETAILS.
2. THE 60 MIL SPRAY APPLIED VAPOR BARRIER MEMBRANE SHALL BE INSTALLED ACCORDING TO MEMBRANE MANUFACTURER'S SPECIFICATIONS AND QA/QC REQUIREMENTS (E.G., COUPON AND SMOKE TESTING) BY A MANUFACTURER APPROVED APPLICATOR. CARRIER FABRIC AND PROTECTION COURSE FABRIC SHALL BE PER MEMBRANE MANUFACTURER'S SPECIFICATIONS.
3. SLAB PENETRATIONS SHALL NOT BE IN CONTACT WITH AN ADJACENT PENETRATION THAT WOULD PREVENT PROPER SEALING OF THE PENETRATION CIRCUMFERENCE. SLAB PENETRATIONS SHALL BE PREPARED AND STUBBED PRIOR TO MEMBRANE INSTALLATION.
4. CRUSHED ROCK LAYER SHALL BE 1/4" X 3/4" (100% PASSING 1-INCH; 90% PASSING ¾-INCH; 10% MAXIMUM PASSING #4). SURFACE OF CRUSHED ROCK LAYER SHALL BE SMOOTH ROLLED PRIOR TO APPLICATION OF THE CARRIER FABRIC. CRUSHED ROCK LAYER SHALL BE 4" MINIMUM.
5. HORIZONTAL COLLECTION PIPE SHALL BE 3" DIAMETER SCH. 40 PVC. INDICATED SECTIONS OF HORIZONTAL COLLECTION PIPE SHALL BE PERFORATED WITH 5/8 INCH DIAMETER HOLES, THREE HOLES ACROSS THE UPPER ONE-THIRD OF THE PIPE, EVERY THREE INCHES ALONG THE PERFORATED SECTION. AN ADDITIONAL 5/8 INCH DIAMETER HOLE SHALL BE DRILLED ON THE UNDERSIDE OF THE PIPE AT LEAST EVERY TWO LINEAR FEET ALONG THE PERFORATED SECTION TO ALLOW WATER, IF ANY, TO DRAIN FROM THE PIPE.
6. VERTICAL RISER PIPES SHALL BE SUPPORTED AT THE PIPE CHASE WALLS, AS NEEDED. PIPE MUST BE 3" DIAMETER CAST IRON PIPE (CIP). MINOR (< 5 FEET) JOGS IN THE VERTICAL RISER AT ATTIC LEVEL ARE ACCEPTABLE.
7. VERTICAL RISER PIPES SHALL BE LABELED AS "CONTAINS VAPORS; DO NOT BREAK OR CUT."
8. TEST PORTS SHALL BE INSTALLED ON VERTICAL RISER PIPES, 36 INCHES ABOVE GROUND LEVEL, FOR AIR SAMPLING. TEST PORT SHALL BE BRASS TUBE FITTING, BORED-TROUGH MALE CONNECTOR, WITH 1/4-INCH TUBE OD 1/4-INCH MALE NPT (SWAGELOCK® B-400-1-4BT OR EQUIVALENT). TEST PORT CAP SHALL BE BRASS CAP FOR 1/4-INCH OD TUBING (SWAGELOCK® B-400-C OR EQUIVALENT). A LOCKABLE ACCESS HATCH AT THE EXTERIOR WALL FACE SHALL BE INSTALLED TO ALLOW ACCESS TO SAMPLING PORTS.
9. THE TOP OF THE VERTICAL RISER PIPES (W) SHALL EXTENDTO AN ELEVATION OF 1 FOOT ABOVE THE ROOF AND ALLOW THE WIND TURBINES TO OPERATE FREELY; THEY SHALL BE LOCATED A MINIMUM OF 15 FEET AWAY FROM FRESH AIR INTAKES FOR BUILDING'S HVAC SYSTEM OR OTHER OPENINGS (O'HAGIN VENTS, WINDOWS, DOORS, ETC.), AND SHALL BE SUPPORTED BY STRUTS OR STRAPS ATTACHED TO AN ADJACENT STRUCTURAL ELEMENT.
10. THE WIND-ASSISTED TURBINE ON TOP OF THE 3 INCH PVC RISER SHALL BE 12 INCH DIAMETER, 680 CFM, TYPE 304 STAINLESS STEEL (MCMASTER-CARR CAT#1992K48) AND SHALL BE SECURED TO THE TOP OF THE RISER. TURBINE SHALL BE ADAPTED TO FIT A 3 INCH PIPE. TURBINE SHALL BE INSTALLED TO RESIST WIND, SEISMIC, AND OTHER LOADS, AS NEEDED.
11. PERIMETER VENTS SHALL BE EQUIPPED WITH A RAIN CAP THAT WILL ALLOW FRESH AIR FLOW INTO THE INLET BUT NOT RAIN OR FOREIGN OBJECTS TO FALL INTO THE VENT.
12. MECHANICAL, ELECTRICAL, AND PLUMBING CONDUIT PENETRATIONS IN THE WALLS ON THE LOWEST LEVEL OF THE STRUCTURE SHALL BE SEALED AIR-TIGHT USING APPROPRIATE SEALING PRODUCT (FIRE CAULKING OR SIMILAR SEALANT).

Date	Description	No.
01/20/17	SUBMITTAL TO ALAMEDA COUNTY	1

REVISIONS

SIGNATURE — DATE SIGNED

PROFESSIONAL ENGINEER STATE LIC. No. 69777

LANGAN

Project: THE BUNGALOWS
BOCKMAN DRIVE
SAN LORENZO — CALIFORNIA

Drawing Title: VAPOR MITIGATION SYSTEM DETAILS

Project No. 770625803	Drawing No.
Date 01/20/17	VMS2.01C
Scale Not to Scale	
Drawn By HB / Checked By SR	
Submission Date 01/20/17	Sheet 3 of 3

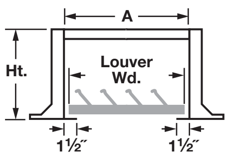
Appendix C

Wind-Turbine Fan and Active Blower Specifications

Movable-Blade Louvers for Roof Exhaust Fans

Louver

Mounting Base



The blades on these louvers are gravity operated. They open when your roof-mounted exhaust fan goes on and close when it's off, preventing backdrafts. They have a galvanized steel frame and aluminum blades for corrosion resistance. Felt seals on the face of the blades ensure quiet closing and better protection from the weather. Mounting bases (sold separately) are galvanized steel. Louvers fit the bottom of the mounting base and must be secured to the lip of the base with sheet metal screws (not included; see pages 2988-2997). Louver is 0.040″ thick; blades are 0.016″ thick. Temperature range is –40° to 180° F. Maximum air velocity is 2,000 fpm.

Also Available: Additional louver sizes. Please ask for 8061T999 and specify louver dimensions.

Louvers				8″ High Mounting Bases			12″ High Mounting Bases		
Overall Lg.	Overall Wd.			Inside Wd. (A)			Inside Wd. (A)		
13¾″	13¾″	8061T3	$41.37	14½″	2230K11	$94.04	14½″	2230K64	$112.98
15¾″	15¾″	8061T5	44.40	16½″	2230K13	100.11	16½″	2230K31	117.77
17¾″	17¾″	8061T9	48.69	—	—	—	19½″	2230K33	129.33
19¾″	19¾″	8061T14	52.86	21½″	2230K16	115.81	—	—	—
21¾″	21¾″	8061T16	60.29	—	—	—	23½″	2230K35	140.46
23¾″	23¾″	8061T19	66.10	—	—	—	25½″	2230K36	147.32
27¾″	27¾″	8061T26	76.22	—	—	—	28½″	2230K39	155.88
34¾″	34¾″	8061T28	106.62	35½″	2230K63	153.52	35½″	2230K94	177.96
36¾″	36¾″	8061T29	112.75	—	—	—	37½″	2230K45	180.80

Wind-Driven Turbine Exhaust Fans

Designed to spin freely with the slightest breeze, these fans create a vacuum that draws air out from buildings and ventilation systems. No electricity is required. Mount fans on your roof away from wind obstructions. Optional mounting bases are sold separately on this page. Maximum temperature is 150° F. For information about exhaust fans, see page 678.

Steel exhaust fans have a galvanized finish for added corrosion resistance.

Dia.	Max. Ht.	Airflow, cfm @ 4 mph	Thick.	Steel		Type 304 Stainless Steel	
6″	14½″	110	0.018″	1992K12	$53.83	1992K43	$159.62
8″	15½″	195	0.018″	1992K14	57.77	1992K45	165.47
10″	16¾″	305	0.018″	1992K16	66.28	1992K47	181.08
12″	17¼″	440	0.024″	1992K17	68.55	1992K48	210.58
14″	20″	600	0.024″	1992K18	84.45	1992K49	255.37
16″	22½″	790	0.024″	1992K21	131.24	1992K52	307.40
18″	24″	1,000	0.024″	1992K22	149.18	1992K53	376.80
20″	24½″	1,200	0.024″	1992K23	167.32	1992K54	406.90
24″	29½″	1,700	0.024″	1992K24	209.94	1992K55	535.38
30″	32″	2,700	0.030″	1992K25	493.59	1992K56	1,292.73
36″	38″	4,000	0.030″	1992K27	672.56	—	—

Bases for Wind-Driven Exhaust Fans

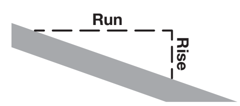
Flat Base

Straight Base

Slope Base

Made of corrosion-resistant galvanized steel, these bases have a square bottom and round top. All have 4″ wide flashing to simplify installation.

To Order: For slope bases, please specify pitch: 1/12-11/12 in increments of 1/12. To determine pitch, use an angle indicator (see page 2303) or divide rise by run (see illustration). For instance, if your roof rises 5″ in 12″ of horizontal space, your pitch is 5/12.



(A)	(B)	Ht.	Flat Bases		Straight Bases		Slope Bases	
8″	10″	10″	2003K91	$47.25	2003K51	$47.25	2003K31	$73.50
10″	12″	10″	2003K92	49.00	2003K52	49.00	2003K32	77.00
12″	14″	10″	2003K93	50.75	2003K53	50.75	2003K33	80.52
14″	16″	10″	2003K94	80.52	2003K54	80.52	2003K34	115.52
16″	18″	10″	2003K95	108.52	2003K55	108.52	2003K35	164.53
18″	22″	10″	2003K96	110.02	2003K56	110.02	2003K36	134.63
20″	24″	10″	2003K97	120.02	2003K57	120.02	2003K37	186.69
24″	30″	12″	2003K98	143.13	2003K58	143.13	2003K38	211.58

Exterior-Mount Wall Exhaust Fans

Fan

Grille

Louver

Attach to an outside wall. Ideal when you don't have room to mount an exhaust fan inside your facility, these fans work with or without duct. To use with duct, add an angle ring (sold separately; see 1764K on page 656). Motor is single-phase, open dripproof, and sealed against contaminants. All have a junction box. They are direct-drive and operate on 120 volts AC, except 18″ dia. fan operates on 120/230 volts AC. Mounting fasteners not included. Maximum temperature is 180° F. UL and C-UL listed. For information about exhaust fans, see page 678. For information about sound levels, see page 665.

Grilles are aluminum. They have fixed blades.

Louvers are aluminum. They are gravity operated. The blades open when air flows and close when it stops, preventing backdrafts.

Blade Dia.	Airflow, cfm★ @0″ SP	Airflow, cfm★ @¼″ SP	Volume, dB	rpm	hp	Fits Opening Dia.	Fits Opening Sq.	Overall Dia.	Overall Dp.	Fans		Grilles		Louvers	
7″	190	—	49	1,050	1/25	8″	8″	17⅛″	13″	1925K1	$420.30	1925K81	$34.56	1925K91	$51.37
10″	550	250	52	1,050	1/25	10″	10″	21⅛″	16″	1925K2	441.78	1925K82	38.29	1925K92	52.30
13″	1,600	1,400	59	1,075	1/6	12″	12″	30 3/16″	28¾″	1925K4	763.08	1925K84	44.83	1925K93	54.17
16″	2,800	2,400	65	1,075	1/3	14″	16″	34 11/16″	30⅞″	1925K5	985.37	1925K85	62.58	1925K94	63.51
18″	4,300	4,000	69	1,125	3/4	18″	20″	39 7/16″	35⅝″	1925K62	1,383.65	1925K87	99.00	1925K97	80.32

★ Airflow depends on the resistance created by louvers, filters, and ductwork in your system. This resistance, known as static pressure (SP), is measured in inches of water.

RadonAway®
The world's leading radon fan manufacturer

RP Series

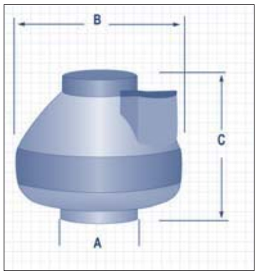
Radon Mitigation Fan

All RadonAway® fans are specifically designed for radon mitigation. RP Series Fans provide superb performance, run ultra-quiet and are attractive. They are ideal for most sub-slab radon mitigation systems.

Features

- Energy efficient
- Ultra-quiet operation
- Meets all electrical code requirements
- Water-hardened motorized impeller
- Seams sealed to inhibit radon leakage (RP140 & RP145 double snap sealed)
- ETL Listed - for indoor or outdoor use
- Thermally protected motor
- Rated for commercial and residential use

MODEL	P/N	FAN DUCT DIAMETER	WATTS	MAX. PRESSURE"WC	TYPICAL CFM vs. STATIC PRESSURE WC				
					0"	.5"	1.0"	1.5"	2.0"
RP140*	23029-1	4"	15-21	0.8	135	70	-	-	-
RP145	23030-1	4"	41-72	2.1	166	126	82	41	3
RP260	23032-1	6"	50-75	1.6	272	176	89	13	-
RP265	23033-1	6"	91-129	2.3	334	247	176	116	52
RP380	28208	8"	95-152	2.3	497	353	220	130	38



Model	A	B	C
RP140	4.5"	9.7"	8.5"
RP145	4.5"	9.7"	8.5"
RP260	6"	11.75"	8.6"
RP265	6"	11.75"	8.6"
RP380	8"	13.41"	10.53"

Made in USA with US and imported parts

ETL Listed

All RadonAway inline radon fans are covered by our 5-year, hassle-free warranty

*Energy Star® Rated

For Further Information Contact

The World's Leading
Radon Fan Manufacturer

RP Series

Installation & Operating Instructions

RadonAway

3 Saber Way | Ward Hill, MA 01835
www.radonaway.com

P/N IN020-REV R 08/15

RadonAway Ward Hill, MA.

Series Fan Installation & Operating Instructions

Please Read and Save These Instructions.

DO NOT CONNECT POWER SUPPLY UNTIL FAN IS COMPLETELY INSTALLED. MAKE SURE ELECTRICAL SERVICE TO FAN IS LOCKED IN "OFF" POSITION. DISCONNECT POWER BEFORE SERVICING FAN.

1. **WARNING!** WARNING! For General Ventilating Use Only. Do Not Use to Exhaust Hazardous, Corrosive or Explosive Materials, Gases or Vapors. See Vapor Intrusion Application Note #AN001 for important information on VI applications. RadonAway.com/vapor-intrusion
2. **WARNING!** NOTE: Fan is suitable for use with solid state speed controls however use of speed controls is not generally recommended.
3. **WARNING!** Check voltage at the fan to insure it corresponds with nameplate.
4. **WARNING!** Normal operation of this device may affect the combustion airflow needed for safe operation of fuel burning equipment. Check for possible backdraft conditions on all combustion devices after installation.
5. **NOTICE!** There are no user serviceable parts located inside the fan unit.
   Do NOT attempt to open. Return unit to the factory for service.
6. **WARNING!** Do not leave fan unit installed on system piping without electrical power for more than 48 hours. Fan failure could result from this non-operational storage.
7. **WARNING!** TO REDUCE THE RISK OF FIRE, ELECTRIC SHOCK, OR INJURY TO PERSONS, OBSERVE THE FOLLOWING:

   a) Use this unit only in the manner intended by the manufacturer. If you have questions, contact the manufacturer.

   b) Before servicing or cleaning unit, switch power off at service panel and lock the service disconnecting means to prevent power from being switched on accidentally. When the service disconnecting means cannot be locked, securely fasten a prominent warning device, such as a tag, to the service panel.

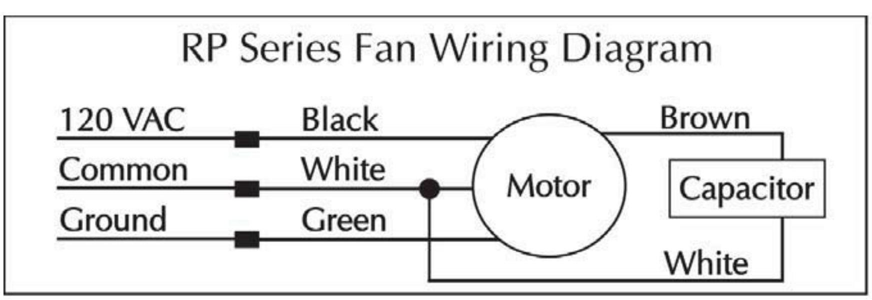
   c) Installation work and electrical wiring must be done by qualified person(s) in accordance with all applicable codes and standards, including fire rated construction.

   d) Sufficient air is needed for proper combustion and exhausting of gases through the flue (chimney) of fuel burning equipment to prevent back drafting. Follow the heating equipment manufacturers guideline and safety standards such as those published by the National Fire Protection Association, and the American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), and the local code authorities.

   e) When cutting or drilling into a wall or ceiling, do not damage electrical wiring and other hidden utilities.

   f) Ducted fans must always be vented to outdoors.

   g) If this unit is to be installed over a tub or shower, it must be marked as appropriate for the application and be connected to a GFCI (Ground Fault Circuit Interrupter) - protected branch circuit.



RP Series

RP140	p/n 23029-1
RP145	p/n 23030-1
RP260	p/n 23032-1
RP265	p/n 23033-1
RP380	p/n 28208

1.0 SYSTEM DESIGN CONSIDERATIONS

1.1. INTRODUCTION

The RP Series Radon Fans are intended for use by trained, professional, certified/licensed Radon mitigators. The purpose of this instruction is to provide additional guidance for the most effective use of an RP Series Fan. This instruction should be considered as a supplement to EPA/radon industry standard practices, state and local building codes and state regulations. In the event of a conflict, those codes, practices and regulations take precedence over this instruction.

1.2. FAN SEALING

The RP Series Fans are factory sealed, no additional caulk or other materials are required to inhibit air leakage.

1.3. ENVIRONMENTALS

The RP Series Fans are designed to perform year-round in all but the harshest climates without additional concern for temperature or weather. For installations in an area of severe cold weather, please contact RadonAway for assistance. When not in operation, the fan should be stored in an area where the temperature is never less than 32 degrees F. or more than 100 degrees F.

1.4. ACOUSTICS

The RP Series Fan, when installed properly, operates with little or no noticeable noise to the building occupants. The velocity of the outgoing air should be considered in the overall system design. In some cases the "rushing" sound of the outlet air may be disturbing. In these instances, the use of a RadonAway Exhaust Muffler is recommended.

(To ensure quiet operation of ENERGY STAR qualified in-line and remote fans, each fan shall be installed using sound attenuation techniques appropriate for the installation. For bathroom and general ventilation applications, at least 8 feet of insulated flexible duct shall be installed between the exhaust or supply grille(s) and the fan). RP Series fans are not suitable for kitchen range hood remote ventilation applications.

1.5. GROUND WATER

In the event that a temporary high water table results in water at or above slab level, water may be drawn into the riser pipes thus blocking air flow to the RP Series Fan. The lack of cooling air may result in the fan cycling on and off as the internal temperature rises above the thermal cutoff and falls upon shutoff. Should this condition arise, it is recommended that the fan be turned off until the water recedes allowing for return to normal operation.

1.6. SLAB COVERAGE

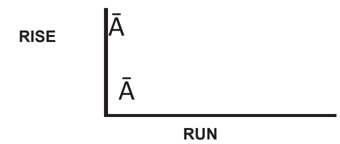
The RP Series Fan can provide coverage up to 2000+ sq. ft. per slab penetration. This will primarily depend on the sub-slab material in any particular installation. In general, the tighter the material, the smaller the area covered per penetration. Appropriate selection of the RP Series Fan best suited for the sub-slab material can improve the slab coverage. The RP140/145/155 are best suited for general purpose use. The RP260 can be used where additional airflow is required and the RP265/380 is best suited for large slab, high airflow applications. Additional suction points can be added as required. It is recommended that a small pit (5 to 10 gallons in size) be created below the slab at each suction hole.

