Advancing Environmental Solutions

Vapor Intrusion Mitigation

VIM-1, 2021

Session 2

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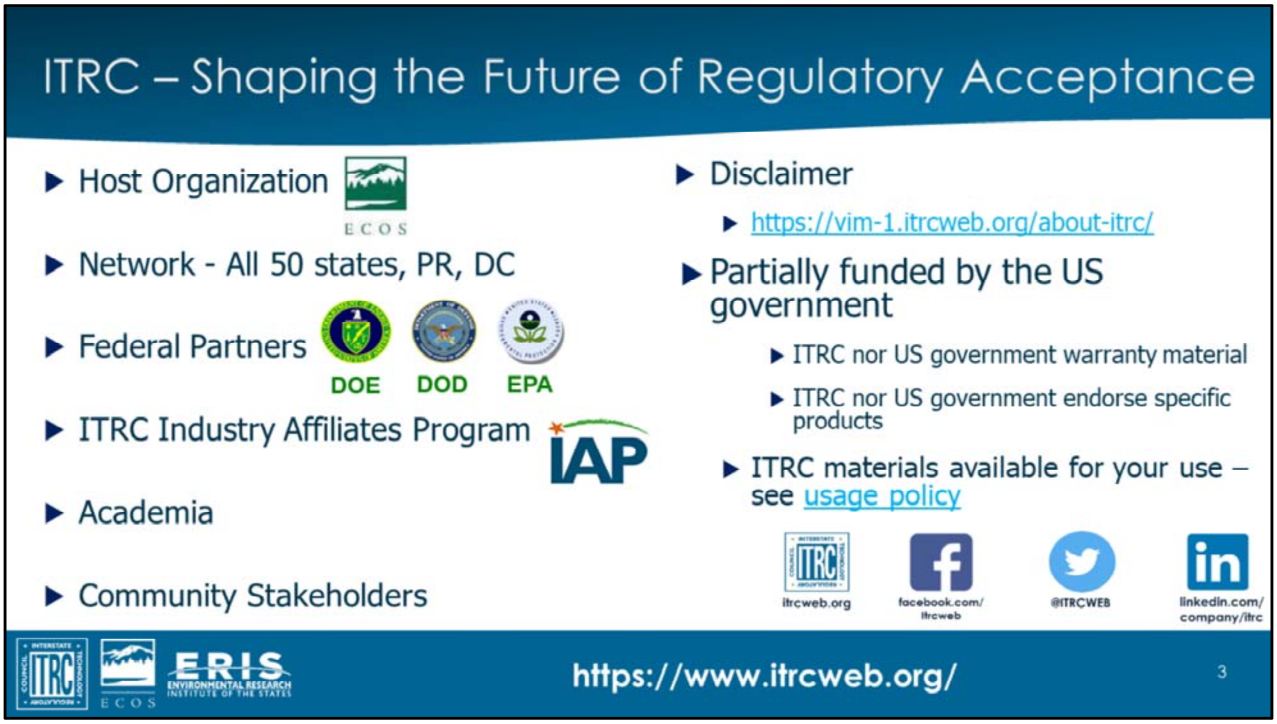
Current time budget = 20-22 minutes (as of 2-10-2021)

Housekeeping

- Recording for On Demand Viewing
- Course Information and Materials: https://clu-in.org/conf/itrc/vim-1/
- Technical difficulties? Use Q&A Pod
- Certificate of Course Completion



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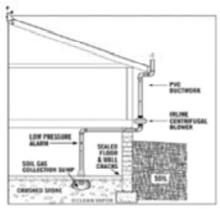
Trainer Bios: https://clu-in.org/conf/itrc/VIM-1/

Internet Based Training (IBT)
Session 2

Passive Mitigation



Source: T. Hamon, 2020. Used with permission.