1.7. CONDENSATION & DRAINAGE

Condensation is formed in the piping of a mitigation system when the air in the piping is chilled below its dew point. This can occur at points where the system piping goes through unheated space such as an attic, garage or outside. The system design must provide a means for water to drain back to a slab hole to remove the condensation. The RP Series Fan **MUST** be mounted vertically plumb and level, with the outlet pointing up for proper drainage through the fan. Avoid mounting the fan in any orientation that will allow water to accumulate inside the fan housing. The RP Series Fans are **NOT** suitable for underground burial.

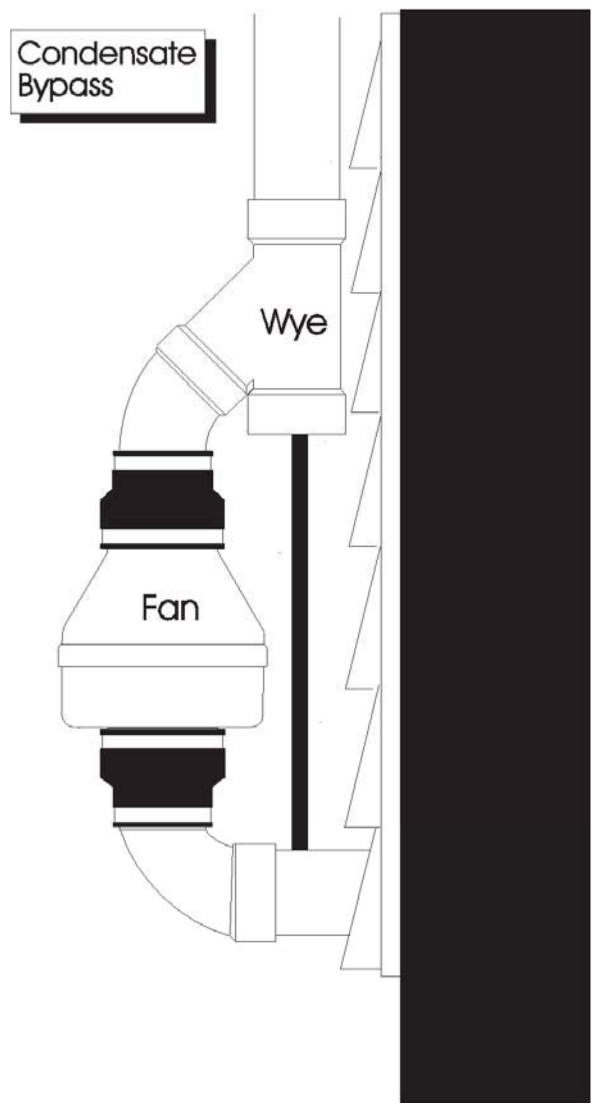
For RP Series Fan piping, the following table provides the minimum recommended pipe diameter and pitch under several system conditions.

Pipe Dia.	Minimum Rise per Ft of Run*				
	@25 CFM	@50 CFM	@100 CFM	@200 CFM	@300 CFM
6"	-	3/16	1/4	3/8	3/4
4"	1/8	1/4	3/8	2 3/8	-
3"	1/4	3/8	1 1/2	-	-



*Typical RP1xx/2xx Series Fan operational flow rate is 25 - 90 CFM 0n 3" and 4" pipe. (For more precision, determine flow rate by measuring Static Pressure, in WC, and correlate pressure to flow in the performance chart in the addendum.)

Under some circumstances in an outdoor installation a condensate bypass should be installed in the outlet ducting as shown. This may be particularly true in cold climate installations which require long lengths of outlet ducting or where the outlet ducting is likely to produce large amounts of condensation because of high soil moisture or outlet duct material. Schedule 20 piping and other thin-walled plastic ducting and Aluminum downspout will normally produce much more condensation than Schedule 40 piping. Schedule 40 piping is preferred for radon mitigation, all joints should fully sealed using the appropriate pipe cement on socket type fittings or flexible coupling firmly attached via worm drive screw clamps. Sealing ducting or pipe with duct tape is not acceptable on radon mitigation installations. No pipe penetrations are permitted, other than the condensation bypass. Silicon caulk is permitted for sealing purposes.



The bypass is constructed with a 45 degree Wye fitting at the bottom of the outlet stack. The bottom of the Wye is capped and fitted with a tube that connects to the inlet piping or other drain. The condensation produced in the outlet stack is collected in the Wye fitting and drained through the bypass tube. The bypass tubing may be insulated to prevent freezing.

1.8. SYSTEM MONITOR & LABEL

A System Monitor, such as a manometer (P/N 50017) or audible alarm (P/N 28001-2) is required to notify the occupants of a fan system malfunction. A System Label (provided with Manometer P/N 50017) with instructions for contacting the installing contractor for service and also identifying the necessity for regular radon tests to be conducted by the building occupants, must be conspicuously placed where the occupants frequent and can see the label.

1.9. VENTILATION

If used as a ventilation Fan any type of ducting is acceptable, however, flexible nonmetallic ducting is recommended for easy installation and quieter operation. Insulated flexible ducting is highly recommended in cold climates to prevent the warm bathroom air from forming condensation in the ducting where it is exposed to colder attic air. The outlet of the fan should always be ducted to the outside. Avoid venting the outlet of the fan directly into an attic area. The excess moisture from the bathroom can cause damage to building structure and any items stored in the attic. Multiple venting points may be connected together using a "T" or "Y" fitting. Ideally Duct should be arranged such that equal duct lengths are used between intake and "T" or "Y" fitting, this will result in equal flow rates in each intake branch. If adjustable intake grilles are used on multi-intake systems then the opening on each grill should be equal in order to minimize noise and resistance. Straight smooth runs of rigid metal ducting will present the least resistance and maximize system performance. The Equivalent Length of Rigid Metal Ducting resulting in .2" WC pressure loss for each Fan Model is provided in the specification section of these Instructions. Flexible ducting, if used, must always be as close to being fully extended as possible. Formed rigid metal duct elbows will present the least resistance and maximize system performance, recommended bend radius of elbow is at least 1.5 x duct diameter.

RP Series fans are not suitable for kitchen range hood remote ventilation applications. For quietest performance, the fan should be mounted further away from the inlet duct, near the outside vent. A minimum distance of 8 feet is recommended between the fan or T/Y of a multi-intake system and intake grille(s).

Backdraft dampers allow airflow in only one direction preventing cold/hot drafts from entering the vented area and minimize possible condensation and icing within the system while the fan is not operating. Backdraft dampers are highly recommended at each intake grille for bathroom ventilation in all cold climate installations. Installation instructions are included with Spruce backdraft dampers.

The ducting from this fan to the outside of the building has a strong effect on the airflow, noise and energy use of the fan. Use the shortest, straightest duct routing possible for best performance, and avoid installing the fan with smaller ducts than recommended. Insulation around the ducts can reduce energy loss and inhibit mold growth. Fans installed with existing ducts may not achieve their rated airflow.

1.10. ELECTRICAL WIRING

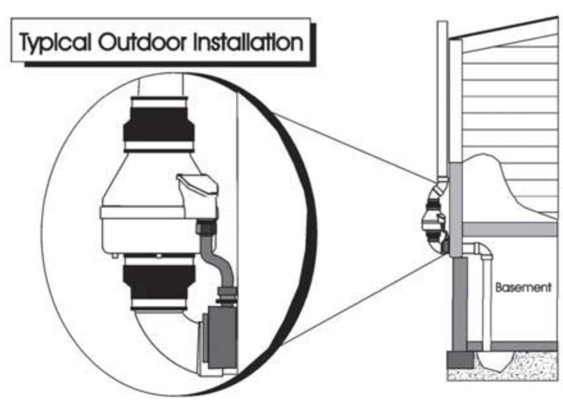
The RP Series Fans operate on standard 120V 60 Hz. AC. All wiring must be performed in accordance with the National Fire Protection Association's (NFPA)"National Electrical Code, Standard #70"-current edition for all commercial and industrial work, and state and local building codes. All wiring must be performed by a qualified and licensed electrician. Outdoor installations require the use of a U.L. listed watertight conduit. Ensure that all exterior electrical boxes are outdoor rated and properly sealed to prevent water penetration into the box. A means, such as a weep hole, is recommended to drain the box.

1.11. SPEED CONTROLS

The RP Series Fans are rated for use with electronic speed controls, however, they are generally not recommended. If used, the recommended speed control is Pass & Seymour Solid State Speed Control Cat. No. 94601-I.

2.0 INSTALLATION

The RP Series Fan can be mounted indoors or outdoors. (It is suggested that EPA recommendations be followed in choosing the fan location.) The RP Series Fan may be mounted directly on the system piping or fastened to a supporting structure by means of optional mounting bracket



2.1 MOUNTING

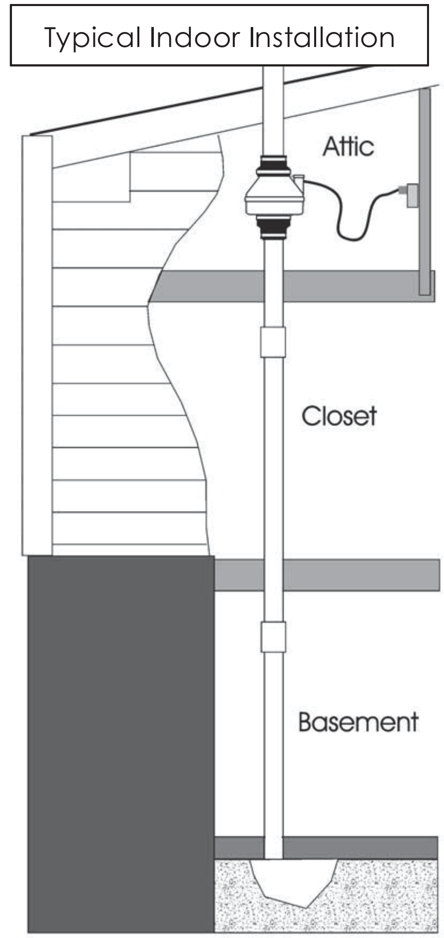
Mount the RP Series Fan vertically with outlet up. Insure the unit is plumb and level. When mounting directly on the system piping assure that the fan does not contact any building surface to avoid vibration noise.

2.2 MOUNTING BRACKET (optional)

The RP Series Fan may be optionally secured with the RadonAway P/N 25007 (25033 for RP385) mounting bracket. Foam or rubber grommets may also be used between the bracket and mounting surface for vibration isolation.

2.3 SYSTEM PIPING

Complete piping run, using flexible couplings as means of disconnect for servicing the unit and vibration isolation. Used as a Radon Fan the fan is typically outside of the building thermal boundary, and is venting to the outside, installation of insulation around the fan is not required. If used as a ventilation fan insulation may be installed around the fan and duct work, insulation should be sized appropriately for the duct size used and secured with duct tape.



2.4 ELECTRICAL CONNECTION

Connect wiring with wire nuts provided, observing proper connections (See Section 1.10). Note that the fan is not intended for connection to rigid metal conduit.

Fan Wire	Connection
Green	Ground
Black	AC Hot
White	AC Common

2.5 VENT MUFFLER (optional)

Install the muffler assembly in the selected location in the outlet ducting. Solvent weld all connections. The muffler is normally installed at the end of the vent pipe.

2.6 OPERATION CHECKS & ANNUAL SYSTEM MAINTENANCE

______**Verify** all connections are tight and **leak-free**.

______**Insure** the RP Series Fan and all ducting is secure and vibration-free.

______**Verify** system vacuum pressure with manometer. **Insure** vacuum pressure is within normal operating range and **less than** the maximum recommended operating pressure.

(Based on sea-level operation, at higher altitudes reduce by about 4% per 1000 Feet.)

(Further reduce Maximum Operating Pressure by 10% for High Temperature environments)

See Product Specifications. If this is exceeded, increase the number of suction points.

______**Verify Radon levels by testing to EPA protocol.**

RP SERIES PRODUCT SPECIFICATIONS

The following chart shows fan performance for the RP Series Fan:

Typical CFM Vs Static Pressure "WC									
Ā	0"	.25"	.5"	.75"	1.0"	1.25"	1.5"	1.75"	2.0"
RP140	135	103	70	14	-	-	-	-	-
RP145	166	146	126	104	82	61	41	21	3
RP260	272	220	176	138	103	57	13	-	-
RP265	334	291	247	210	176	142	116	87	52
RP380*	497	401	353	281	220	176	130	80	38

* Tested with 6″ inlet and discharge pipe.

Power Consumption 120 VAC, 60Hz 1.5 Amp Maximum			Maximum Recommended Operating Pressure* (Sea Level Operation)**	
RP140	17 - 21	watts	RP140	0.8" W.C.
RP145	41 - 72	watts	RP145	1.7" W.C.
RP260	52 - 72	watts	RP260	1.5" W.C.
RP265	91 - 129	watts	RP265	2.2" W.C.
RP380	95 - 152	watts	RP380	2.0" W.C.

**Reduce by 10% for High Temperature Operation*
***Reduce by 4% per 1000 feet of altitude*

Ā	Size	Weight	Inlet/Outlet	L.2
RP140	8.5H" x 9.7" Dia.	5.5 lbs.	4.5" OD (4.0" PVC Sched 40 size compatible)	25
RP145	8.5H" x 9.7" Dia.	5.5 lbs.	4.5" OD (4.0" PVC Sched 40 size compatible)	15
RP260	8.6H" x 11.75" Dia.	5.5 lbs.	6.0″ OD	48
RP265	8.6H" x 11.75" Dia.	6.5 lbs.	6.0″ OD	30
RP380	10.53H" x 13.41" Dia.	11.5 lbs.	8.0″ OD	57

L.2 = Estimated Equivalent Length of Rigid Metal Ducting resulting in .2in WC pressure loss for Duct Size listed. Longer Equivalent Lengths can be accommodated at Flows Lower than that at .2in WC pressure loss (see CFM Vs Static Pressure "WC Table).

Recommended ducting: 3" or 4" RP1xx/2xx, 6″ RP380, Schedule 20/40 PVC Pipe

Mounting: If used for Ventilation use 4", 6" or 8" Rigid or Flexible Ducting

Mount on the duct pipe or with optional mounting bracket.

Storage temperature range: 32 - 100 degrees F.

Normal operating temperature range: -20 - 120 degrees F.

Maximum inlet air temperature: 80 degrees F.

Continuous Duty

Class F Insulation [RP140 Class B]

Class B Insulation

Thermally Protected

3000 RPM

Rated for Indoor or Outdoor Use

LISTED
Electric Fan

Intertek
77728

Conforms to
UL STD. 507

Certified to
CAN/CSA STD.
C22.2 No.113

RP140 Only

IMPORTANT INSTRUCTIONS TO INSTALLER

Inspect the GP/XP/XR/RP/SF Series Fan for shipping damage within 15 days of receipt. Notify **RadonAwayĀ of any damages immediately**. RadonAwayĀ is not responsible for damages incurred during shipping. However, for your benefit, RadonAwayĀ does insure shipments.

There are no user serviceable parts inside the fan. **Do not attempt to open.** Return unit to factory for service.

Install the GP/XP/XR/RP/SF Series Fan in accordance with all EPA standard practices, and state and local building codes and state regulations.

Provide a copy of this instruction or comparable radon system and testing information to the building occupants after completing system installation.

WARRANTY

RadonAway® warrants that the GPX01/XP/XR/RP/SF Series Fan (the "Fan") will be free from defects in materials and workmanship for a period of 90 days from the date of purchase (the "Warranty Term").

RadonAway® will replace any Fan which fails due to defects in materials or workmanship during the Warranty Term. The Fan must be returned (at Owner's cost) to the RadonAway® factory. Any Fan returned to the factory will be discarded unless the Owner provides specific instructions along with the Fan when it is returned regardless of whether or not the Fan is actually replaced under this warranty. Proof of purchase must be supplied upon request for service under this Warranty.

This Warranty is contingent on installation of the Fan in accordance with the instructions provided. This Warranty does not apply where any repairs or alterations have been made or attempted by others, or if the unit has been abused or misused. Warranty does not cover damage in shipment unless the damage is due to the negligence of RadonAway®.

5 YEAR EXTENDED WARRANTY WITH PROFESSIONAL INSTALLATION.

RadonAway® will extend the Warranty Term of the fan to five (5) years from date of purchase or sixty-three (63) months from the date of manufacture, whichever is sooner, if the Fan is installed in a professionally designed and professionally installed active soil depressurization system or installed as a replacement fan in a professionally designed and professionally installed active soil depressurization system by a qualified installer. Proof of purchase and/or proof of professional installation may be required for service under this warranty. Outside the Continental United States and Canada the extended Warranty Term is limited to one (1) year from the date of manufacture.

RadonAway® is not responsible for installation, removal or delivery costs associated with this Warranty.

LIMITATION OF WARRANTY

EXCEPT AS STATED ABOVE, THE GPx01/XP/XR/RP SERIES FANS ARE PROVIDED WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

IN NO EVENT SHALL RADONAWAY BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES ARISING OUT OF, OR RELATING TO, THE FAN OR THE PERFORMANCE THEREOF. RADONAWAY'S AGGREGATE LIABILITY HEREUNDER SHALL NOT IN ANY EVENT EXCEED THE AMOUNT OF THE PURCHASE PRICE OF SAID PRODUCT. THE SOLE AND EXCLUSIVE REMEDY UNDER THIS WARRANTY SHALL BE THE REPAIR OR REPLACEMENT OF THE PRODUCT, TO THE EXTENT THE SAME DOES NOT MEET WITH RADONAWAY'S WARRANTY AS PROVIDED ABOVE.

For service under this Warranty, contact RadonAway for a Return Material Authorization (RMA) number and shipping information. No returns can be accepted without an RMA. If factory return is required, the customer assumes all shipping costs, including insurance, to and from factory.

RadonAway® 3 Saber Way
Ward Hill, MA 01835 USA TEL (978) 521-3703
FAX (978) 521-3964
Email to: Returns@RadonAway.com

Record the following information for your records:

Serial No.____
Purchase Date______________________________________

Appendix D

GeoSeal™ Vapor Barrier Information

Land Science™
Technologies

Geo-Seal®
Vapor Intrusion Barrier

Land Science™ Technologies

A DIVISION OF REGENESIS, Inc.

Geo-Seal®

Vapor Intrusion Barrier

Mixed Sources
Product group from well-managed forests and other controlled sources
www.fsc.org Cert no. SW-COC-001851
© 1996 Forest Stewardship Council
FSC

www.landsciencetech.com

Geo-Seal®

Geo-Seal® is an advanced composite gas vapor management technology (patent pending) designed to eliminate potential indoor air quality health risks associated with subsurface contaminant vapor intrusion.

Geo-Seal is an ideal gas vapor management technology designed for use on Brownfields or any type of environmentally impaired site, i.e. manufacturing facilities, dry cleaners, gasoline service stations, landfills, etc. ***Geo-Seal*** is placed between the foundation of the building and the soil pad to eliminate vapor exposure pathways and stop contaminated vapors from permeating through the slab. Vapor management systems incorporating both ***Geo-Seal*** vapor barrier and *Vapor-Vent* ventilation provide industry leading sub-foundation vapor mitigation technology. By deploying these systems developers ensure a healthy indoor environment while reducing the cost of site remediation and expediting site construction.

Triple-Layer Protection

The triple-layer system used in ***Geo-Seal*** provides maximum redundancy and protection against the formation of vapor pathways both during and after installation. Such pathways can result from chemically induced materials breakdown, punctures, and seam weaknesses resulting from poor detail work and/or application installation imperfections around penetrations. ***Geo-Seal*** also provides unmatched protection from a range of contaminant vapors including those from petroleum-based products and chlorinated hydrocarbons.

Field-Proven Technology

Geo-Seal is manufactured in partnership with E-Pro™ Systems which has over 20 years experience in the building products industry and a leading track record in barrier systems for vapor and waterproofing applications.

Geo-Seal®

Diagram

Diagram labels

1 *Geo-Seal* BASE - The BASE layer is rolled out geotextile facing down, which allows Geo-Seal CORE to be applied directly to the high density polyethylene. The BASE layer provides the ultimate substrate and enables the spray layer to be free of shadowing and pinholes.

2 *Geo-Seal* CORE - The CORE is applied at 60 mils, is sprayed to the base layer, seals around penetrations and seals the seams of the BASE layer.

3 *Geo-Seal* BOND - A proprietary protection layer is placed over the CORE layer to enhance the curing of the membrane and increase puncture resistance.