Active Mitigation

System Verification and OM&M/ Exit Strategy

Matt

What You Should Learn

- Background on the VIM Training team
- Overview of available documentation
- How access the mitigation strategies information
- Identify the sections that will be discussed in today's session

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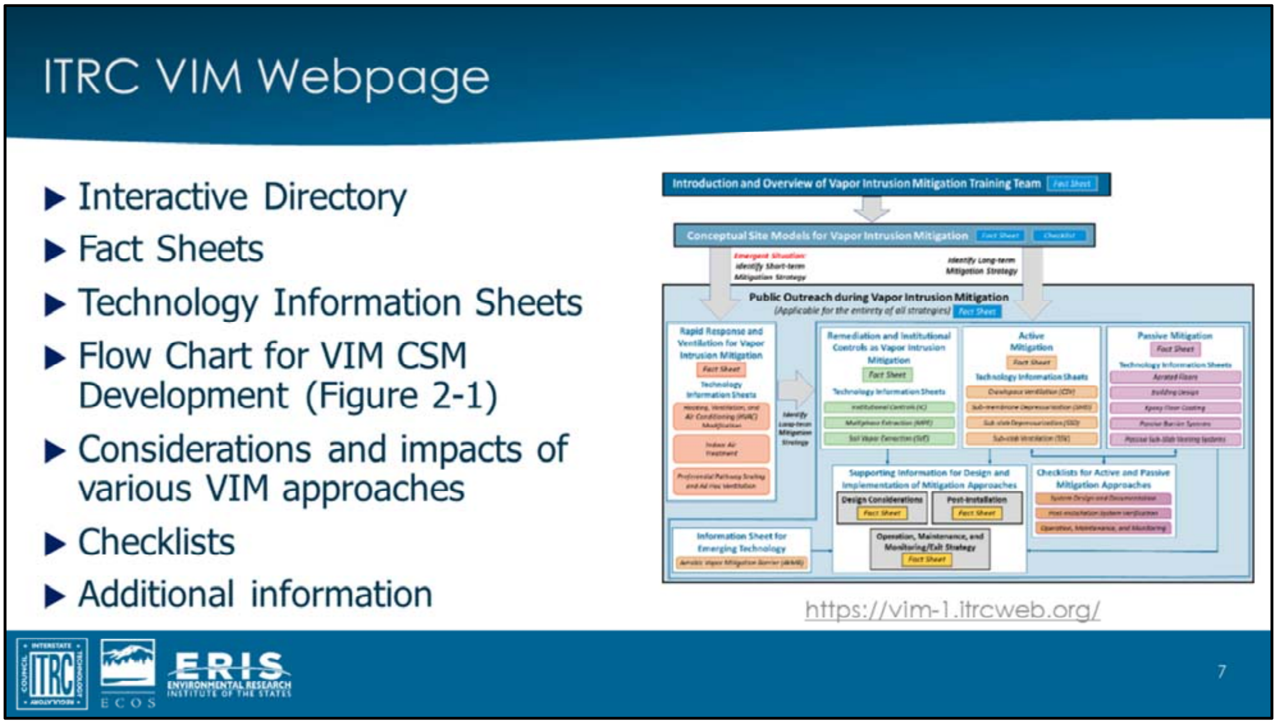


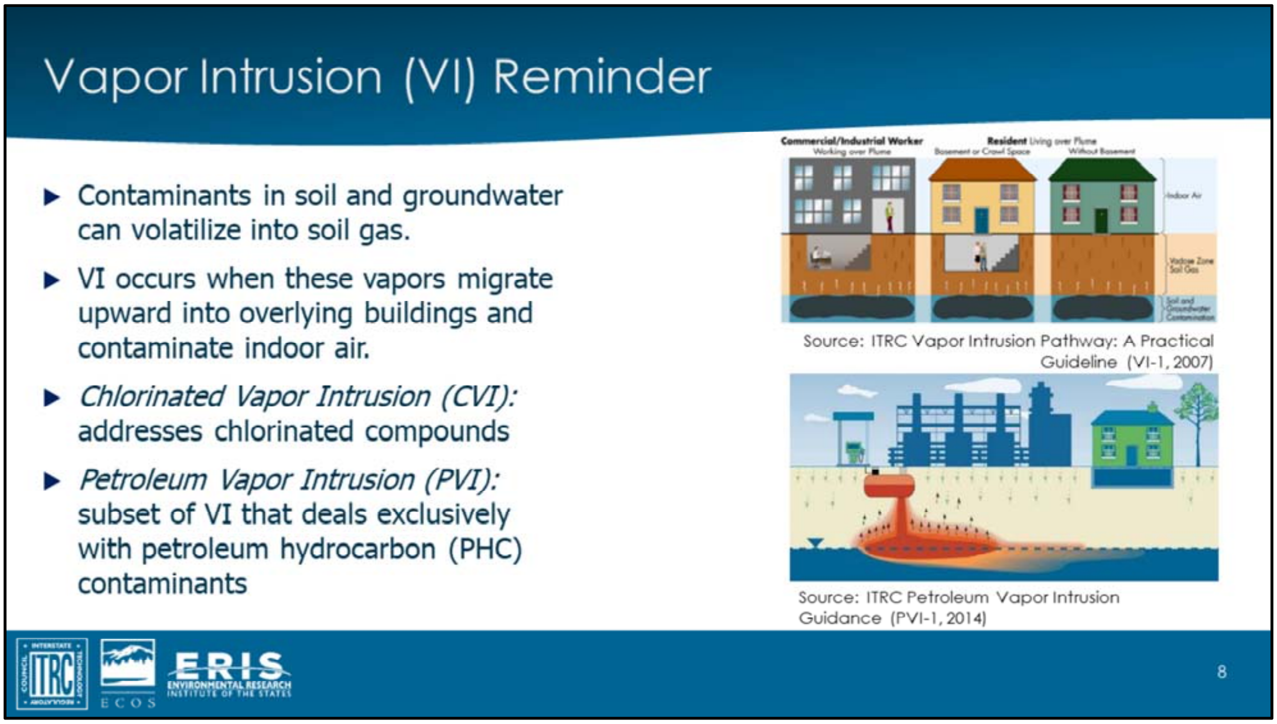
Supporting Information:

Design Considerations; Post-Installation; and Operation, Maintenance, and Monitoring/Exit Strategy

Checklists for Active and Passive Mitigation:

System Design and Documentation; Post-Installation System Verification, and Operation, Maintenance, and Monitoring

***NOTE THAT checklists for active and passive are covered in their respective modules, not as a separate module



Start by talking about "What is Vapor Intrusion" or VI and why we are here so that there is a common understanding of what it is.

First it requires contaminants or hazardous substances to be released into soil and groundwater that can volatilize into soil gas.

Vapor Intrusion occurs when these vapors migrate upward into overlying buildings and contaminate indoor air.

It requires soil for vapors to migrate and diffuse through

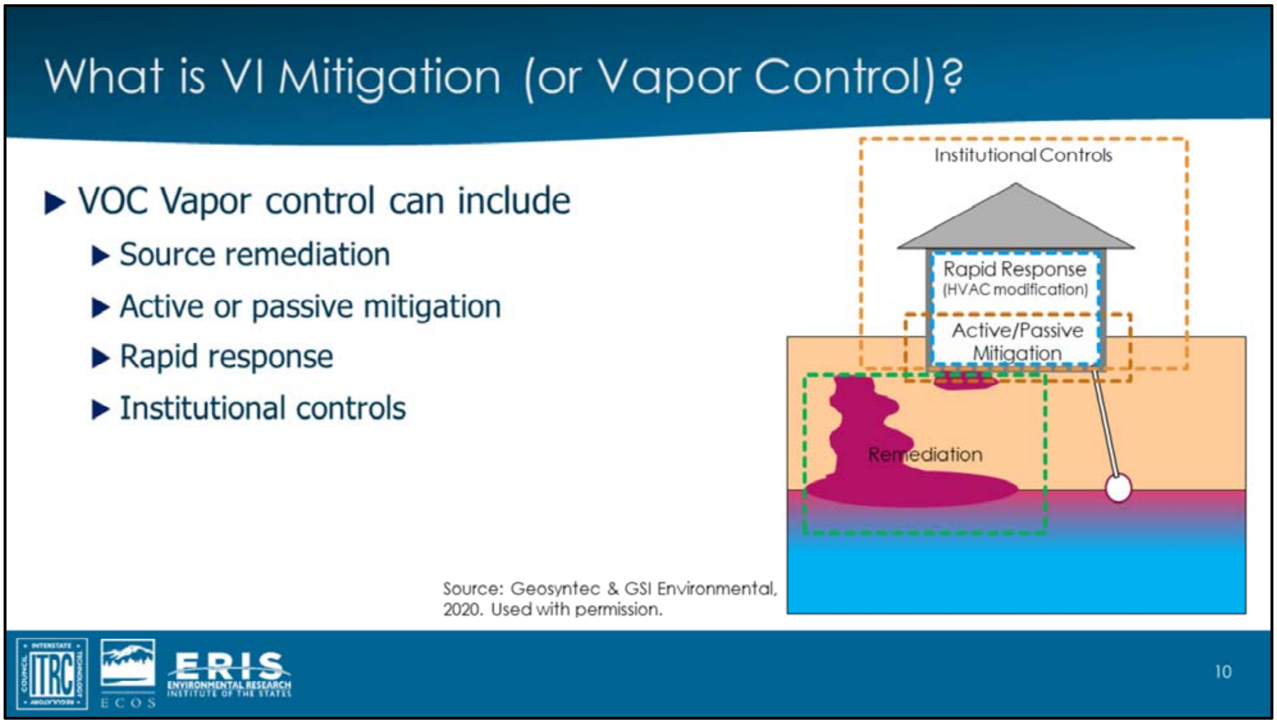
If present at sufficiently high concentrations, these vapors may present a threat to the health and safety of building occupants.