4 **Vapor-Vent:**

- Eliminates the need for trenching
- Cost-effective compared to pipe and gravel systems
- Eliminates long-term costs when configured as a passive system
- Allows for rapid installation
- When used with *Geo-Seal* provides maximum protection against contaminated vapor

Geo-Seal® Triple-Layer System
(2 Chemical Resistant Layers + 1 Spray Applied Core Layer)

Dual Chemical Resistant Layers

The ***BASE*** layer (bottom) and the ***BOND*** layer (top) are composed of a high-density polyethylene material bonded to a geo-textile on the out-facing side. High density polyethylene is known for chemical resistance, high tensile strength, excellent stress-crack resistance and for highly reliable subsurface containment. The geo-textile which is physically bonded to the chemical resistant layer accomplishes two goals; it allows the BOND layer to adhere to the slab, and provides a friction course between the BASE layer and the soil.

Spray Applied CORE Layer

The CORE layer is composed of a unique, elastic co-polymer modified asphaltic membrane which also provides additional protection against vapor transmission. This layer creates a highly-effective seal around slab penetrations and eliminates the need for mechanical fastening at termination points.

Chemical Resistance

The dual chemical resistant layers combined with the spray CORE form a barrier resistant to the most concentrated chemical pollutant vapors.

Enhanced Curing

Geo-Seal is "construction friendly" as the reduced curing time of the ***Geo-Seal*** CORE layer and the ability to apply it in cooler temperatures ensures quick installation and minimizes the impact on construction schedules.

Puncture Resistance

Geo-Seal forms a highly puncture resistant barrier that greatly reduces the chance of damage occurring after installation and prior to the placement of concrete.

Removing Contained Vapors

Vapor-Vent can be used in conjunction with ***Geo-Seal*** to alleviate the buildup of vapors beneath structures as a result of vapor barrier implementation. ***Vapor-Vent*** can be utilized as an active or passive ventilation system depending on the requirements of the design engineer.

Certified Applicator Network

The application of ***Geo-Seal*** and ***Vapor-Vent*** can be performed by any one of many certified applicators throughout the country.

Service and Support

Geo-Seal representatives are available to provide job and site specific assistance. A local representative can ensure ***Geo-Seal*** and ***Vapor-Vent*** is installed as per the specification

Geo-Seal®

Land Science™
Technologies

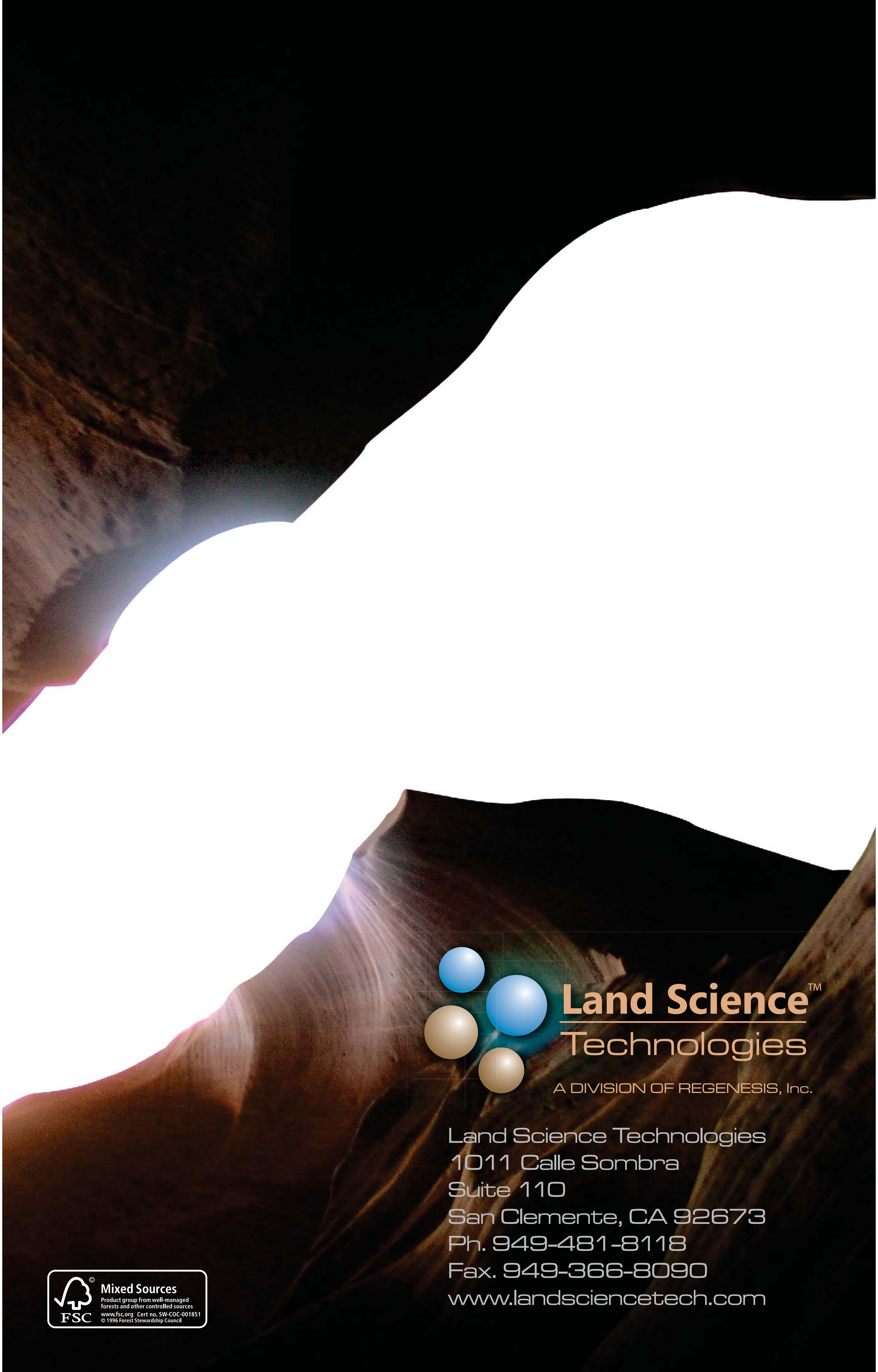
A DIVISION OF REGENESIS, Inc.

Land Science Technologies **(LST) ™** is dedicated to providing advanced technologies for sustainable land development. A goal of LST is to provide innovative and technically sound development solutions for underutilized environmentally impaired properties, commonly referred to as Brownfields.

LST's cost-effective, industry leading technologies offer engineering firms and real estate developers solutions to issues facing the development of Brownfields toda . LST is a division of ***Regenesis, Inc.***, a global leader in groundwater and soil remediation technologies since 1994.

REGENESIS

www.regenesis.com



Land Science™ Technologies

A DIVISION OF REGENESIS, Inc.

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Ph. 949-481-8118
Fax. 949-366-8090
www.landsciencetech.com

FSC Mixed Sources
Product group from well-managed forests and other controlled sources
www.fsc.org Cert no. SW-COC-001851
© 1996 Forest Stewardship Council

Land Science Technologies
www.landsciencetech.com

Product Data Sheet

Geo-Seal® CORE

Geo-Seal® CORE is an elastic water-based co-polymer modified asphaltic membrane spray applied to a minimum dry thickness of 60 mils. The CORE material has exceptional bonding to a wide variety of substrates and will build up to the specified thickness in a single application. Since the CORE material is water-based, there is little or no odor during or after product application, making it safe for use in sensitive areas. This material can also be applied to green concrete as it exhibits exceptional bonding capability that will not delaminate from the intended substrate. The seamless application of the CORE material makes for easy installation around penetrations, uneven surfaces and oddly shaped areas.

COVERAGES	TEST METHOD	UNITS
Application to BASE Layer		60 mils (17 ft^2/gal)
Typical Uncured Properties		
Specific Gravity	ASTM D 244	1.00
Viscosity	ASTM D 1200	>25 centipoise
PH		12.3
Flammability	ASTM D 3143	500^0 F
Color		Brown to Black
Non-Toxic		No Solvents
Shelf Life		6 months
Typical Cured Properties		
Tensile Strength	ASTM 412	32 psi
Elongation	ASTM 412	4140%
Resistance to Decay	ASTM E 125 Section 13	4% Perm Loss
Accelerated Aging	ASTM G 23	No Effect
Moisture Vapor Transmission	ASTM E 96	0.026 g / ft^2 per hour
Hydraulic Water Pressure	ASTM D 751	26 psi
Perm Rating	ASTM E 96 (US Perms)	0.21
Methane Transmission Rate	ASTM D 1434	Passed
Adhesion to Concrete & Masonry	ASTM C 836 & ASTM C 704	11 lbf / inch
Hardness	ASTM C 836	80
Crack Bridging	ASTM C 836	No Cracking
Low Temp Flexibility	ASTM C 836-00	No Cracking at -20^0 C
Resistance to Acids		
Acetic		30%
Sulfuric and Hydrochloric		13%
Temperature Effect:		
Stable		248^0 F
Flexible		13^0 F
Packaging: 330 gal. totes or 55 gal. drums		

Approvals: City of Los Angeles RR# 25478, NSF

Product Data Sheet

Geo-Seal® CORE DETAIL

Geo-Seal® CORE DETAIL is ideally used to perform detailing and repairs to the Geo-Seal system. It is also ideal for those areas where the necessary clearance is not available for the application of the Geo-Seal spray. This proprietary and unique material can be used all at once or over a period of a few days without breaking down or hardening. Geo-Seal CORE DETAIL is water-based and can be applied to green concrete with exceptional bonding capability that will not delaminate from the intended substrate. Geo-Seal CORE DETAIL's viscosity allows high build applications to be done easily due to its ability to set quickly and get jobs done fast.

PROPERTIES	TEST METHOD	UNITS
TYPICAL UNCURED PROPERTIES		
Specific Gravity		1.034
Viscosity		9m-13m centipoise
PH		11.5
Flammability		270^0 F
Color		Brown to Black
Non-Toxic		No Solvents
Shelf Life		6 months
TYPICAL CURED PROPERTIES		
Initial Cure		30 minutes
Final Cure		24-24 hours
Tensile Strength	ASTM 412	32 psi
Elongation	ASTM 412	3860%
Resistance to Decay	ASTM E 125 Section 13	9% Perm Loss
Accelerated Aging	ASTM G 23	No Effect
Moisture Vapor Transmission	ASTM E 96	0.026 gal/ft^2 per hour
Hydrostatic Water Pressure	ASTM D 751	28 psi
Perm Rating (US Perms)	ASTM E 96	0.17
Methane Transmission Rate	ASTM D 1434	0
Adhesion to Concrete & Masonry	ASTM C 836	7 lbf/inch
Hardness	ASTM C 836	85
Crack Bridging	ASTM C 836	No Cracking
Low Temp Flexibility	ASTM C 836-00	No Cracking at -20^0 C
Resistance to Acids		
Acetic		30%
Sulfuric and Hydrochloric		13%
COVERAGES		
60-mils (dry)		19 ft^2/gal
Packaging: Available in 1 or 5 gal. buckets		

Approvals: City of Los Angeles RR# 25478 (for methane and waterproofing), NSF Standard 61 for potable water containment

Land Science Technologies
www.landsciencetech.com

Product Data Sheet

Geo-Seal™ BASE Layer

The Geo-Seal™ BASE layer is comprised of a high strength laminated HDPE membrane that is thermally bonded to a polypropylene geotextile giving the BASE layer a high puncture resistance (Class A Rating) as well as high chemical resistance. The BASE layer is installed over the substrate with the HDPE side facing up and provides the ideal surface for the application of the Geo-Seal CORE component.

PROPERTIES	TEST METHOD	Geo-Seal BASE
Film Thickness		5 mil
Composite Thickness		18 mil
Tensile @ ULT	ASTM D 882 MD	37.3 lbs / in
	ASTM D 882 TD	32.0 lbs / in
Elongation @ ULT	ASTM D 882 MD	51.00%
	ASTM D 882 TD	55.30%
Dart Impact	ASTM D 1709	
	Method A	>1070 gms
	Method B	594 gms
Modulus	ASTM D 882 MD	295.5 lbs / in
	ASTM D 882 TD	270.6 lbs / in
Elmendorf Tear	ASTM D 1922 MD	5,260 gms
	ASTM D 1922 TD	5,140 gms
Puncture Prop. Tear	ASTM B 2582 MD	11,290 gms
	ASTM B 2582 TD	13,150 gms
Beach Puncture Tear	ASTM D 751 MD	160 lb / in
	ASTM D 751 TD	165 lb / in
Permeability (water vapor)	ASTM E96	0.214
Chemical Resistance		Excellent
Packaging: 15’x150’ = 100 lbs		

Land Science™ Technologies
www.landsciencetech.com

Product Data Sheet

Geo-Seal™ BOND Layer

The Geo-Seal™ BOND layer is comprised of a high strength laminated HDPE membrane that is thermally bonded to a polypropylene geotextile giving the BASE layer a high puncture resistance (Class A Rating) as well as high chemical resistance. The BOND layer is installed as a protection course over the BASE and CORE layers with the geotextile side facing up. The BOND layer also provides an excellent substrate and friction surface for concrete to adhere to.

PROPERTIES	TEST METHOD	Geo-Seal BOND
Film Thickness		5 mil
Composite Thickness		18 mil
Tensile @ ULT	ASTM D 882 MD	37.3 lbs / in
	ASTM D 882 TD	32.0 lbs / in
Elongation @ ULT	ASTM D 882 MD	51.00%
	ASTM D 882 TD	55.30%
Dart Impact	ASTM D 1709	
	Method A	>1070 gms
	Method B	594 gms
Modulus	ASTM D 882 MD	295.5 lbs / in
	ASTM D 882 TD	270.6 lbs / in
Elmendorf Tear	ASTM D 1922 MD	5,260 gms
	ASTM D 1922 TD	5,140 gms
Puncture Prop. Tear	ASTM B 2582 MD	11,290 gms
	ASTM B 2582 TD	13,150 gms
Beach Puncture Tear	ASTM D 751 MD	160 lb / in
	ASTM D 751 TD	165 lb / in
Permeability (water vapor)	ASTM E96	0.214
Chemical Resistance		Excellent
Packaging: 15'x150' = 100 lbs		

Land Science™ Technologies
www.landsciencetech.com

Product Data Sheet

Geo-Seal™ Reinforcement Fabric

The Geo-Seal™ Reinforcement Fabric is a textile material composed of staple fibers hydraulically entangled, which is composed of 100% polyester. The basic use of the Geo-Seal Reinforcement Fabric is designed to act as reinforcement when used in conjunction with Geo-Seal CORE spray applied membrane.

CHEMICAL	EXPOSURE (at room temperature)	% STRENGTHENED RETAINED
Dimethyl Formamide	1000 hours	100%
Ethylene Glycol	1000 hours	100%
1% Sodium Hydroxide	6 hours	100%
60% Sulfuric Acid	150 hours	54%
Perchlorethylene	1000 hours	100%
Acetone	1000 hours	100%
Distilled Water	1000 hours	100%
PHYSICAL PROPERTY DATA		
Weight/Square (lbs.)	ASTM D 3776	1.1
Oz./Sq./Yd. (oz.)	ASTM D 3776	1.6
Bulk (mills)		22
Dry Tensile-MD (lbs.)	ASTM D1777	25
Dry Tensile-CD (lbs.)	ASTM D 1777	18
Elongation-MD (per/cent)	ASTM D 1682	45
Elongation-CD (per/cent)	ASTM D 1682	100
Mullen Burst (P. S. I.)	ASTM D 3786	35
Packaging: 6” x 360’, 12” x 360’		

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Product Data Sheet

Vapor-Vent™

Vapor-Vent™ is a low profile, trenchless, flexible, sub slab vapor collection system used in lieu of perforated piping. Installation of Vapor-Vent increases construction productivity as it eliminates time consuming trench digging and costly gravel importation. Vapor-Vent is offered with two different core materials, Vapor-Vent POLY is recommended for sites with inert methane gas and Vapor-Vent is recommended for sites with aggressive chlorinated volatile organic or petroleum vapors.

VENT PROPERTIES	**TEST METHOD**	**Vapor-Vent POLY**	**Vapor-Vent**
Material		Polystyrene	HDPE
Comprehensive Strength	ASTM D-1621	9,500 lbs / ft^2	11,400 psf
Flow Rate (Hydraulic gradient = .1)	ASTM D-4716	30 gpm/ft width	30 gpm/ft width
Chemical Resistance		N/A	Excellent
FABRIC PROPERTIES	**TEST METHOD**	**Vapor-Vent POLY**	**Vapor-Vent**
Grab Tensile Strength	ASTM D-4632	100 lbs.	110 lbs.
Puncture Strength	ASTM D-4833	65 lbs.	30 lbs.
Mullen Burst Strength	ASTM D-3786	N/A	90 PSI
AOS	ASTM D-4751	70 U.S. Sieve	50 U.S. Sieve
Flow Rate	ASTM D-4491	140 gpm / ft2	95 gpm / ft2
UV Stability (500 hours)	ASTM D-4355	N/A	70% Retained
DIMENSIONAL DATA		**Vapor-Vent POLY**	**Vapor-Vent**
Thickness		1”	1”
Standard Widths		12”	12”
Roll Length		165 ft	165 ft
Roll Weight		65 lbs	68 lbs

Geo-Seal® Vapor Intrusion Barrier
02 56 19.13
Fluid-Applied Gas Barrier
Version 1.30

Note: If membrane will be subjected to hydrostatic pressure, please contact Land Science Technologies™ for proper recommendations.

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplementary conditions and Division 1 specification sections, apply to this section.

1.2 SUMMARY

A. This section includes the following:

1. Substrate preparation:
2. Vapor intrusion barrier components:
3. Seam sealer and accessories.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Division 2 Section "Earthwork", "Pipe Materials", "Sub-drainage Systems", "Gas Collection Systems":
2. Division 3 Section "Cast-in-Place Concrete" for concrete placement, curing, and finishing:
3. Division 5 Section "Expansion Joint Cover Assemblies", for expansion-joint covers assemblies and installation.

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide a vapor intrusion barrier system that prevents the passage of methane gas and/or volatile organic compound vapors and complies with physical requirements as demonstrated by testing performed by an independent testing agency of manufacturer's current vapor intrusion barrier formulations and system design.

1.4 SUBMITTALS

A. Submit product data for each type of vapor intrusion barrier, including manufacturer's printed instructions for evaluating and preparing the substrate, technical data, and tested physical and performance properties.

B. Project Data - Submit shop drawings showing extent of vapor intrusion barrier, including details for overlaps, flashing, penetrations, and other termination conditions.

C. Samples – Submit representative samples of the following for approval:

1. Vapor intrusion barrier components.

D. Certified Installer Certificates – Submit certificates signed by manufacturer certifying that installers comply with requirements under the "Quality Assurance" article.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has been trained and certified in writing by the membrane manufacturer, Land Science Technologies™ for the installation of the Geo-Seal® System.

B. Manufacturer Qualification: Obtain vapor intrusion barrier materials and system components from a single manufacturer source Land Science Technologies.

C. Field Sample: Apply vapor intrusion barrier system field sample to 100 ft^2 (9.3 m^2) of field area demonstrate application, detailing, thickness, texture, and standard of workmanship.

1. Notify engineer or special inspector one week in advance of the dates and times when field sample will be prepared.

2. If engineer or special inspector determines that field sample, does not meet requirements, reapply field sample until field sample is approved.

3. Retain and maintain approved field sample during construction in an undisturbed condition as a standard for judging the completed methane and vapor intrusion barrier. An undamaged field sample may become part of the completed work.

D. Pre-installation Conference: A pre-installation conference shall be held prior to application of the vapor intrusion barrier system to assure proper site and installation conditions, to include contractor, applicator, architect/engineer, other trades influenced by vapor intrusion barrier installation and special inspector (if any).

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to project site as specified by manufacturer labeled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for storing and mixing with other components.

B. Store materials as specified by the manufacturer in a clean, dry, protected location and within the temperature range required by manufacturer. Protect stored materials from direct sunlight. If freezing temperatures are expected, necessary steps should be taken to prevent the freezing of the Geo-Seal CORE and Geo-Seal CORE Detail components.

C. Remove and replace material that cannot be applied within its stated shelf life.

1.7 PROJECT CONDITIONS

A. Protect all adjacent areas not to be installed on. Where necessary, apply masking to prevent staining of surfaces to remain exposed wherever membrane abuts to other finish surfaces.

B. Perform work only when existing and forecasted weather conditions are within manufacturer's recommendations for the material and application method used.

C. Minimum clearance of 24 inches is required for application of product. For areas with less than 24-inch clearance, the membrane may be applied by hand using Geo-Seal CORE Detail.

D. Ambient temperature shall be within manufacturer's specifications. (Greater than +45ºF/+7ºC.) Consult manufacturer for the proper requirements when desiring to apply Geo-Seal CORE below 45ºF/7ºC.

E. All plumbing, electrical, mechanical and structural items to be under or passing through the vapor intrusion barrier system shall be positively secured in their proper positions and appropriately protected prior to membrane application.

F. Vapor intrusion barrier shall be installed before placement of fill material and reinforcing steel. When not possible, all exposed reinforcing steel shall be masked by general contractor prior to membrane application.

G. Stakes used to secure the concrete forms **shall not penetrate** the vapor intrusion barrier system after it has been installed. If stakes need to puncture the vapor intrusion barrier system after it has been installed, the necessary repairs need to be made by a certified Geo-Seal applicator. To confirm the staking procedure is in agreement with the manufactures recommendation, contact Land Science Technologies.

1.8 WARRANTY

A. General Warranty: The special warranty specified in this article shall not deprive the owner of other rights the owner may have under other provisions of the contract documents, and shall be in addition to, and run concurrent with, other warranties made by the contractor under requirements of the contract documents.

B. Special Warranty: Submit a written warranty signed by vapor intrusion barrier manufacturer agreeing to repair or replace vapor intrusion barrier that does not meet requirements or that does not remain methane gas and/or volatile organic compound vapor tight within the specified warranty period. Warranty does not include failure of vapor intrusion barrier due to failure of substrate prepared and treated according to requirements or formation of new joints and cracks in the attached to structures that exceed 1/16 inch (1.58 mm) in width.

1. Warranty Period: 1 year after date of substantial completion. Longer warranty periods are available upon request to the manufacturer.

C. Labor and material warranties are available upon request to the manufacturer.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Geo-Seal; Land Science Technologies™, San Clemente, CA. (949) 481-8118

1. Geo-Seal BASE sheet layer
2. Geo-Seal CORE spray layer and Geo-Seal CORE Detail
3. Geo-Seal BOND protection layer

2.2 VAPOR INTRUSION BARRIER SPRAY MATERIALS

A. Fluid applied vapor intrusion barrier system – Geo-Seal CORE; a single course, high build, polymer modified, asphalt emulsion. Waterborne and spray applied at ambient temperatures. A nominal thickness of 60 dry mils, unless specified otherwise. Non-toxic and odorless. Geo-Seal CORE Detail has similar properties with greater viscosity and is roller or brush applied. Manufactured by Land Science Technologies.

B. Fluid applied vapor intrusion barrier physical properties.

Geo-Seal CORE – TYPICAL CURED PROPERTIES

Properties	Test Method	Results
Tensile Strength - CORE only	ASTM 412	32 psi
Tensile Strength - Geo-Seal System	ASTM 412	662 psi
Elongation	ASTM 412	4140%
Resistance to Decay	ASTM E 154 Section 13	4% Perm Loss
Accelerated Aging	ASTM G 23	No Effect
Moisture Vapor Transmission	ASTM E 96	.026 g/ft^2/hr
Hydrostatic Water Pressure	ASTM D 751	26 psi
Perm rating	ASTM E 96 (US Perms)	0.21
Methane transmission rate	ASTM D 1434	Passed
Adhesion to Concrete & Masonry	ASTM C 836 & ASTM C 704	11 lbf./inch
Hardness	ASTM C 836	80
Crack Bridging	ASTM C 836	No Cracking
Heat Aging	ASTM D 4068	Passed
Environmental Stress Cracking	ASTM D 1693	Passed
Oil Resistance	ASTM D543	Passed
Soil Burial	ASTM D 4068	Passed
Low Temp. Flexibility	ASTM C 836-00	No Cracking at –20°C
Resistance to Acids:		
Acetic		30%
Sulfuric and Hydrochloric		13%
Temperature Effect:		
Stable		248°F
Flexible		13°F

Geo-Seal CORE Detail – TYPICAL CURED PROPERTIES

Properties	Test Method	Results
Tensile Strength	ASTM 412	32 psi
Elongation	ASTM 412	3860%
Resistance to Decay	ASTM E 154 Section 13	9% Perm Loss
Accelerated Aging	ASTM G 23	No Effect
Moisture Vapor Transmission	ASTM E 96	.026 g/ft^2/hr
Hydrostatic Water Pressure	ASTM D 751	28 psi
Perm rating (US Perms)	ASTM E 96	0.17
Methane transmission rate	ASTM D 1434	Passed
Adhesion to Concrete & Masonry	ASTM C 836	7 lbf./inch
Hardness	ASTM C 836	85
Crack Bridging	ASTM C 836	No Cracking
Low Temp. Flexibility	ASTM C 836-00	No Cracking at –20ºC
Resistance to Acids:		
Acetic		30%
Sulfuric and Hydrochloric		13%
Temperature Effect:		
Stable		248°F
Flexible		13°F

2.3 VAPOR INTRUSION BARRIER SHEET MATERIALS

A. The Geo-Seal BASE layer and Geo-Seal BOND layer are chemically resistant sheets comprised of a 5 mil high density polyethylene sheet thermally bonded to a 3 ounce non woven geotextile.

B. Sheet Course Usage

1. As foundation base layer, use Geo-Seal BASE course and/or other base sheet as required or approved by the manufacturer.

2. As top protective layer, use Geo-Seal BOND layer and/or other protection as required or approved by the manufacturer.

C. Geo-Seal BOND and Geo-Seal BASE physical properties.

Properties	Test Method	Results
Film Thickness		5 mil
Composite Thickness		18 mil
Water Vapor Permeability	ASTM E 96	0.214
Adhesion to Concrete	ASTM D 1970	9.2 lbs/inch^2
Dart Impact	ASTM D 1790	>1070 gms, method A
		594 gms, method B
Puncture Properties Tear	ASTM B 2582 MD	11,290 gms
	ASTM B 2582 TD	13,150 gms

2.4 AXILLARY MATERIALS

A. Sheet Flashing: 60-mil reinforced modified asphalt sheet good with double-sided adhesive.

B. Reinforcing Strip: Manufacturer's recommended polypropylene and polyester fabric.

C. Gas Venting Materials: Geo-Seal Vapor-Vent HD or Geo-Seal Vapor-Vent Poly, and associated fittings.

D. Seam Detailing Sealant Mastic: Geo-Seal CORE Detail, a high or medium viscosity polymer modified water based asphalt material.

1. Back Rod: Closed-cell polyethylene foam.

PART 3 – EXECUTION

3.1 AUXILIARY MATERIALS

A. Examine substrates, areas, and conditions under which vapor intrusion barrier will be applied, with installer present, for compliance with requirements. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 SUBGRADE SURFACE PREPARATION

A. Verify substrate is prepared according to manufacturer's recommendations. On a horizontal surface, the substrate should be free from material that can potentially puncture the vapor intrusion barrier. Additional protection or cushion layers might be required if the earth or gravel substrate contains too many jagged points and edges that could puncture one or more of the system components. Contact manufacturer to confirm substrate is within manufactures recommendations.

B. Geo-Seal can accommodate a wide range of substrates, including but not limited to compacted earth, sand, aggregate, and mudslabs.

1. Compacted Earth: Remove pieces of debris, gravel and/or any other material that can potentially puncture the Geo-Seal BASE. Remove any debris from substrate that can potentially puncture the Geo-Seal system prior to application.

2. Sand: A sand subgrade requires no additional preparation, provided any material that can potentially puncture the Geo-Seal BASE layer is not present.

3. Aggregate: Contact the manufacturer to ensure the aggregate layer will not be detrimental to the membrane. **The gravel layer must be compacted and rolled flat.** Ideally a ¾" minus gravel layer with rounded edges should be specified; however the Geo-Seal system can accommodate a wide variety of different substrates. Contact Land Science Technologies if there are questions regarding the compatibility of Geo-Seal and the utilized substrate. Exercise caution when specifying pea gravel under the membrane, if not compacted properly, pea gravel can become an unstable substrate.

4. Mudslabs: The use of a mubslab under the Geo-Seal system is acceptable, contact Land Science Technologies for job specific requirements.

C. Mask off adjoining surface not receiving the vapor intrusion barrier system to prevent the spillage or over spray affecting other construction.

D. Earth, sand or gravel subgrades should be prepared and compacted to local building code requirements.

3.3 CONCRETE SURFACE PREPARATION

A. Clean and prepare concrete surface to manufacturer's recommendations. In general, only apply the Geo-Seal CORE material to dry, clean and uniform substrates. Concrete surfaces must be a light trowel, light broom or equivalent finish. Remove fins, ridges and other projections and fill honeycomb, aggregate pockets, grout joints and tie holes, and other voids with hydraulic cement or rapid-set grout. It is the applicator's responsibility to point out unacceptable substrate conditions to the general contractor and ensure the proper repairs are made.

B. When applying the Geo-Seal CORE or Geo-Seal CORE Detail material to concrete it is important to not apply the product over standing water. Applying over standing water will result in the membrane not setting up properly on the substrate

C. Surfaces may need to be wiped down or cleaned prior to application. This includes, but is not limited to, the removal of forming oils, concrete curing agents, dirt accumulation, and other debris. Contact form release agent manufacturer or concrete curing agent manufacturer for VOC content and proper methods for removing the respective agent.

D. Applying the Geo-Seal CORE to "green" concrete is acceptable and can be advantageous in creating a superior bond to the concrete surface. To help reduce blistering, apply a primer coat of only the asphalt component of the Geo-Seal CORE system. Some blistering of the membrane will occur and may be more severe on walls exposed to direct sunlight. Blistering is normal and will subside over time. Using a needle nose depth gauge confirm that the specified mil thickness has been applied.

3.4 PREPARATIONS AND TREATMENT OF TERMINATIONS

A. Prepare the substrate surface in accordance with Section 3.3 of this document. Concrete surfaces that are not a light trowel, light broom or equivalent finish, will need to be repaired.

B. Terminations on horizontal and vertical surfaces should extend 6" onto the termination surface. Job specific conditions may prevent a 6" termination. In these conditions, contact manufacturer for recommendations.

C. Apply 30 mils of Geo-Seal CORE to the terminating surface and then embed the Geo-Seal BASE layer by pressing it firmly into the Geo-Seal CORE layer. Next, apply 60 mils of Geo-Seal CORE to the BASE layer. When complete, apply the Geo-Seal BOND layer. After the placement of the Geo-Seal BOND layer is complete, apply a final 30 mil seal of the Geo-Seal CORE layer over the edge of the termination. For further clarification, refer to the termination detail provided by manufacturer.

D. The stated termination process is appropriate for terminating the membrane onto exterior footings, pile caps, interior footings and grade beams. When terminating the membrane to stem walls or vertical surfaces the same process should be used.

3.5 PREPARATIONS AND TREATMENT OF PENETRATIONS

A. All pipe penetrations should be securely in place prior to the installation of the Geo-Seal system. Any loose penetrations should be secured prior to Geo-Seal application, as loose penetrations could potentially exert pressure on the membrane and damage the membrane after installation.

B. To properly seal around penetrations, cut a piece of the Geo-Seal BASE layer that will extend 6" beyond the outside perimeter of the penetration. Cut a hole in the Geo-Seal BASE layer just big enough to slide over the penetration, ensuring the Geo-Seal BASE layer fits snug against the penetration, this can be done by cutting an "X" no larger than the inside diameter of the penetration. There should not be a gap larger than a 1/8" between the Geo-Seal BASE layer and the penetration. Other methods can also be utilized, provided, there is not a gap larger than 1/8" between the Geo-Seal BASE layer and the penetration.

C. Seal the Geo-Seal BASE layer using Geo-Seal CORE or Geo-Seal CORE Detail to the underlying Geo-Seal BASE layer.

D. Apply one coat of Geo-Seal CORE Detail or Geo-Seal CORE spray to the Geo-Seal BASE layer and around the penetration at a thickness of 30 mils. Penetrations should be treated in a 6-inch radius around penetration and 3 inches onto penetrating object.

E. Embed a fabric reinforcing strip after the first application of the Geo-Seal CORE spray or Geo-Seal CORE Detail material and then apply a second 30 mil coat over the embedded joint reinforcing strip ensuring its complete saturation of the embedded strip and tight seal around the penetration.

F. After the placement of the Geo-Seal BOND layer, a cable tie should then be placed around the finished penetration. The cable tie should be snug, but not overly tight so as to slice into the finished seal.

OPTION: A final application of Geo-Seal CORE may be used to provide a finishing seal after the Geo-Seal BOND layer has been installed.

NOTE: Metal or other slick penetration surfaces may require treatment in order to achieve proper adhesion. For plastic pipes, sand paper may be used to achieve a profile, an emery cloth is more appropriate for metal surfaces. An emery cloth should also be used to remove any rust on metal surfaces.

3.6 GEO-SEAL BASE LAYER INSTALLATION

A. Install the Geo-Seal BASE layer over substrate material in one direction with six-inch overlaps and the geotextile (fabric side) facing down.

B. Secure the Geo-Seal BASE seams by applying 60 mils of Geo-Seal CORE between the 6" overlapped sheets with the geotextile side down.

C. Visually verify there are no gaps/fish-mouths in seams.

D. For best results, install an equal amount of Geo-Seal BASE and Geo-Seal CORE in one day. Leaving unsprayed Geo-Seal BASE overnight might allow excess moisture to collect on the Geo-Seal BASE. If excess moisture collects, it needs to be removed.

NOTE: In windy conditions it might be necessary to encapsulate the seam by spraying the Geo-Seal CORE layer over the completed Geo-Seal BASE seam.

3.7 GEO-SEAL CORE APPLICATION

A. Set up spray equipment according to manufacturer's instructions.

B. Mix and prepare materials according to manufacturer's instructions.

C. The two catalyst nozzles (8001) should be adjusted to cross at about 18" from the end of the wand. This apex of catalyst and emulsion spray should then be less than 24" but greater than 12" from the desired surface when spraying. When properly sprayed the fan pattern of the catalyst should range between 65° and 80°.

D. Adjust the amount of catalyst used based on the ambient air temperature and surface temperature of the substrate receiving the membrane. In hot weather use less catalyst as hot conditions will quickly "break" the emulsion and facilitate the curing of the membrane. In cold conditions and on vertical surfaces use more catalyst to "break" the emulsion quicker to expedite curing and set up time in cold conditions.

E. To spray the Geo-Seal CORE layer, pull the trigger on the gun. A 42° fan pattern should form when properly sprayed. Apply one spray coat of Geo-Seal CORE to obtain a seamless membrane free from pinholes or shadows, with an average dry film thickness of 60 mils (1.52 mm).

F. Apply the Geo-Seal CORE layer in a spray pattern that is perpendicular to the application surface. The concern when spraying at an angle is that an area might be missed. Using a perpendicular spray pattern will limit voids and thin spots, and will also create a uniform and consistent membrane.

G. Verify film thickness of vapor intrusion barrier every 500 ft^2. (46.45 m^2), for information regarding Geo-Seal quality control measures, refer to the quality control procedures in Section 3.9 of this specification.

H. The membrane will generally cure in 24 to 48 hours. As a rule, when temperature decreases or humidity increases, the curing of the membrane will be prolonged. The membrane does not need to be fully cured prior the placement of the Geo-Seal BOND layer, provided mil thickness has been verified and a smoke test will be conducted.

I. **Do not penetrate** membrane after it has been installed. If membrane is penetrated after the membrane is installed, it is the responsibility of the general contractor to notify the certified installer to make repairs.

J. If applying to a vertical concrete wall, apply Geo-Seal CORE directly to concrete surface and use manufacturer's recommended protection material based on site specific conditions. If applying Geo-Seal against shoring, contact manufacturer for site specific installation instructions.

NOTE: Care should be taken to not trap moisture between the layers of the membrane. Trapping moisture may occur from applying a second coat prior to the membrane curing. Repairs and detailing may be done over the Geo-Seal CORE layer when not fully cured.

3.8 GEO-SEAL BOND PROTECTION COURSE INSTALLATION

A. Install Geo-Seal BOND protection course perpendicular to the direction of the Geo-Seal BASE course with overlapped seams over nominally cured membrane no later than recommended by manufacturer and before starting subsequent construction operations.

B. Sweep off any water that has collected on the surface of the Geo-Seal CORE layer, prior to the placement of the Geo-Seal BOND layer.

C. Overlap and seam the Geo-Seal BOND layer in the same manner as the Geo-Seal BASE layer.

D. To expedite the construction process, the Geo-Seal BOND layer can be placed over the Geo-Seal CORE immediately after the spray application is complete, provided the Geo-Seal CORE mil thickness has been verified.

3.9 QUALITY ASSURANCE

A. The Geo-Seal system must be installed by a trained and certified installer approved by Land Science Technologies.

B. For projects that will require a material or labor material warranty, Land Science Technologies will require a manufacturer's representative or certified 3rd party inspector to inspect and verify that the membrane has been installed per the manufacturer's recommendations.

The certified installer is responsible for contacting the inspector for inspection. Prior to application of the membrane, a notice period for inspection should be agreed upon between the applicator and inspector.

C. The measurement tools listed below will help verity the thickness of the Geo-Seal CORE layer. As measurement verification experience is gained, these tools will help confirm thickness measurements that can be obtained by pressing one's fingers into the Geo-Seal CORE membrane.

To verify the mil thickness of the Geo-Seal CORE, the following measurement devices are required.

1. Mil reading caliper: Calipers are used to measure the thickness of coupon samples. To measure coupon samples correctly, the thickness of the Geo-Seal sheet layers (18 mils each) must be taken into account. Mark sample area for repair.

2. Wet mil thickness gauge: A wet mil thickness gauge may be used to quickly measure the mil thickness of the Geo-Seal CORE layer. The thickness of the Geo-Seal sheet layers do not factor into the mil thickness reading.

   NOTE: When first using a wet mil thickness gauge on a project, collect coupon samples to verify the wet mil gauge thickness readings.

3. Needle nose digital depth gauge: A needle nose depth gauge should be used when measuring the Geo-Seal CORE thickness on vertical walls or in field measurements. Mark measurement area for repair.

To obtain a proper wet mil thickness reading, take into account the 5 to 10 percent shrinkage that will occur as the membrane fully cures. Not taking into account the thickness of the sheet layers, a freshly sprayed membrane should have a minimum wet thickness of 63 (5%) to 66 (10%) mils.

Methods on how to properly conduct Geo-Seal CORE thickness sampling can be obtained by reviewing literature prepared by Land Science Technologies.

D. It should be noted that taking too many destructive samples can be detrimental to the membrane. Areas where coupon samples have been removed need to be marked for repair.

E. Smoke Testing is highly recommended and is the ideal way to test the seal created around penetrations and terminations. Smoke Testing is conducted by pumping non-toxic smoke underneath the Geo-Seal vapor intrusion barrier and then repairing the areas where smoke appears. Refer to smoke testing protocol provided by Land Science Technologies. For projects that will require a material or labor material warranty, Land Science Technologies will require a smoke test.

F. Visual inspections prior to placement of concrete, but after the installation of concrete reinforcing, is recommended to identify any punctures that may have occurred during the installation of rebar, post tension cables, etc. Punctures in the Geo-Seal system should be easy to indentify due to the color contrasting layers of the system.

Vapor-Vent™
SOIL GAS COLLECTION SYSTEM
Version 1.5

SECTION 02 56 19 – GAS CONTROL

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Substrate preparation.
2. Vapor-Vent™ installation.
3. Vapor-Vent accessories.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 2 Section "Earthwork", "Pipe Materials", "Sub-drainage systems", "Gas Control System", "Fluid-Applied gas barrier".
2. Division 3 Section "Cast-in-Place Concrete" for concrete placement, curing, and finishing.
3. Division 5 Section "Expansion Joint Cover Assemblies", for expansion-joint covers assemblies and installation.

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide a gas venting material that collects gas vapors and directs them to discharge or to collection points as specified in the gas vapor collection system drawings and complies with the physical requirements set forth by the manufacturer.

1.4 SUBMITTALS

A. Submit Product Data for each type of gas venting system specified, including manufacturer's specifications.

B. Sample – Submit representative samples of the following for approval:

1. Gas venting, Vapor-Vent.
2. Vapor-Vent accessories.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who is certified in writing and approved by vapor intrusion barrier manufacturer Land Science Technologies for the installation of the Geo-Seal® vapor intrusion barrier system.

B. Manufacturer Qualification: Obtain gas venting, vapor intrusion barrier and system components from a single manufacturer Land Science Technologies

C. Pre-installation Conference: A pre-installation conference shall be held prior to installation of the venting system, vapor intrusion barrier and waterproofing system to assure proper site and installation conditions, to include contractor, applicator, architect/engineer and special inspector (if any).

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to project site as specified by manufacturer labeled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for handling.