Also, quickly **mention preferential pathways**
There are generally considered 2 specific types of vapor intrusion Chlorinated Vapor Intrusion (CVI) which addresses chlorinated compounds and Petroleum Vapor Intrusion (PVI) is a subset of VI that deals exclusively with petroleum hydrocarbon (PHC) contaminants

Understanding the differences between each is critical as there may be different mitigation strategies for each type of vapor intrusion

VI Mitigation (VIM)

- Implemented to reduce indoor air contaminants due to VI below applicable action or screening levels
- Accomplished by
  - Modifying the VI pathway to reduce the mass flux of contaminants entering the building
  - Reducing indoor air contaminant concentrations by removal or dilution

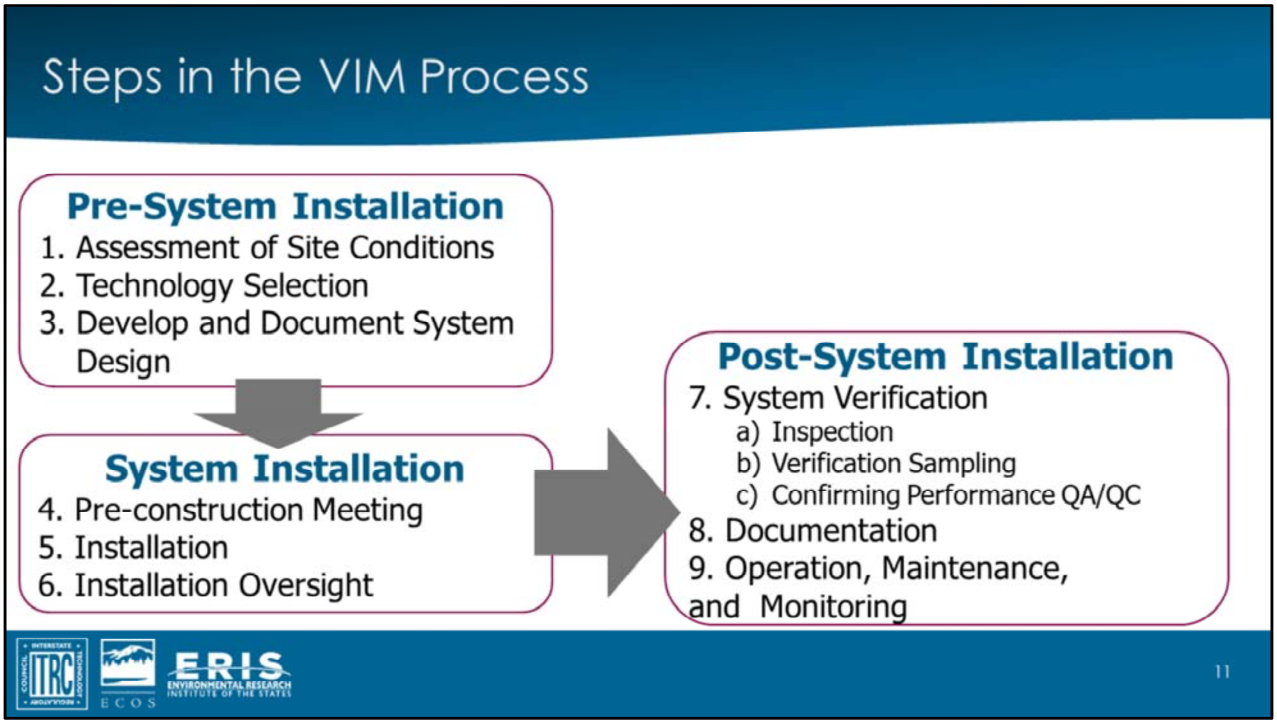


NOTE: THESE SLIDES WILL STEP THROUGH EACH

Multiple different mitigation strategies which is also called vapor control

Environmental remediation **(CLICK)** which address the contamination at the source
Building mitigation measures **(CLICK)** which typically involve active and passive mitigation
Rapid Response **(CLICK)** which is employed to quickly address known or potential vapor intrusion until longer term remedies can be implemented
Institutional controls (ICs) **(CLICK)** which are tools used to restrict different types of development or event the development itself