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B. Store materials as specified by the manufacturer in a clean, dry, protected location and within the temperature range required by manufacturer. Protect stored materials from direct sunlight.

C. Remove and replace material that is damaged.

PART 2 – PRODUCTS

2.1 MANUFACTURER

A. Land Science Technologies, San Clemente, CA. (949) 481-8118

1. Vapor-Vent™

2.2 GAS VENT MATERIALS

A. Vapor-Vent – Vapor-Vent is a low profile, trenchless, flexible, sub slab vapor collection system used in lieu or in conjunction with perforated piping. Vapor-Vent is offered with two different core materials, Vapor-Vent POLY is recommended for sites with inert methane gas and Vapor-Vent is recommended for sites with aggressive chlorinated volatile organic or petroleum vapors. Manufactured by Land Science Technologies

B. Vapor-Vent physical properties

VENT PROPERTIES	**TEST METHOD**	**VAPOR-VENT POLY**	**VAPOR-VENT**
Material		Polystyrene	HDPE
Comprehensive Strength	ASTM D-1621	9,000 lbs / ft^2	11,400 lbs / ft^2
In-plane flow (Hydraulic gradient-0.1)	ASTM D-4716	30 gpm / ft of width	30 gpm / ft of width
Chemical Resistance		N/A	Excellent
FABRIC PROPERTIES	**TEST METHOD**	**VAPOR-VENT POLY**	**VAPOR-VENT**
Grab Tensile Strength	ASTM D-4632	100 lbs.	110 lbs.
Puncture Strength	ASTM D-4833	65 lbs.	30 lbs.
Mullen Burst Strength	ASTM D-3786	N/A	90 PSI
AOS	ASTM D-4751	70 U.S. Sieve	50 U.S. Sieve
Flow Rate	ASTM D-4491	140 gpm / ft^2	95 gpm / ft^2
UV Stability (500 hours)	ASTM D-4355	N/A	70% Retained
DIMENSIONAL DATA			
Thickness		1”	1”
Standard Widths		12”	12”
Roll Length		165 ft	165 ft
Roll Weight		65 lbs	68 lbs

2.3 AUXILIARY MATERIALS

A. Vapor-Vent End Out

B. Reinforced Tape.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions under which gas vent system will be installed, with installer present, for compliance with requirements. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 SUBSTRATE PREPARATION

A. Verify substrate is prepared according to project requirements.

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3.3 PREPARATION FOR STRIP COMPOSITE

A. Mark the layout of strip geocomposite per layout design developed by engineer.

3.4 STRIP GEOCOMPOSITE INSTALLATION

A. Install Vapor-Vent over substrate material where designated on drawings with the flat base of the core placed down and shall be overlapped in accordance with manufacturer's recommendations.

B. At areas where Vapor-Vent strips intersect cut and fold back fabric to expose the dimpled core. Arrange the strips so that the top strip interconnects into the bottom strip. Unfold fabric to cover the core and use reinforcing tape, as approved by the manufacturer, to seal the connection to prevent sand or gravel from entering the core.

C. When crossing Vapor-Vent over footings or grade beams, **consult with the specifying environmental engineer and structural engineer for appropriate use and placement of solid pipe materials**. Place solid pipe over or through concrete surface and attach a Vapor-Vent End Out at both ends of the pipe before connecting the Vapor-Vent to the pipe reducer. Seal the Vapor-Vent to the Vapor-Vent End Out using fabric reinforcement tape. Refer to Vapor-Vent detail provided by Land Science Technologies.

D. Place vent risers per specifying engineer's project specifications. Connect Vapor-Vent to Vapor-Vent End Out and seal with fabric reinforced tape. Use Vapor-Vent End Out with the specified diameter piping as shown on system drawings.

3.5 PLACEMENT OF OVERLYING AND ADJACENT MATERIALS

A. All overlying and adjacent material shall be placed or installed using approved procedures and guidelines to prevent damage to the strip geocomposite.

B. Equipment shall not be directly driven over and stakes or any other materials may not be driven through the strip geocomposite.

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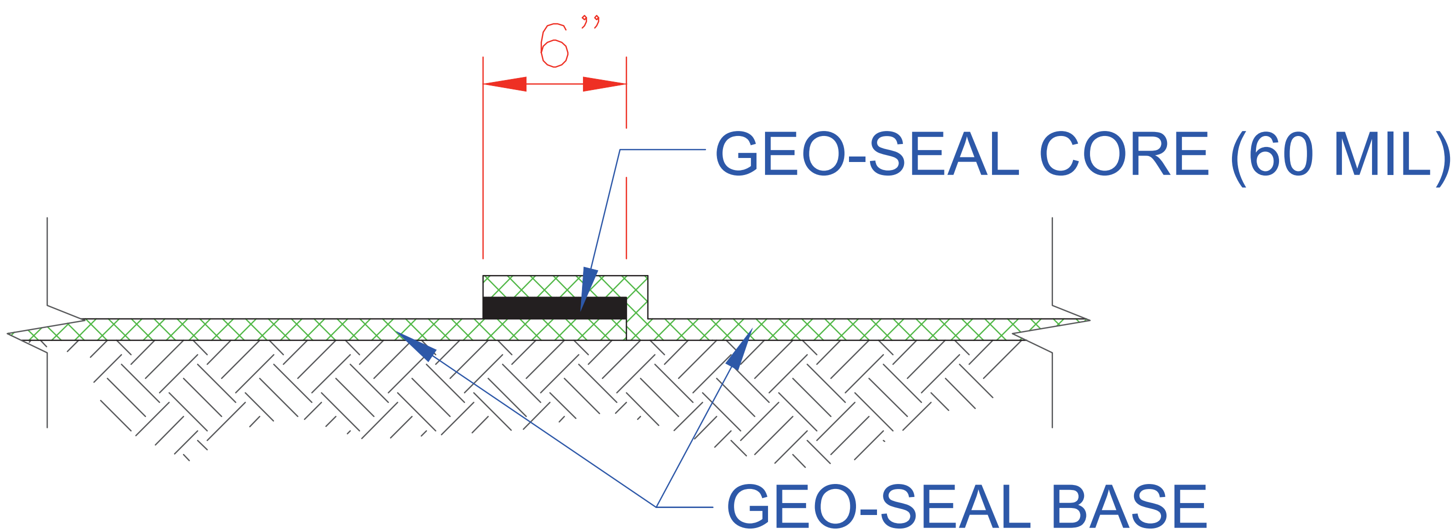

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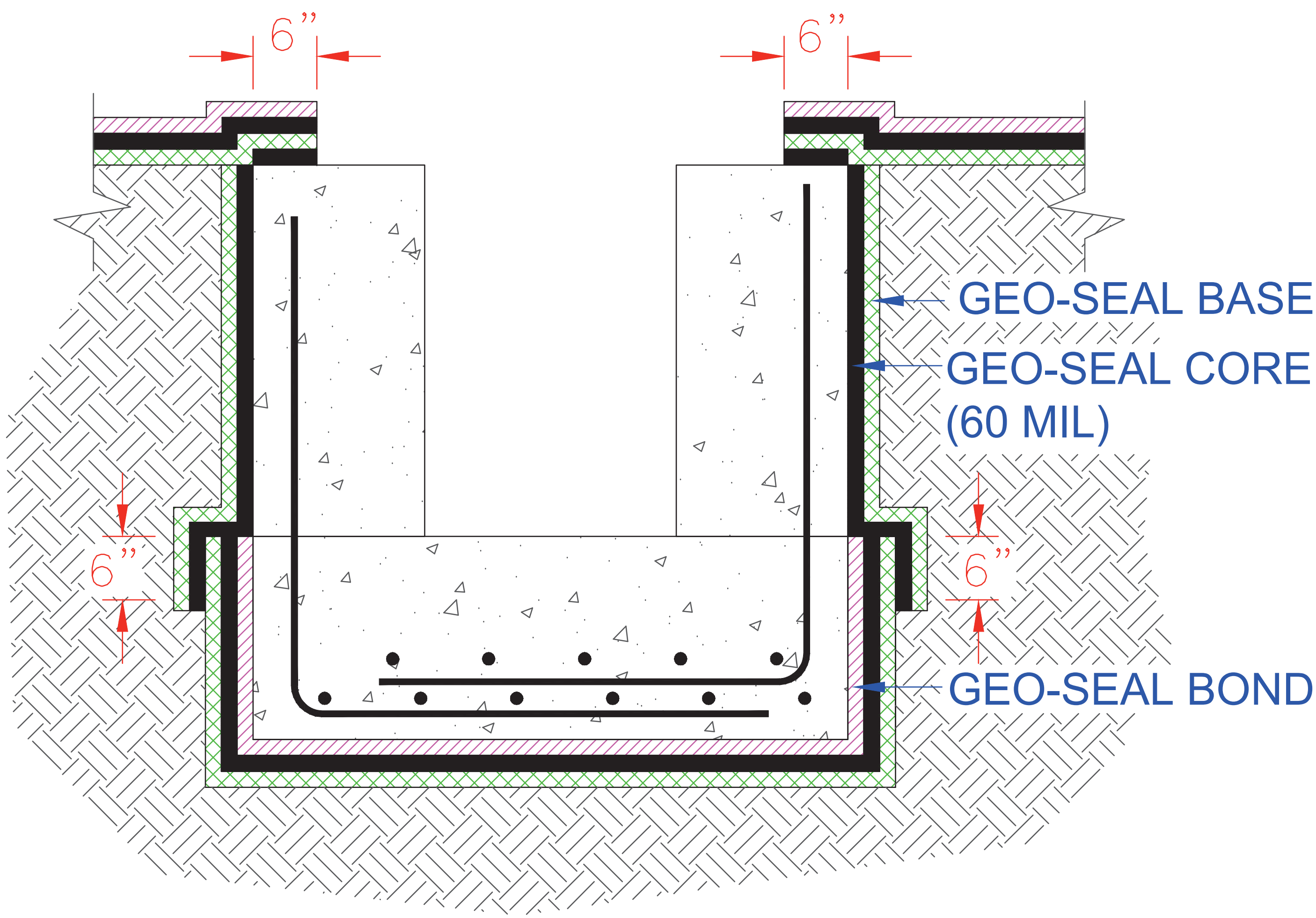
Geo-Seal® Vapor Intrusion Barrier

DATE

SCALE

TITLE

BASE OVERLAP DETAIL



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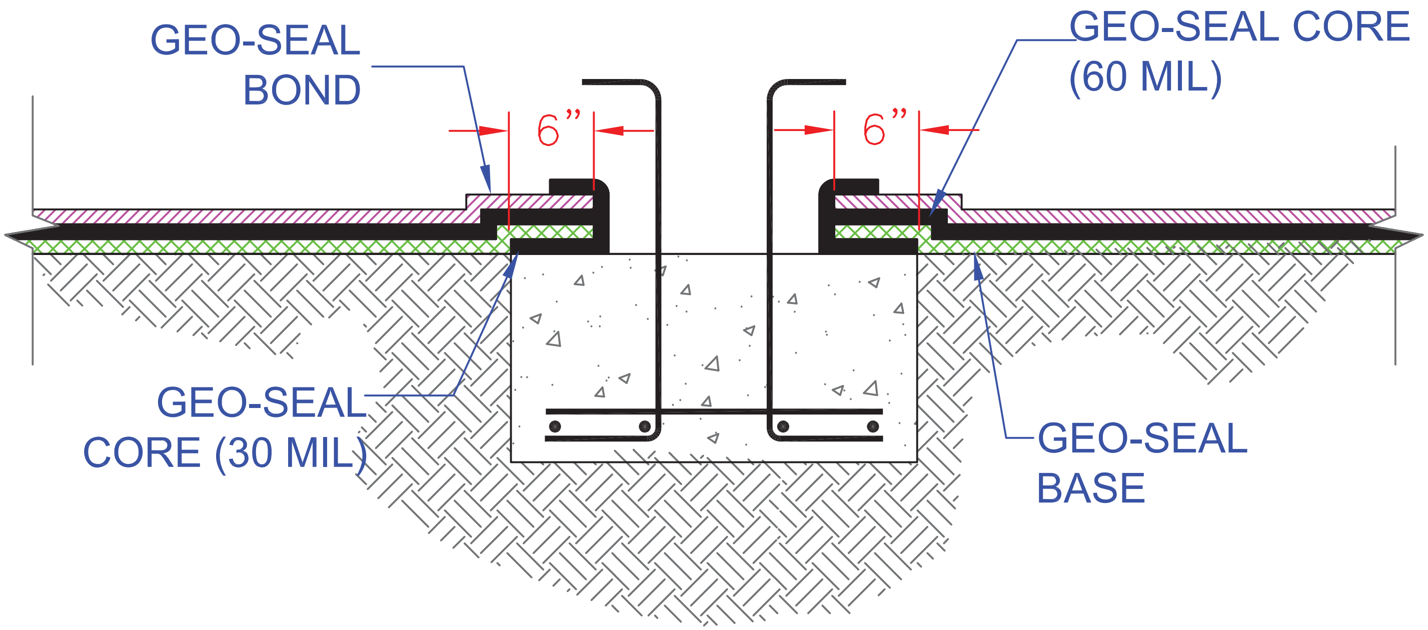
ELEVATOR PIT DETAIL



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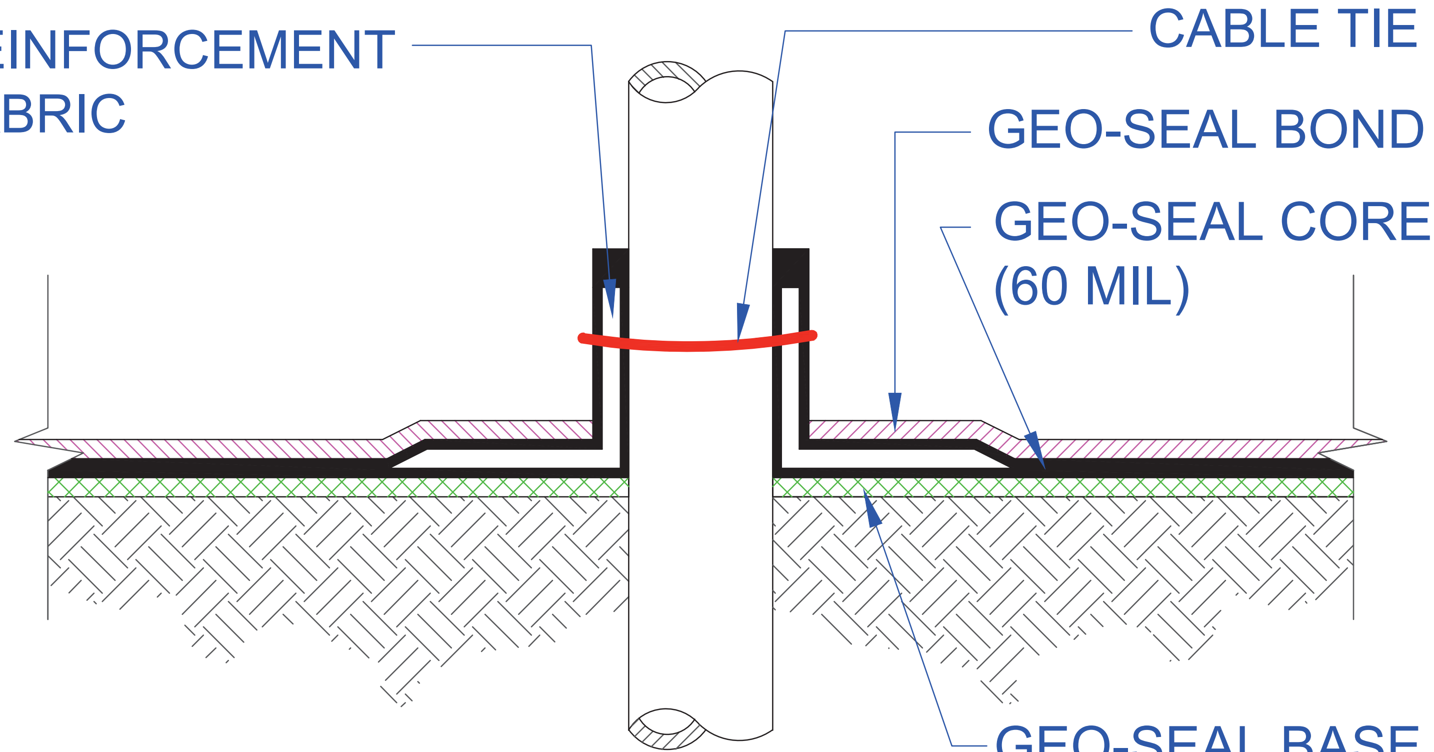
TITLE

FOOTING TERMINATION



STEP 5

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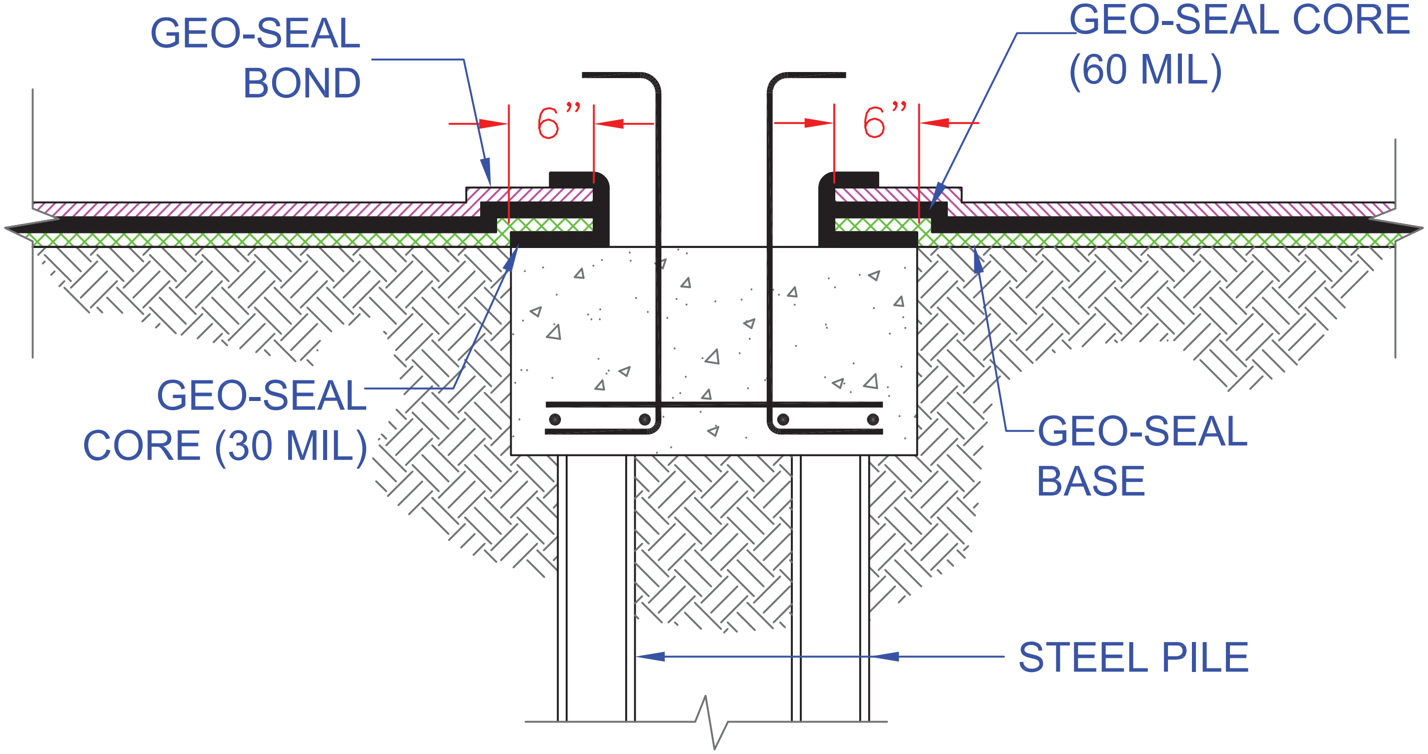
TITLE

PENETRATION SEQUENCE

STEP 5



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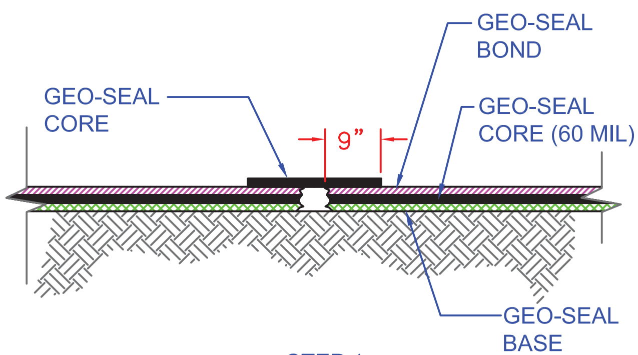
TITLE