You will learn about the tools for each today and when appropriate each of these methods can be designed to reduce or prevent VI from occurring


Steps in the VIM Process
Pre-System Installation
1. Assessment of Site Conditions
2. Technology Selection
3. Develop and Document System Design
System Installation
4. Pre-construction Meeting
5. Installation
6. Installation Oversight
Post-System Installation
7. System Verification
a) Inspection
b) Verification Sampling
c) Confirming Performance QA/QC
8. Documentation
9. Operation, Maintenance, and Monitoring
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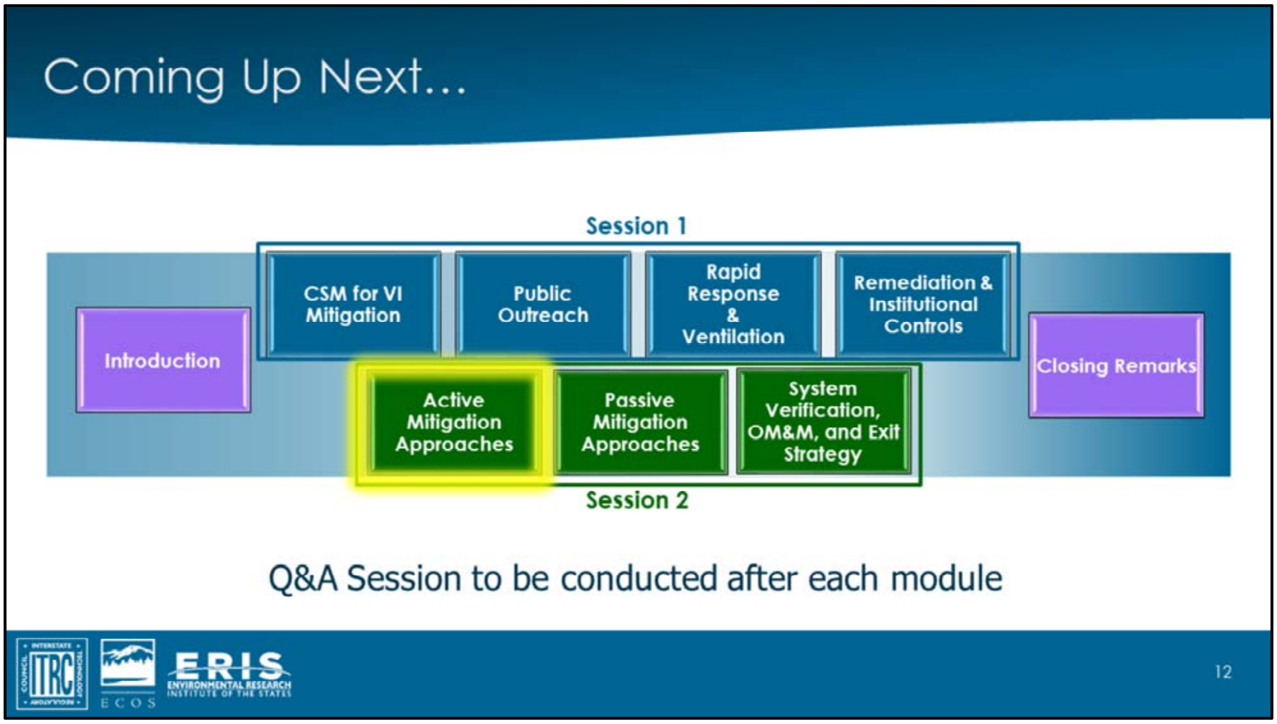
Coming Up Next…
Session 1
Introduction
CSM for VI Mitigation
Public Outreach
Rapid Response & Ventilation
Remediation & Institutional Controls
Closing Remarks
Active Mitigation Approaches
Passive Mitigation Approaches
System Verification, OM&M, and Exit Strategy
Session 2
Q&A Session to be conducted after each module
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Active Mitigation Approaches