PILE CAP DETAIL



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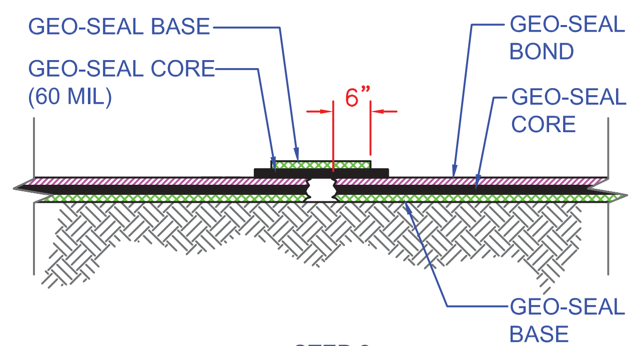

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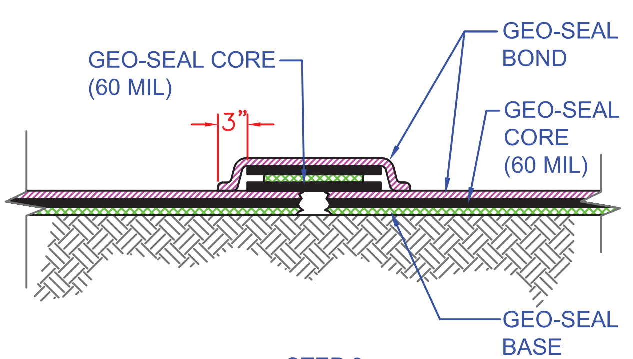

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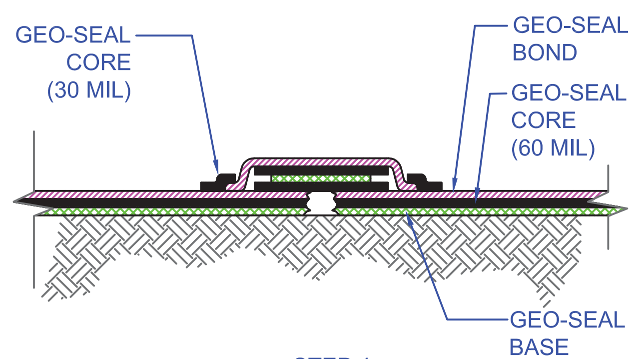

STEP 4

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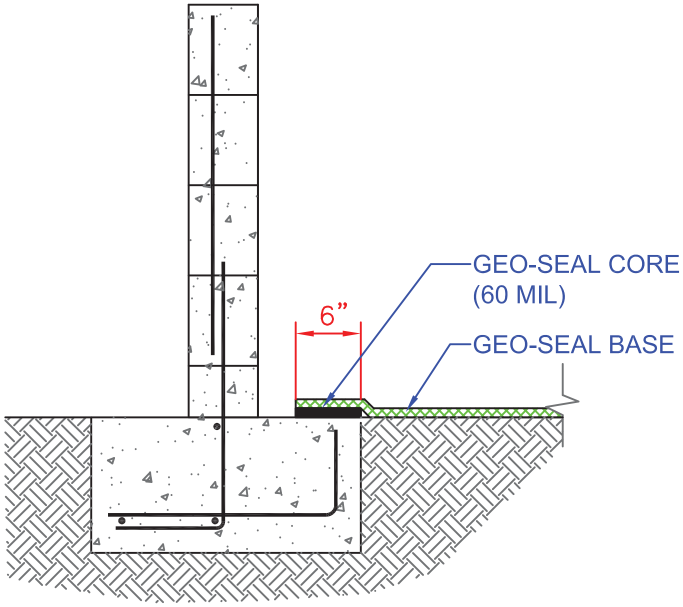
REPAIR SEQUENCE



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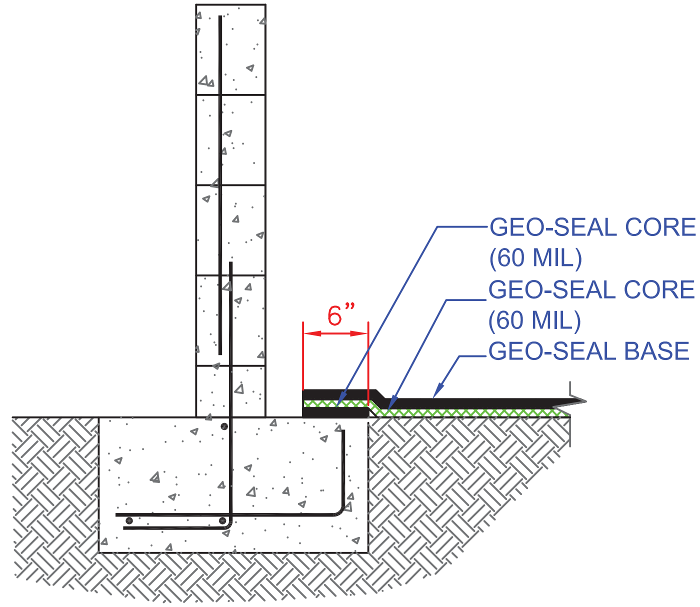

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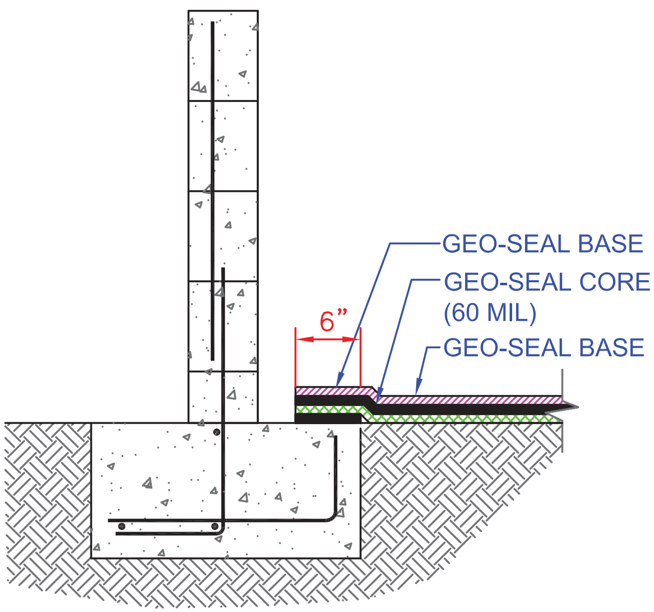

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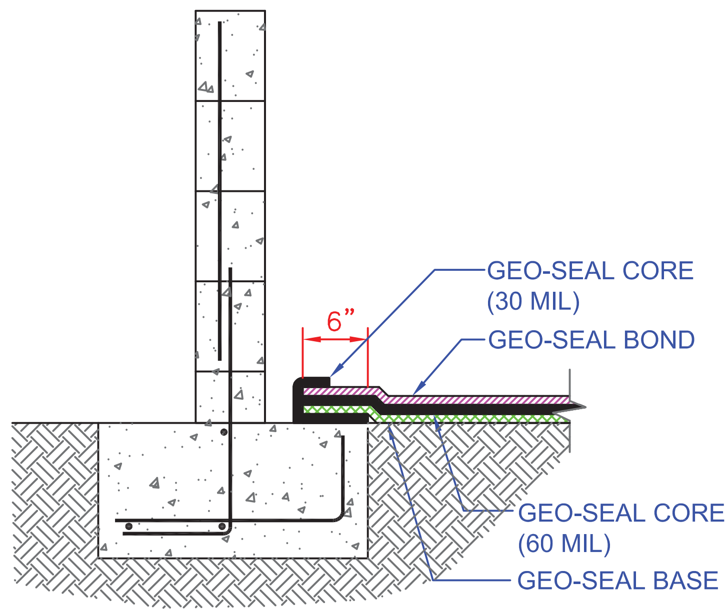

STEP 4

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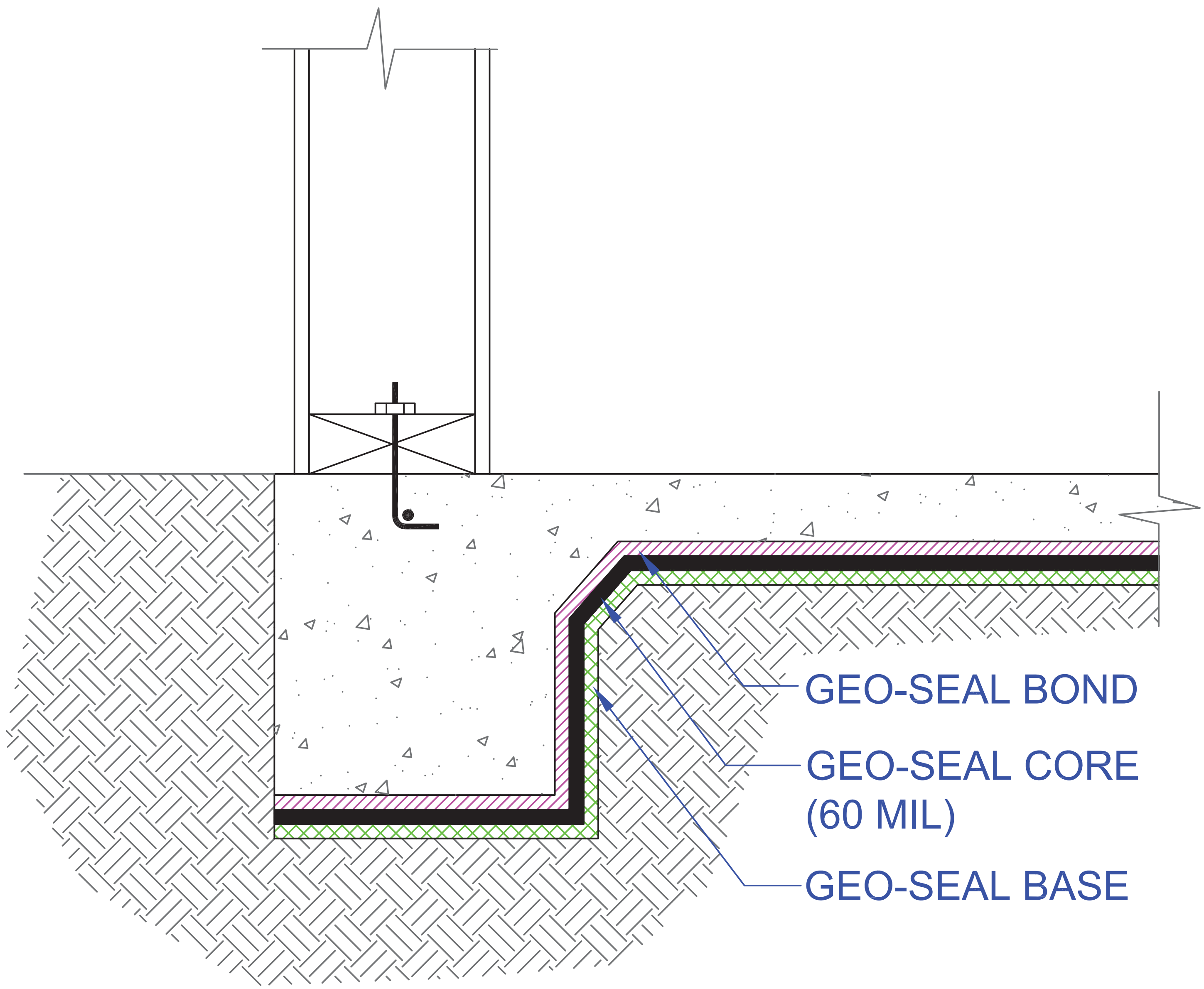
TERMINATION SEQUENCE



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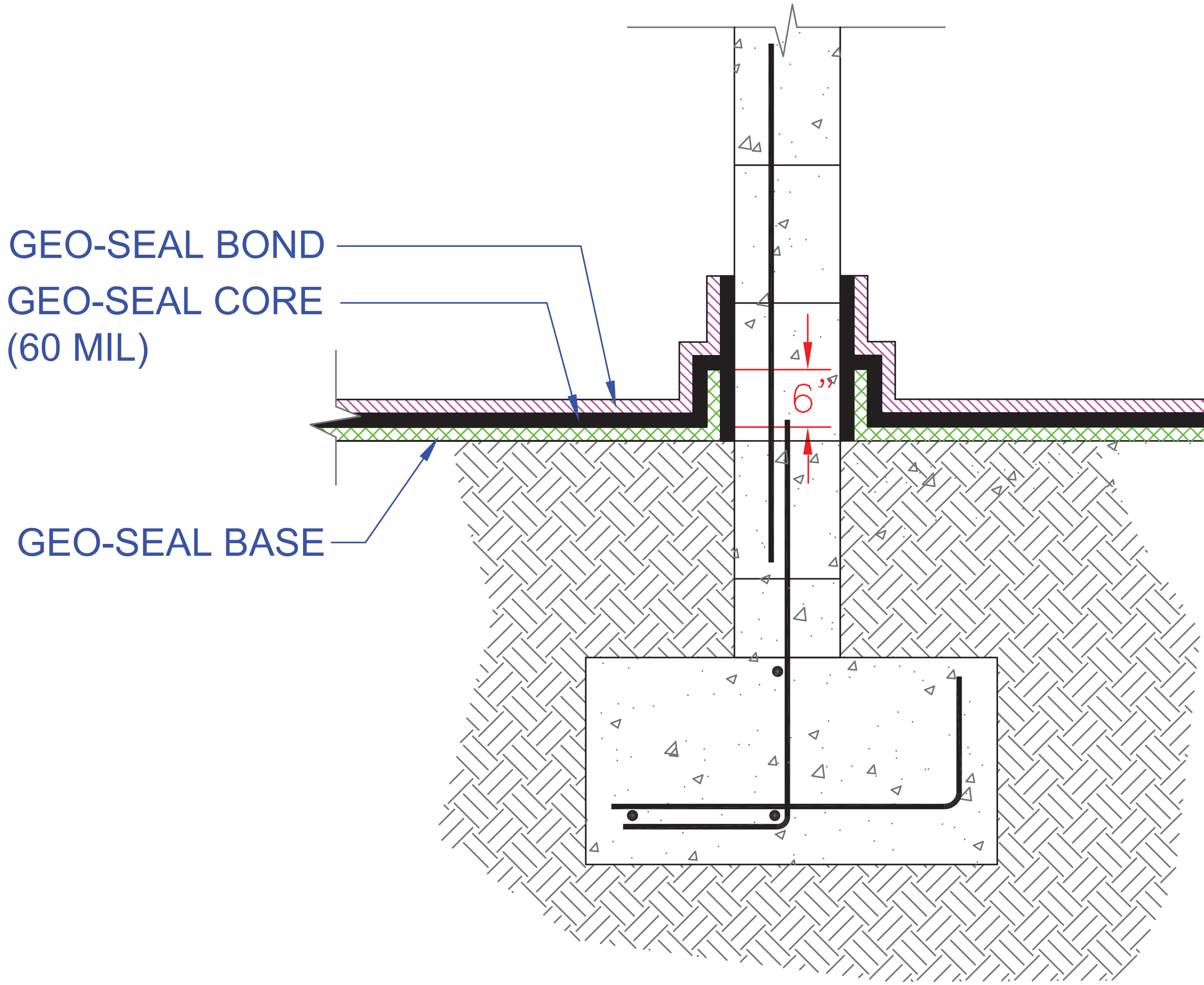
UNDER FOOTING DETAIL



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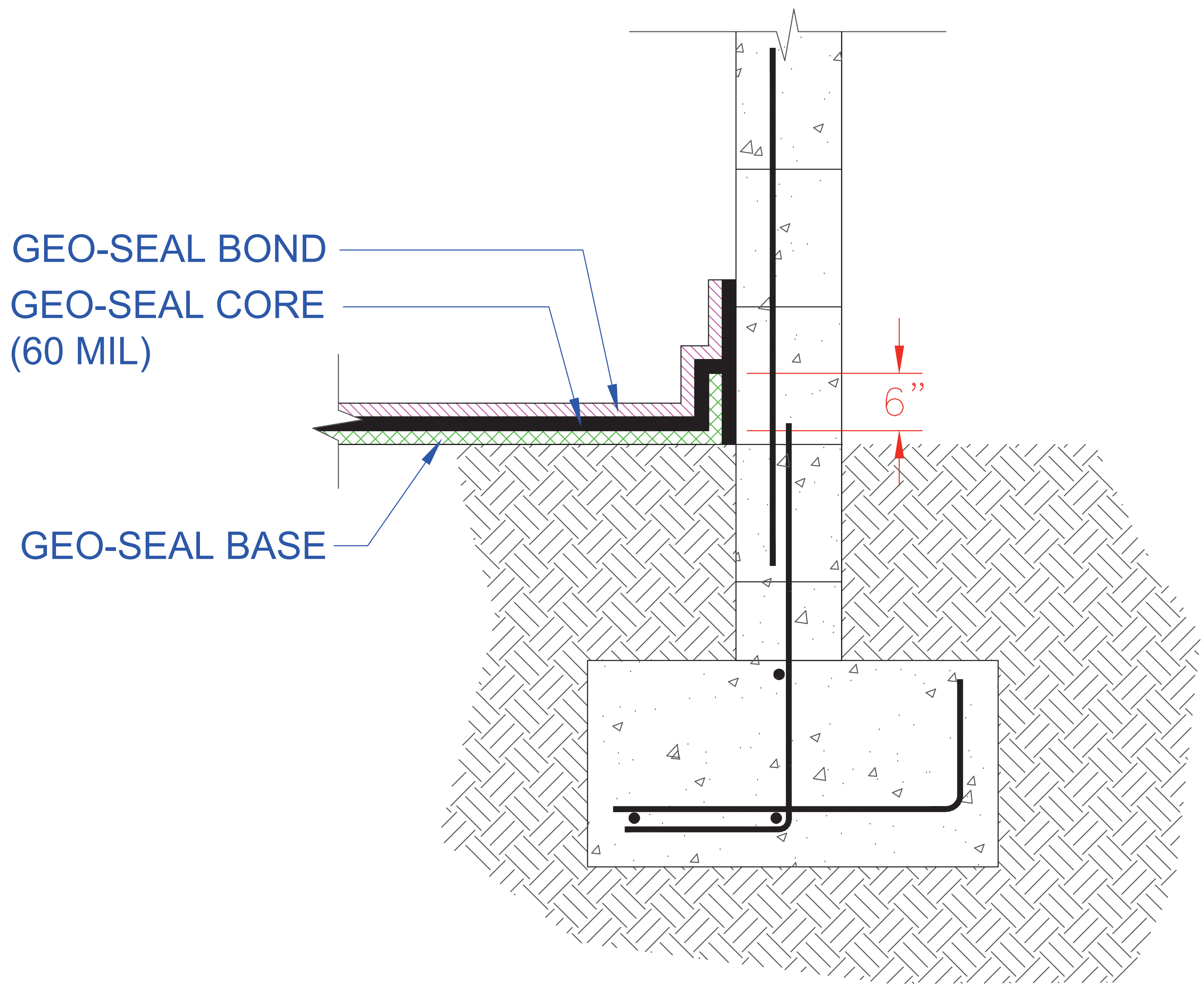
VERTICAL TERMINATION DETAIL