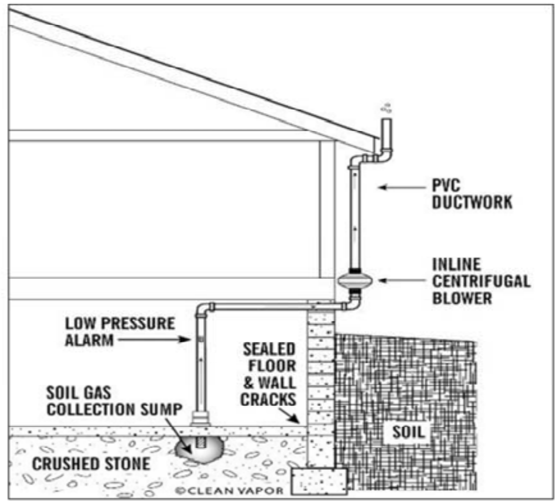

Figure 1 of the Sub-slab Depressurization (SSD) Technology Information Sheet.

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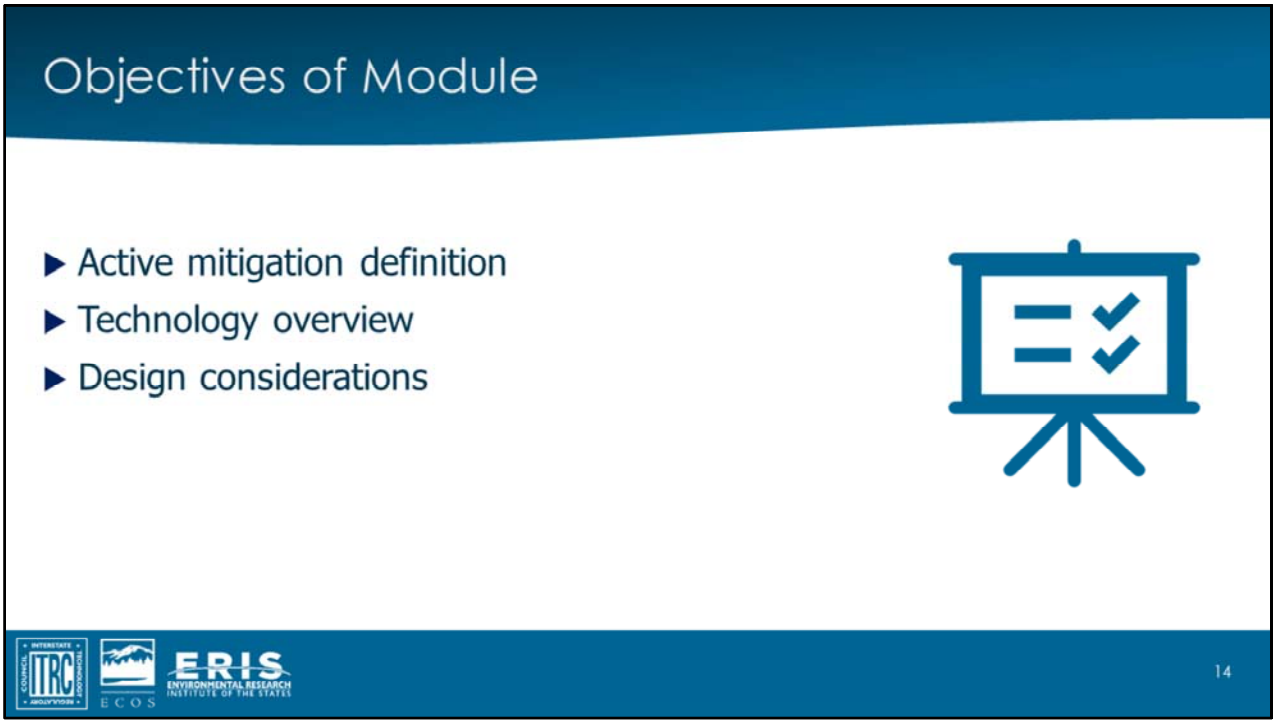
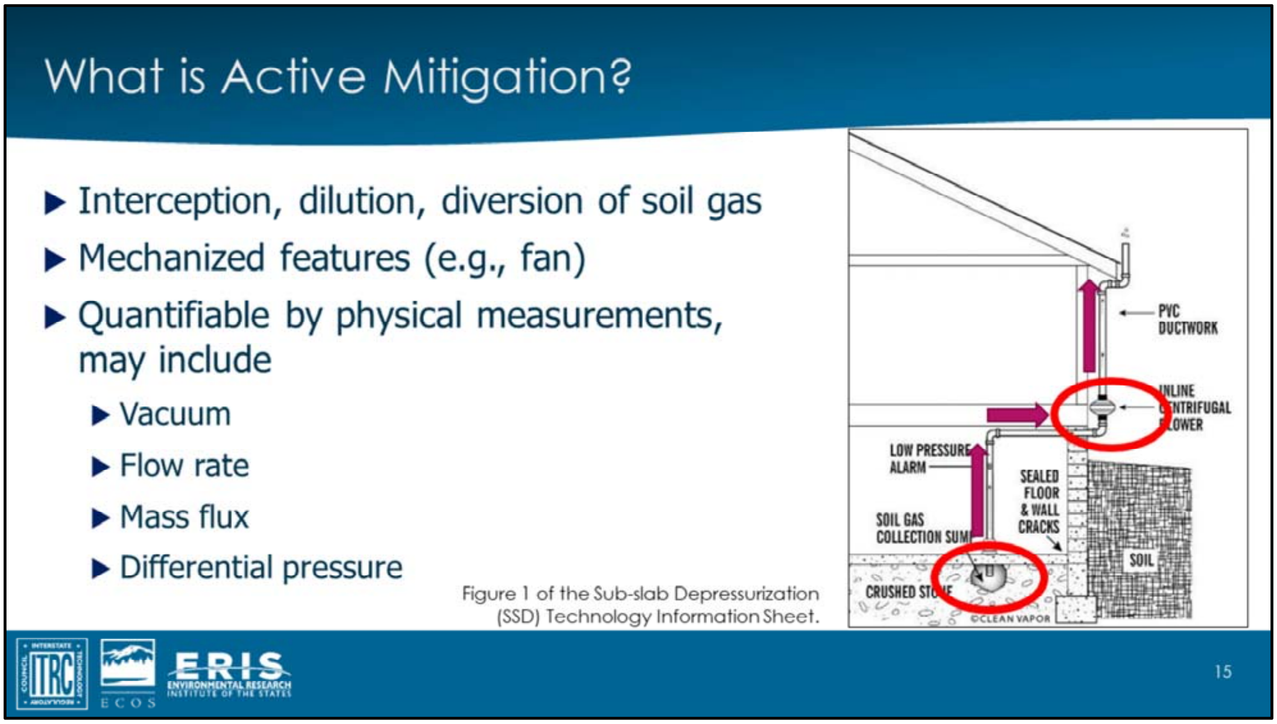
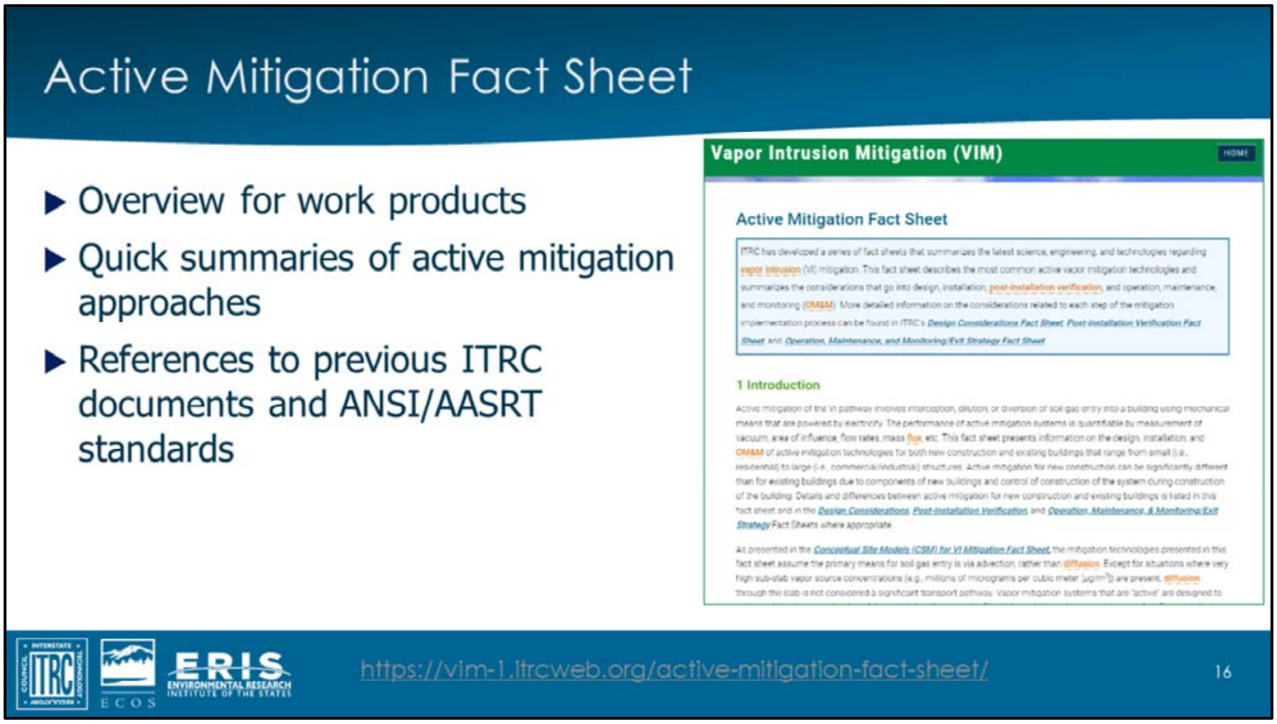