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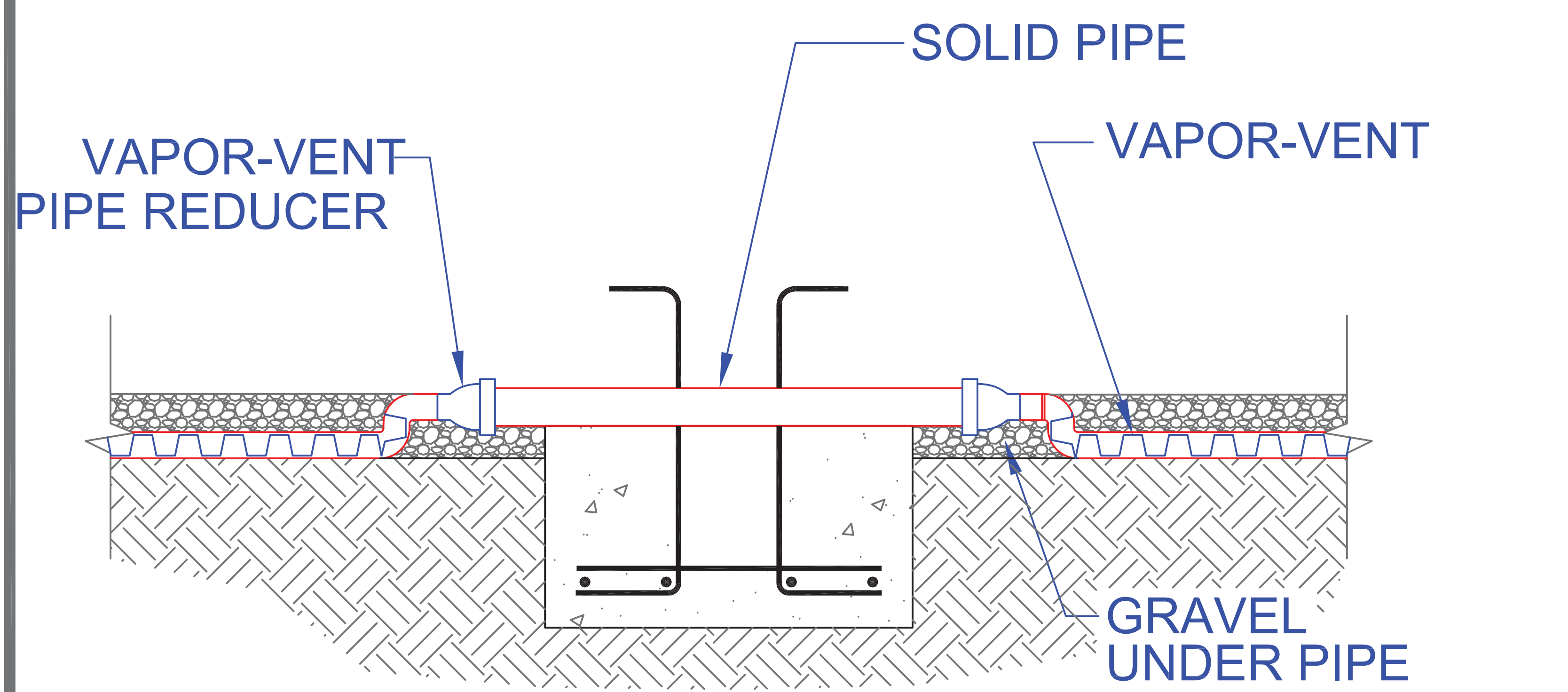
VERTICAL TERMINATION DETAIL



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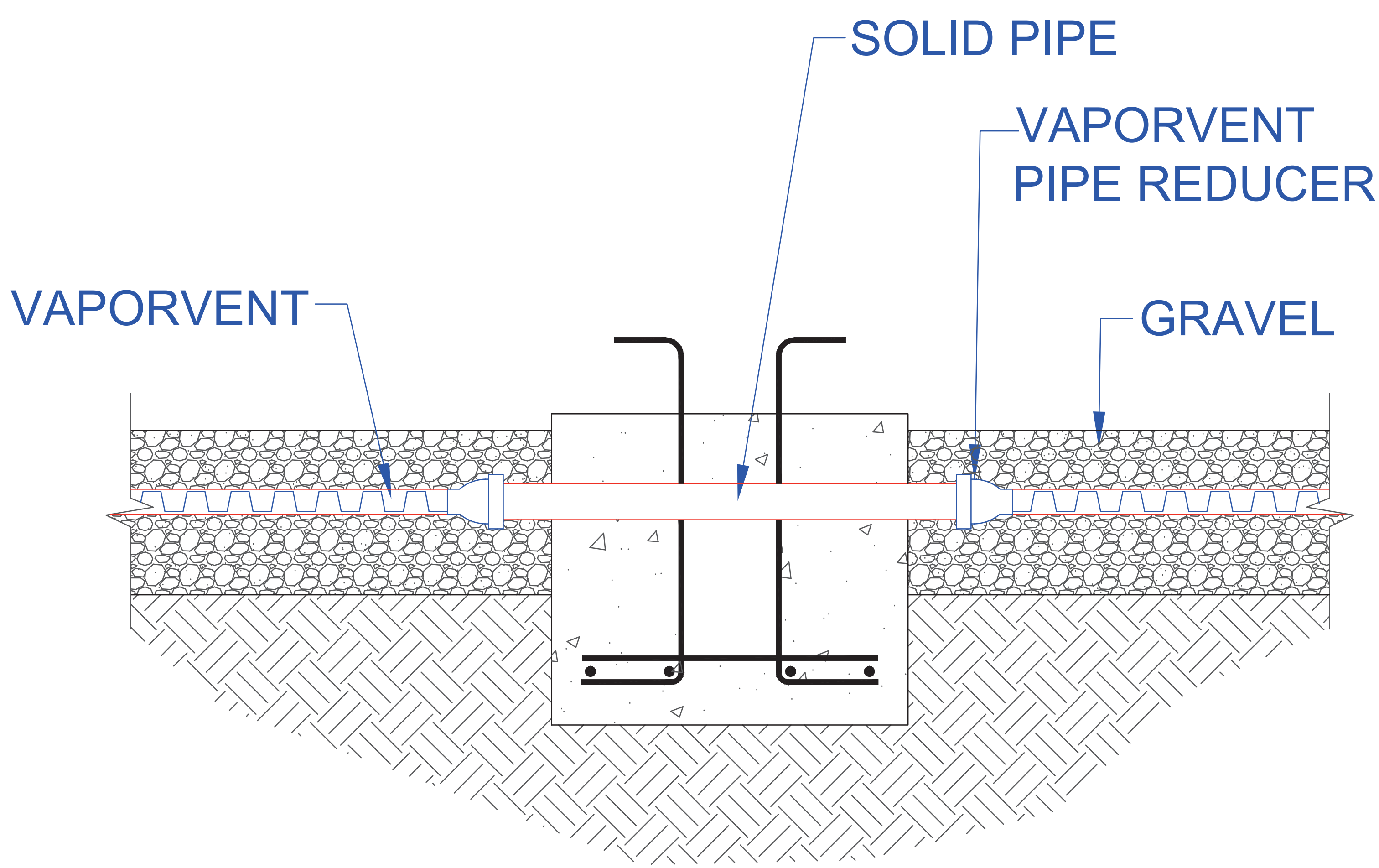
VAPOR-VENT OVER FOOTING



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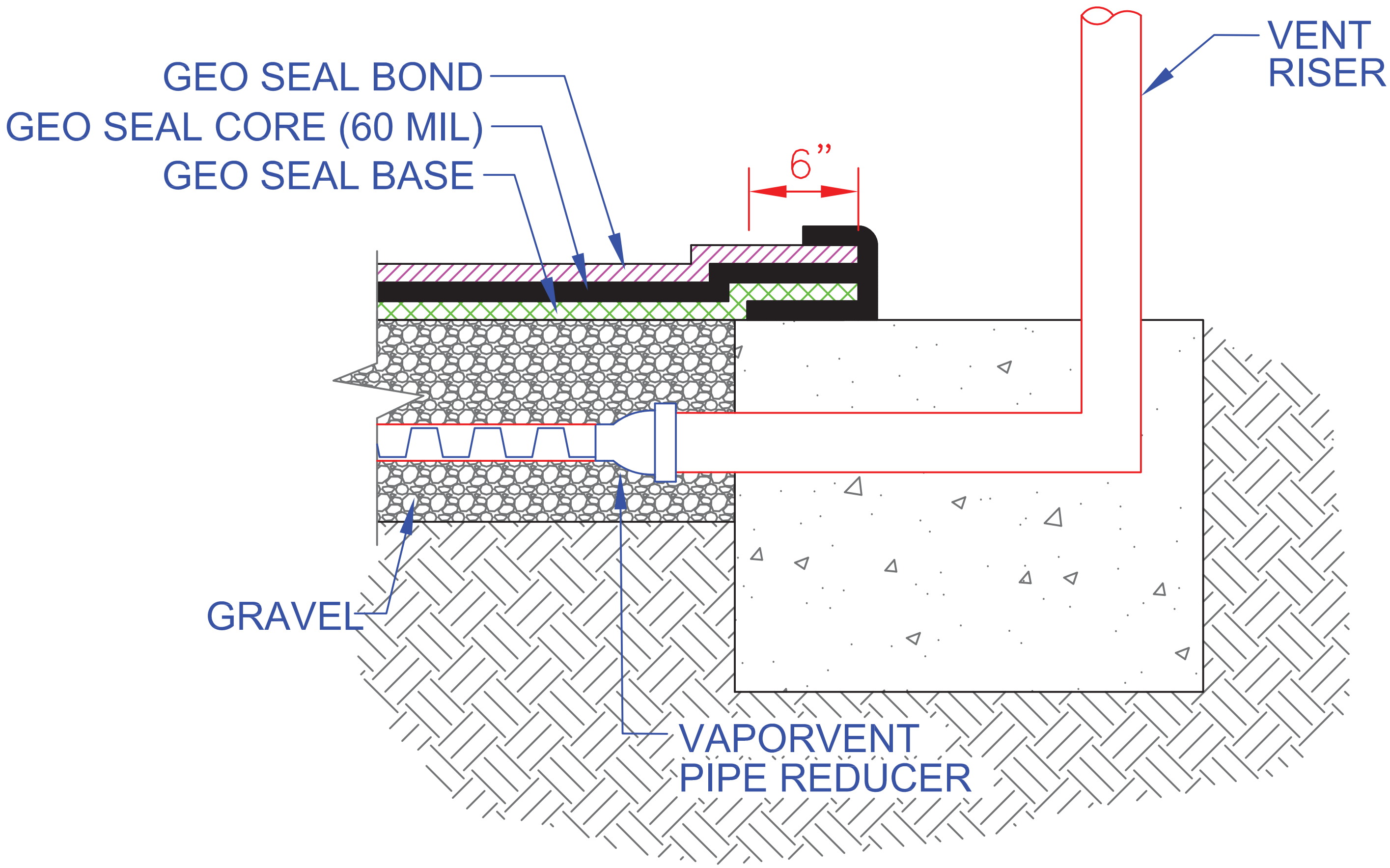
VAPORVENT THROUGH FOOTING



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VAPORVENT VENT RISER

Geo-Seal Quality Control

Certified Applicator

Authorized installation of Geo-Seal can only be accomplished by one of Land Science Technologies Certified Applicators.

Membrane Inspections

For projects that will require a material or system (workmanship and material) warranty, Land Science Technologies will require a manufacturer's representative or certified 3rd party inspector to inspect and verify that the membrane has been installed per the manufacturer's recommendations.

The applicator is responsible for contacting the inspector for inspection. Prior to application of the membrane, a notice period for inspection should be agreed upon between the applicator and inspector.

Material Yield

Material yield is one of the first indicators in determining if the Geo-Seal CORE layer has been installed correctly. A baseline standard for yield is as follows:

Material Container	60 dry mils	80 dry mils	100 dry mils
55 Gallon Drum	935 ft^2	660 ft^2	550 ft^2
275 Gallon Tote	4,675 ft^2	3,300 ft^2	2,750 ft^2
330 Gallon Tote	5,610 ft^2	3,960 ft^2	3,300 ft^2

The estimated yield is 17 ft^2 per gallon for a 60 dry mil application using the recommended thickness, unless otherwise noted by a specified engineer or regulatory agency.

Yields can decrease based on the complexity of the foundation. Projects containing many penetrations and areas where a lot of detailing is required might reduce the material yield to 16 ft^2 or 15 ft^2 per gallon for a 60 mil membrane.

Millage Verification

The measurement tools listed below will help verify the thickness of the Geo-Seal CORE layer. As measurement verification experience is gained, these tools will help confirm thickness measurements that can be obtained by pressing one's fingers into the Geo-Seal CORE membrane.

To verify the mil thickness of the Geo-Seal CORE, the following measurement devices are required:

Mil reading caliper: Calipers are used to measure the thickness of coupon samples. To measure coupon samples correctly, the thickness of the Geo-Seal sheet layers must be taken into account (This is best done by obtaining a sample of the Geo-Seal BASE layer and then zeroing out the caliper to the Geo-Seal BASE layer). Mark sample area for repair.

Wet mil thickness gauge: A wet mil thickness gauge may be used to quickly measure the mil thickness of the Geo-Seal CORE layer. The thickness of the Geo-Seal sheet layers do not factor into the mil thickness reading, but the softness of the subgrade might result in inaccurate readings.

NOTE: When first using a wet mil thickness gauge on a project, collect coupon samples to verify the wet mil gauge thickness readings.

Needle nose digital depth gauge: A needle nose depth gauge can be used when measuring the Geo-Seal CORE thickness on vertical walls or in field measurements. Mark measurement area for repair.

To obtain a proper wet mil thickness reading, take into account the 5 to 10 percent shrinkage that will occur as the membrane fully cures. Not taking into account the thickness of the sheet layers, a freshly sprayed membrane should have a minimum wet thickness of 63 (5%) to 66 (10%) mils.

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Visual Inspections

The guidelines outlined in this section provide ways to quantify and observe the proper installation of the Geo-Seal system. However, a visual inspection should also be done to ensure any visual imperfections are not present, i.e. fish-mouths, punctures, voids, etc. During a visual inspection, punctures in the Geo-Seal system should be easy to indentify due to the color contrasting layers of the system.

Membrane Testing Log

To aid in the inspection process and properly document the Geo-Seal membrane inspection, create a membrane testing log. We recommend creating the log by using the foundation plan (plan view) of the structure and then creating a 500 square foot grid over the foundation. If this is not able to be done, enclosed is a membrane testing log template that can also be used. (Appendix E)

Wet Mil Thickness Readings

A wet mil thickness gauge is one method to verify the mil thickness of the Geo-Seal CORE layer. An advantage to this method is the ability to verify the Geo-Seal CORE thickness by minimizing destructive coupon sampling.

1. Create a membrane testing log by obtaining a copy of the foundation plan and then draw a 500 square foot grid over the foundation plan. Make two copies of the membrane testing log; one should be used when collecting coupon samples and the other should be used when conducting the smoke test.

2. Note time, date, project name, inspector name, temperature and weather conditions on testing log.

3. Number each quadrant and inspect sequentially.

4. When arriving at each quadrant quickly assess if there are any conditions that might present any challenges in establishing a proper seal. Note areas and discuss with applicator.

5. Conduct a visual inspection of the membrane. Look for areas where a proper seal was not created, i.e. a fish-mouth at the termination and areas where the membrane might be sprayed thin. Mark areas needed for repair in the field with florescent paint or with chalk. Also make a note on the testing log.

6. Conduct a thickness sample in the area that is suspected to be sprayed thin and take three readings within 3" of one another. **When beginning a project, verify the wet mil gauge thickness reading by cutting a coupon sample and measuring the thickness with a caliper.** Once wet mil thickness readings have been confirmed and established, confirm wet mil thickness periodically by taking a coupon sample and caliper measurement.

7. After sampling 5 quadrants it is at the discretion of the inspector to continue collecting samples every 500 ft^2 or 1,000 ft^2.

8. This method will verify the thickness of the Geo-Seal CORE layer prior to it fully curing. Observed shrinkage of the Geo-Seal CORE layer during the curing process ranges from 5% to 10%. When taking uncured samples assume a minimum of 10% loss for horizontal surfaces and 5% for vertical surfaces. Assuming a 10% loss, the gauge should read a mil thickness between 65 and 70 mils (≥66 mils).

9. If using a wet mil gauge to verify a fully cured membrane the gauge should read 60 mils.

10. When testing is complete, send a copy of the membrane testing log to Land Science Technologies. Keep the coupon samples for the file, or send them to Land Science Technologies.

Coupon Sampling

Coupon sampling is the most accurate way to verify the Geo-Seal CORE thickness. However, please note that taking too many coupon samples, or destructive samples, can be counter-productive. To collect a coupon sample the following steps should be followed:

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1. Create a membrane testing log by obtaining a copy of the foundation plan and then draw a 500 square foot grid over the foundation plan. Make two copies of the membrane testing log, one should be used when collecting coupon samples and the other should be used when conducting the smoke test.

2. Note time, date, project name, inspector name, temperature and weather conditions on testing log.

3. Number each quadrant and inspect sequentially.

4. When arriving at each quadrant quickly assess if there are any conditions that might present any challenges in establishing a proper seal. Note areas and discuss with applicator.

5. Conduct a visual inspection of the membrane. Look for areas where a proper seal was not created, i.e. a fish-mouth at the termination and areas where the membrane might be sprayed thin. Mark areas needed for repair in the field with florescent paint or with chalk. Also make a note on the testing log.

6. Calibrate mil reading caliper to account for the thickness of the Geo-Seal BASE layer. This is best done by obtaining a sample of the Geo-Seal BASE layer and then zeroing out the caliper to the Geo-Seal BASE layer.

7. Collect a coupon sample in the area that is suspected to be sprayed thin. Use a box cutter to cut a 3 square inch sample from the membrane. Measure each side to confirm the specified minimum thickness has been obtained. Number each sample and save in the job file. Mark the area for repair in the field and on the site plan.

8. After sampling 5 quadrants it is at the discretion of the inspector to continue collecting samples every 500 ft^2 or 1,000 ft^2.

9. Samples may be collected prior to the Geo-Seal CORE layer fully curing. Observed shrinkage of the Geo-Seal CORE layer during the curing process for horizontal surfaces is 10%. Assuming a 10% loss, a minimum of 66 mills thickness should be measured for a cured measurement of 60 mils.

10. When testing is complete, send a copy of the membrane testing log to Land Science Technologies. Keep the coupon samples for the file, or send them to Land Science Technologies.

Smoke Testing

This test is intended to visually verify and confirm the proper installation of the Geo-Seal system. Land Science Technologies requires a smoke test on all projects in order to obtain a warranty. The smoke test will be performed by the applicator.

Smoke testing should occur after the Geo-Seal CORE layer has been installed and mil thickness verified. Smoke testing may occur after the Geo-Seal BOND layer is installed, if preferred by the applicator. Upon completion of the original smoke test, additional smoke tests can be conducted per the membrane manufacturer's, specifying engineer or regulatory agency's request. To conduct a smoke test follow these steps:

1. One smoke test can cover between 2000-3000 square feet per test. However, coverage will greatly depend on the sub grade under the membrane. On sites where multiple smoke tests will be needed, use the first two smoke tests to estimate the coverage area per test.

2. Visual verification of soundness of seams, terminations and penetrations should be performed. Identify/correct any apparent deficiencies and/or installation problems.

3. Note time, date, project name, inspector name, temperature and weather conditions on testing log. In addition, record humidity, barometric pressure, and wind speed/direction. Confirm wind speed is below 15 mph. Visual identification of leaks becomes more difficult with increasing wind speed.

4. Cap other vent outlet(s) not being used. If the installation has no sub-slab vent system or the membrane is isolated from the vent system, connect the smoke testing system directly to the membrane using a temporary boot collar or other method. Insert the smoke test hose into coupon sampling locations, creating a seal around the smoke test hose with a rag.

5. Activate the smoke generator/blower system and connect to sub-slab vent riser or directly to the membrane.

6. To confirm the adequate flow of smoke under the membrane cut a 2” vent in the membrane to facilitate the purging of air pockets under it. If working properly, smoke will consistently flow though the 2” vent. If a low rate of smoke flow is observed it is an indication of poor smoke flow under the membrane. If low flow does occur, insert the smoke testing hose into the 2” membrane vent.

7. Mark sampling locations with fluorescent paint or chalk. Repair sampling locations per Land Science Technologies recommendations

8. Maintain operation of smoke generator/blower system for at least 15 minutes following purging of membrane. Thoroughly inspect entire membrane surface. Use fluorescent paint or chalk to mark/label any leak locations. Mark/label leak locations on testing log. NOTE: The duration of the smoke test will vary depending on the size of the area being tested. To help determine the duration, monitor the pressure building up under the membrane. If excessive lifting of the membrane occurs, decrease the duration or pressure of the smoke test.

9. Prepare membrane inspection log. Identify the type of leak found, i.e. poor seal around penetration, fish-mouth, puncture, etc.

10. Repair leak locations marked in step 7 and step 8 per procedures outlined in “Geo-Seal Repair Procedures” section using Geo-Seal CORE or Geo-Seal DETAIL.

11. Repeat steps 4 through 10 as necessary to confirm the integrity of the membrane.

12. Complete the smoke testing inspection form indicating the successful completion of the smoke test.

Post Installation Inspection

After a manufacturer’s representative or 3rd party inspector signs off on the membrane installation and the steel workers begin to install the rebar, it is recommended to conduct a visual inspection prior to the pouring of concrete. Damages are most likely to occur during this time and it is imperative that punctures are indentified prior to the placement of the slab. The system configuration of Geo-Seal, the top white Geo-Seal BOND layer with a middle black layer, will make rebar punctures easy to identify when conducting a visual inspection.

Appendix E

Estimating VOC Emissions in VMS Systems

Estimating VOC Emissions from Vapor Management Systems for Air District Permitting

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ABSTRACT: Treadwell & Rollo, Inc. designed passive sub-slab vapor management systems (VMS) to mitigate volatile organic compound (VOC) vapor intrusion into indoor air for 28 buildings at a new shopping mall located on a 55-acre property in the San Francisco Bay Area formerly occupied by a manufacturing facility. Previous site investigations indicated the presence of historical VOC impacts to soil, soil gas, and groundwater. The soil gas data and risk assessment results indicated that VMS would be required for the new buildings. VMS discharge of VOCs is subject to Bay Area Air Quality Management District (BAAQMD) regulations and permitting requirements, which can include significant fees and monitoring requirements. To minimize these potential impacts, Treadwell & Rollo, on behalf of the developer, applied for a permit exemption with the BAAQMD. To evaluate the request for exemption, the BAAQMD required an estimate of the total annual VOC emissions from the VMS effluent (discharge) risers from the 28 new buildings. The methodology used to calculate estimated VOC emissions for the site includes two empirical parameters that were derived based on an evaluation of pre-construction soil gas data and post-construction VMS monitoring data (effluent concentrations and airflow measurements) obtained at three existing buildings at other properties. The BAAQMD granted the requested permit exemption, resulting in significant cost savings to the project.

REGULATORY BACKGROUND AND PURPOSE OF CALCULATIONS

The project site consists of 55 acres undergoing redevelopment. The site was previously used for heavy industrial manufacturing; when redevelopment is complete, the commercial retail center will have approximately 646,000 square feet of retail space. Site characterization and remediation activities were previously conducted by various consultants on behalf of the prior site owner. Additional remediation activities are ongoing and anticipated to continue several years post-redevelopment. Per the agreement between the prior site owner and the California Regional Water Quality Control Board (RWQCB), all post-redevelopment structures will be constructed with a passive soil vapor management system (VMS) to protect building occupants from volatile organic compound (VOC) vapor intrusion, particularly trichloroethylene (TCE). Treadwell & Rollo, Inc. (Treadwell & Rollo) designed the VMS for each site structure. The VMS beneath the buildings provide a preferential pathway for VOCs to vent to the atmosphere instead of accumulating beneath the building floor slabs. The VMS are not intended to maximize VOC mass removal from the subsurface, thus the emissions rates from these systems are anticipated to be low.

This paper presents a methodology for calculating estimated annual emissions from the passive VMS of VOCs in soil gas at the site and then compare them to Chronic Trigger Levels (CTLs) established by the Bay Area Air Quality Management District (BAAQMD). These calculations rely on soil gas data collected at the site within the past two years, and on historical

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VMS performance data collected at two other brownfields redevelopment projects with similar systems.

VMS DESIGN FOR SITE STRUCTURES

The VMS system includes a vapor barrier beneath the building floor slab and a vapor collection and ventilation system beneath the vapor barrier. A second, separate vent piping system is installed to allow fresh air to enter the sub-slab area and assist in "sweeping" the VOCs towards the risers. The two horizontal networks of perforated 4-inch diameter polyvinyl chloride (PVC) pipes are embedded in a 12-inch layer of ¾-inch crushed rock beneath the vapor barrier and connected to risers that extend above the roof level. A sampling port is installed in each riser (both influent and effluent) to allow collection of VMS performance monitoring data. The vapor barrier consists of three components: a woven geotextile carrier-fabric (G-1000 by LBI Technologies, Inc. (LBI)); an elastomeric asphaltic-emulsion membrane (Liquid Boot® by LBI) that is spray-applied onto the carrier fabric to a thickness of 60 mils; and a protection course of felt fabric (Mirifi 1100N ®) on top of the Liquid Boot® membrane. The VMS systems are considered passive because the soil vapors move through the venting system primarily by means of convection and in certain cases with the assistance of roof-mounted wind turbines.

TOXIC AIR CONTAMINANTS IN SITE SOIL VAPOR

Toxic Air Contaminant Trigger Levels are specified in Table 2-5-1 of BAAQMD Regulation 2 (Permits) Rule 5 (New Source Review of Toxic Air Contaminants). The table lists over 200 compounds, of which 13 have been detected in soil gas at the site, including: TCE, benzene, 1,1-dichloroethane (1,1-DCA), 1,1-dichlorothene (1,1-DCE), ethyl benzene, 1,1,1-trichloroethane (1,1,1-TCA), naphthalene, perchloroethylene (PCE), toluene, vinyl chloride, m-xylene, o-xylene, and p-xylene.

ESTABLISHING ESTIMATED EMISSIONS CALCULATION PARAMETERS BASED ON DATA FROM OTHER PROPERTIES

An examination of historical performance data for VMS at other properties provides information pertinent to the calculation of estimated emissions rates for VMS systems being installed at the subject redevelopment project. The following subsections describe the VMS performance monitoring data collected at those properties and the two parameters established from those data.

Property Descriptions and Historical Monitoring Data – Other Properties. Treadwell & Rollo collected monitoring data for two methane mitigation systems that we had designed to evaluate their performance. The first set of data was collected at the new Port of Oakland's Harbor Facilities Center. The VMS for this property is typical of new construction, with lateral piping in a 6-inch thick crushed rock layer located beneath the floor slab and vapor barrier membrane. The facility consists of two buildings connected by a breezeway. Each building has an independent VMS. The risers are located within their respective buildings and terminate above the roof level with a wind-assisted turbine. Each building is surrounded by a series of perimeter vents, which allow fresh air to enter the sub-slab rock layer and assist the movement of soil vapors through the piping laterals towards the risers.

The second set of data was collected at a small retail facility in a shopping mall in San Mateo, California. Site investigation data indicate that total petroleum hydrocarbons as gasoline

(TPHg) is responsible for elevated levels of methane and TPHg in the soil gas. Consequently, at the request of the San Mateo County Department of Environmental Health, the building was retrofitted with a VMS as an interim measure to protect building occupants while additional soil and groundwater remediation activities are pending. Treadwell & Rollo designed a VMS that would not require access to the interior of the building or otherwise disrupt operations. The system therefore does not include a system of piping laterals in the gravel layer beneath the floor slab. However, it does include a series of perimeter inlet vents to allow fresh air to enter the existing subslab gravel layer as well as a series of exhaust vents, which are connected via a piping lateral to a riser. The riser is outside the building, terminates above the roof level, and is fitted with a wind turbine.

Monitoring data collected at the Port of Oakland facility included air velocity (feet per minute), volumetric air flow (cubic feet per minute), methane concentration (parts per million by volume), oxygen concentration (percent by volume), and vacuum (inches of water). The data were collected on nineteen occasions using hand-held instruments. Monitoring data collected at the San Mateo property included TPHg (micrograms per liter of air), oxygen (percent by volume), carbon dioxide (percent by volume), and methane (percent by volume) by analyzing a Tedlar bag sample collected from the riser. Additional monitoring data included VOCs (parts per million), oxygen, and methane collected using hand-held instruments on three occasions.

The initial (pre-construction) site investigation data and the in-service (post-construction) performance monitoring data from these two sites provide a basis for establishing two key parameters for the calculation of estimated future emissions rates from VMS at the subject site's buildings. These two parameters are the number of Air Exchanges Per Day occurring in the sub-slab gravel layer containing the venting pipe and the Constituent Attenuation Factor. The derivation of the values for these two parameters is presented in the sections below. The values of these two parameters based on existing, historical monitoring data are used in the estimated emissions calculations presented in the following section.

Sub-slab Air Exchange Rate. Table 1 presents the inputs and the results of the calculation of daily air exchange rates for the two buildings that comprise the Port of Oakland Harbor Facilities Center and the retail building in San Mateo. The daily air exchange rate, expressed in units of exchanges per day, is a function of the volume of the subslab gravel layer and the volumetric airflow (measured in the VMS riser in cubic feet per minute). The volume of the gravel layer is calculated as follows:

$$\begin{aligned} &Gravel\ Layer\ Volume\ (cubic\ feet) = \\ &Building\ Area\ (square\ feet) \times Gravel\ Layer\ Thickness\ (inches) \times \left(\frac{foot}{12\ inches} \right) \end{aligned} \quad (1)$$

Then, the number of air exchanges per day in the subslab gravel layer is calculated as follows:

$$Daily\ Air\ Exchanges \left(\frac{Exchanges}{Day} \right) =$$

$$\left[Flowrate \left(\frac{cubic\ feet}{\text{minute}} \right) \times \frac{60 \text{ minutes}}{hour} \times \frac{24\ hours}{day} \right] \div \left[Gravel\ Layer\ Volume\ \left(cubic\ feet \right) \right] \quad (2)$$

The effective porosity of the permeable material, which is approximately 20% to 30 % (n = 0.2 – 0.3) is ignored in these calculations. Therefore the calculated values for air exchange rates are likely lower (i.e., more conservative) than the actual values.

TABLE 1. Air Exchange Rates Calculated from Historical Monitoring Data for Two Sites.

Building	Building Area (square feet)	Gravel Layer Thickness (inches)	Gravel Layer Volume (cubic feet)		Volumetric Airflow (cfm)	Air Exchanges per Day
Port of Oakland, Building 1	29,740	6	14,870	Maximum: Minimum: Average:	24.5 4.9 14.3	2.4 0.5 1.4
Port of Oakland Building 2	23,550	6	11,775	Maximum: Minimum: Average:	30.2 5.6 11.7	3.7 0.7 1.4
San Mateo, Retail Facility	4,500	6	2,250	Maximum: Minimum: Average:	1.7 0.0 0.6	1.1 0.0 0.4

cfm – cubic feet per minute

The column in Table 1 presenting the volumetric airflow indicates the maximum, minimum, and average of the values obtained during monitoring. For example, the volumetric airflow for Building 1 of the Port of Oakland Harbor Facilities Center was measured on 19 occasions between December 2005 and March 2006. Using the average value of 14.3 cfm, the calculation of the number of air exchanges per day is as follows:

$$\left[14.3 cfm \times \left(\frac{60 \text{ minutes}}{day} \times \frac{24\ hours}{day} \right) \right] \div \left[29{,}740\ sf \times 6\ inches \times \left(1\ foot \Big/ 12\ inches \right) \right] = 1.4\ \frac{exchanges}{day} \quad (3)$$

The engineering design and operating environment of the VMS at the subject site is much more similar to that of the Port of Oakland facility than the San Mateo facility. Therefore, for the purposes of the estimated emissions calculations presented in the following section, a nominal value of 1.5 air exchanges per day was used.

Constituent Attenuation Factor. Table 2 presents the inputs and the results of the calculation of Constituent Attenuation Factor for the two buildings that comprise the Port of Oakland Harbor Facilities Center and the retail building in San Mateo. The pre-construction/pre-mitigation data consists of soil gas sampling results for methane (both sites) and total petroleum hydrocarbons as gasoline (TPHg) (San Mateo site). For Building 1 at the Port, five soil gas sampling locations selected for the pre-construction field investigation are within the footprint of the future building; the data for these locations are shown in the table. For Building 2 at the Port, no soil gas sampling locations were within the footprint of the future building, however five sampling locations were within 70 feet or less of the footprint; the data for these locations are presented in Table 2. At the San Mateo site, one soil gas sample (SG-1) was collected from the permeable layer located immediately beneath the existing building floor slab, and one soil gas sample (SG-2) was collected from beneath the parking lot pavement immediately outside the building and within the footprint of the existing TPHg groundwater plume. The methane and TPHg data for these two locations are presented in Table 2. The post-construction data consists of methane and TPHg concentrations measured in the VMS effluent; these data are from samples collected using Tedlar bags or measurements taken using field instruments via a sampling port in the effluent riser pipe.

The percent reduction in concentration between the pre-construction site conditions (soil gas) and post-construction site conditions (riser effluent) is calculated as follows:

$$Concentration\ \mathrm{Re}duction\ (\%) = \frac{\mathrm{Pr}econstruction\ Concentration\ (ppm) - Postconstruction\ Concentration\ (ppm)}{\mathrm{Pr}econstruction\ Concentration\ (ppm)} \times 100 \quad (4)$$

The calculations were performed using maximum values and average values. Using the average values of 148,340 ppm for the soil gas and 355 ppm for the effluent riser in Building 1, the calculation of the percent reduction in concentration is as follows:

$$\frac{148{,}340\,ppm - 355\,ppm}{148{,}340\,ppm} \times 100 = 99.761\% \quad (5)$$

The order-of-magnitude reduction in concentration between the pre-construction and post-construction site conditions was determined based on an examination of the data as follows. Using the average values of 148,340 ppm for the soil gas and 355 ppm for the effluent riser in Building 1, the order-of-magnitude reduction in concentration is 3-fold. Either the percent reduction or the order-of-magnitude reduction could be used in the estimated emissions calculations. Use of the order-of-magnitude reduction was considered more appropriate than percent reduction, since the constituent attenuation factor is based on field data collected during a broad range of site and atmospheric conditions.

An examination of the order-of-magnitude reductions in concentration presented in Table 2 indicates that the average and maximum constituent attenuation factors calculated for the two Port of Oakland buildings are slightly higher (3 to 5 orders of magnitude) than those for the San Mateo building (2 to 5 orders of magnitude). The lower attenuation rate (2) for TPHg is likely biased low due to the fact that the post-construction data point used (120 ppm) is from a Tedlar bag sample collected soon after installation of the venting system. Subsequent PID measurements indicate that VOC concentrations declined steadily over the three months following the date that the Tedlar bag sample was collected. For the purposes of the estimated emissions calculations, a nominal value of 3 orders of magnitude was used as the Constituent Attenuation Factor (CAF).

TABLE 2. Constituent Attenuation Rates Calculated from Historical Monitoring Data for Two Sites.

Building	Pre-Construction/Pre-Mitigation Soil Gas Sample ID	Constituent Concentration in Soil Gas (ppm)	Post-Construction Constituent Concentration in Effluent Riser (ppm)	Constituent Attenuation Factor Percent Reduction in Concentration	Orders-of-Magnitude Reduction in Concentration
Constituent: Methane					
Port of Oakland Building 1	MFC-31	380,000			
	MFC-33	170,000			
	MFC-35	190,000			
	MFC-38	1,700			
	MFC-41	2.1			
	Maximum:	380,000	940	99.753	3
	Average	148,340	355	99.761	3
Port of Oakland Building 2	MFC-28	560,000			
	MFC-29	780,000			
	MFC-33	170,000			
	MFC-36	19,000			
	MFC-45	770			
	Maximum:	780,000	20	99.997	4
	Average	305,954	1	100.000	5
San Mateo, Retail Facility	SG-1	130,000	2	99.998	5
	SG-2	45,000	2	99.996	4
Constituent: TPHg					
San Mateo, Retail Facility	SG-1	97,000			
	SG-2	6,000			
	Maximum:	97,000	120	99.876	2
	Average:	51,500	120	99.767	2

ESTIMATED ANNUAL VOC EMISSIONS FOR THE SITE

Methodology and Calculations. The annual emissions rate is a function of constituent concentration and flowrate, as follows:

$$\left[Concentration\left(\frac{mass}{volume}\right)\right]\times\left[Flowrate\left(\frac{volume}{time}\right)\right]=\left[Emissions\ Rate\left(\frac{mass}{time}\right)\right] \quad (6)$$

For this project, constituent concentrations in soil gas are expressed in units of micrograms per liter (µg/L). In the BAAQMD regulations, CTLs are specified in units of pounds per year (pounds/year). The flowrate is a function of the volume of the high-permeability layer beneath the floor slab, which for this project is a 12-inch (1-foot) crushed rock layer over the entire footprint of each of the structures, as well as the estimated air exchange rate in the high-permeability layer. The following equation represents the necessary unit conversions to calculate the emission rate in pounds per year using constituent concentrations expressed in micrograms per liter and flowrate up the riser(s) in cubic feet per day, including the dimensionless Constituent Attenuation Factor (CAF) described previously:

$$\left(\frac{\mu g}{L}\right)\times\left(\frac{ft^3}{day}\right)\times\left(\frac{28.31L}{ft^3}\times\frac{365days}{year}\times\frac{1x10^{-9}\,kg}{\mu g}\times\frac{2.20lbs}{kg}\right)\times CAF=\frac{lbs}{year} \quad (7)$$

The calculation of the estimated annual emission of TCE using the average concentration for the entire site (all buildings) and assuming 1.5 air exchanges per day through the permeable (crushed rock) layer and a CAF of 3 orders of magnitude is as follows:

$$\frac{12.682\mu g}{L}\times 1.5\times\frac{646{,}000\,ft^3}{day}\times\frac{28.31L}{ft^3}\times\frac{365days}{year}\times\frac{1x10^{-9}\,kg}{\mu g}\times\frac{2.20lbs}{kg}\times\left(1\times 10^{-3}\right)=0.2794\,\frac{lbs}{year} \quad (8)$$

The result of 0.2794 lbs/year is well below the CTL for TCE of 91 lbs/year.

Similar calculations were performed for the other 12 compounds. For the site as a whole, the emissions rates for the 13 compounds as compared to their respective CTLs are as shown in Table 3. The results indicate that the estimated emissions rates for this project are all well below the CTLs for each of the thirteen compounds.

TABLE 3. Summary of Estimated Emissions Rates for Entire Site (All Buildings).

Constituent	Estimated Emissions Rate (pounds/year)	BAAQMD Chronic Trigger Level (CTL) (pounds/year)	Percentage of CTL (%)
TCE	0.2794	91	0.31%
Benzene	0.0008	6.4	0.01%
11-DCA	0.0008	110	0.00%
1,1-DCE	0.0019	2,700	0.00%
Ethyl Benzene	0.0013	77,000	0.00%
1,1,1-TCA	0.0038	39,000	0.00%
Naphthalene	0.0042	5.3	0.08%
PCE	0.0216	30	0.07%
Toluene	0.0029	12,000	0.00%
Vinyl Chloride	0.0005	2.4	0.02%
m-xylene	0.0030	27,000	0.00%
o-xylene	0.0013	27,000	0.00%
p-xylene	0.0030	27,000	0.00%

Sensitivity Analysis. The parameters (air exchange rate of 1.5 per day and constituent attenuation factor of 3 orders of magnitude) have been selected judiciously, so as to not over- or under-estimate the future performance of the systems at the redevelopment project. Nevertheless, a sensitivity analysis was performed to assess how variation in either of these two parameters would affect the results of the estimated emissions rate calculations. The sensitivity analysis was performed by varying each of the two parameters such that the calculation of the estimated emissions rate was performed using a "low" and a "high" value for each parameter, selected based on the results of the historical monitoring data evaluations summarized in Tables 1 and 2. The results of that sensitivity analysis are presented in Table 4. The sensitivity analysis indicates that the estimated emissions rates at the site are highly unlikely to exceed CTLs.

TABLE 4. Sensitivity Analysis for Calculation of Estimated TCE Emissions Rate.

Average TCE Concentration (µg/L)	Building Area (square feet)	Gravel Layer Thickness (inches)	Gravel Layer Volume (cubic feet)	Air Exchanges per day	Constituent Attenuation Rate (Orders of Magnitude)	Estimated Emissions Rate (pounds/year)
Nominal Case: Air Exchanges per Day = 1.5; CAF = 1 x 10^{-3}						
12.682	646,000	12	646,000	1.5	3	0.2794
"Low" Air Exchange Rate Case: Air Exchanges per Day = 1.0; CAF = 1 x 10^{-3}						
12.682	646,000	12	646,000	1.0	3	0.1862
"High" Air Exchange Rate Case: Air Exchanges per Day = 4.0; CAF = 1 x 10^{-3}						
12.682	646,000	12	646,000	4.0	3	0.7450
"Low" CAF Case: Air Exchanges per Day = 1.5; CAF = 1 x 10^{-5}						
12.682	646,000	12	646,000	1.5	5	0.0028
"High" CAF Case: Air Exchanges per Day = 1.5; CAF = 1 x 10^{-2}						
12.682	646,000	12	646,000	1.5	2	2.794

Note: Chronic Trigger Level (CTL) for TCE is 91 pounds per year.

SUMMARY AND CONCLUSIONS

The calculations presented in this paper were used to support the developer's request for a Certification of Exemption from the BAAQMD for a new redevelopment project in San Jose, California. A combination of pre-construction soil gas data and post-construction VMS performance monitoring data previously collected at other sites have provided a rational basis for the development of the empirically-based variables (Air Exchange Rate and Constituent Attenuation Factor) used in the estimated emissions calculations for the Site. All estimated emissions rates for regulated VOCs that have been detected in soil gas at the Site are below BAAQMD Chronic Trigger Levels (CTLs) for each constituent, and only one constituent (TCE) is anticipated to be present in detectable concentrations in the emissions of only a limited number of site structures.

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