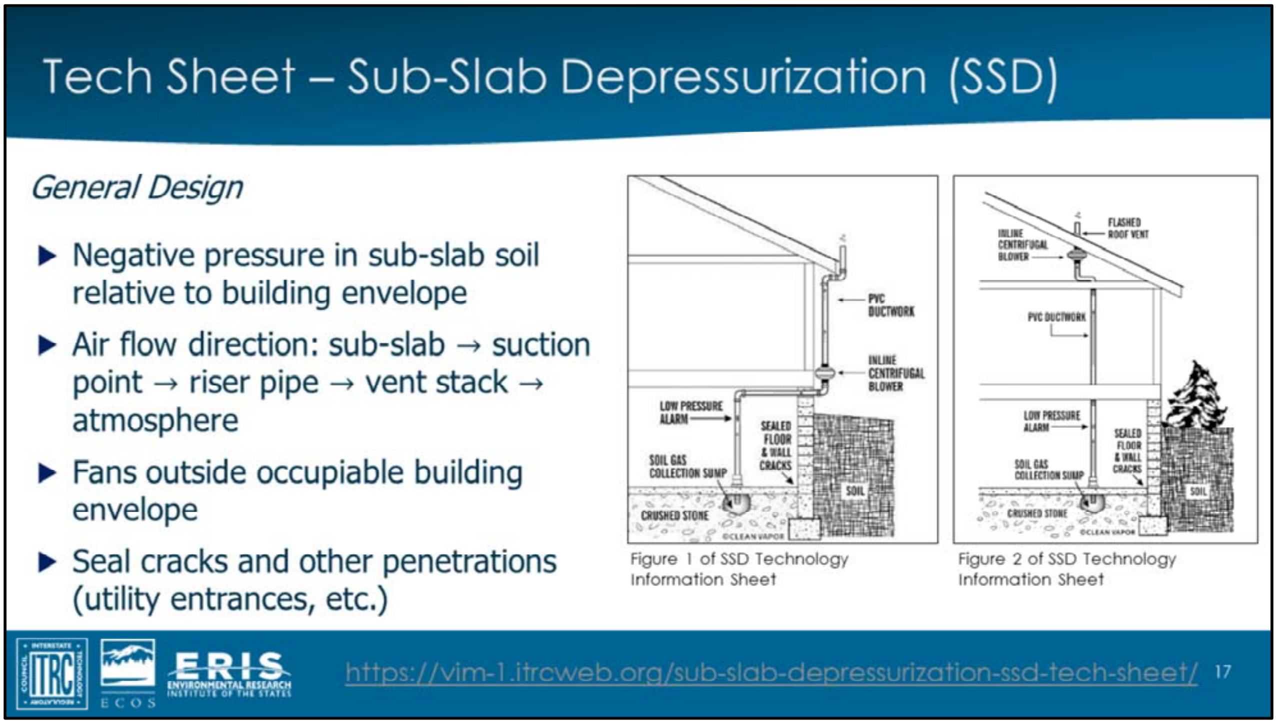
- The goal of today's presentation is to provide an overview of active mitigation to a wide audience with varying degrees of experience with these technologies.
- Training is applicable to state and federal regulators who may be tasked with evaluating active mitigation designs, industry professionals who are considering various technology options
- The training content based on the work documents developed by the ITRC VIMT
- Objectives are
  - Set definition for what we consider active mitigation when developing docs
  - Provide an overview of various Active approaches covered by the VIMT .
  - Review key design considerations for active mitigation



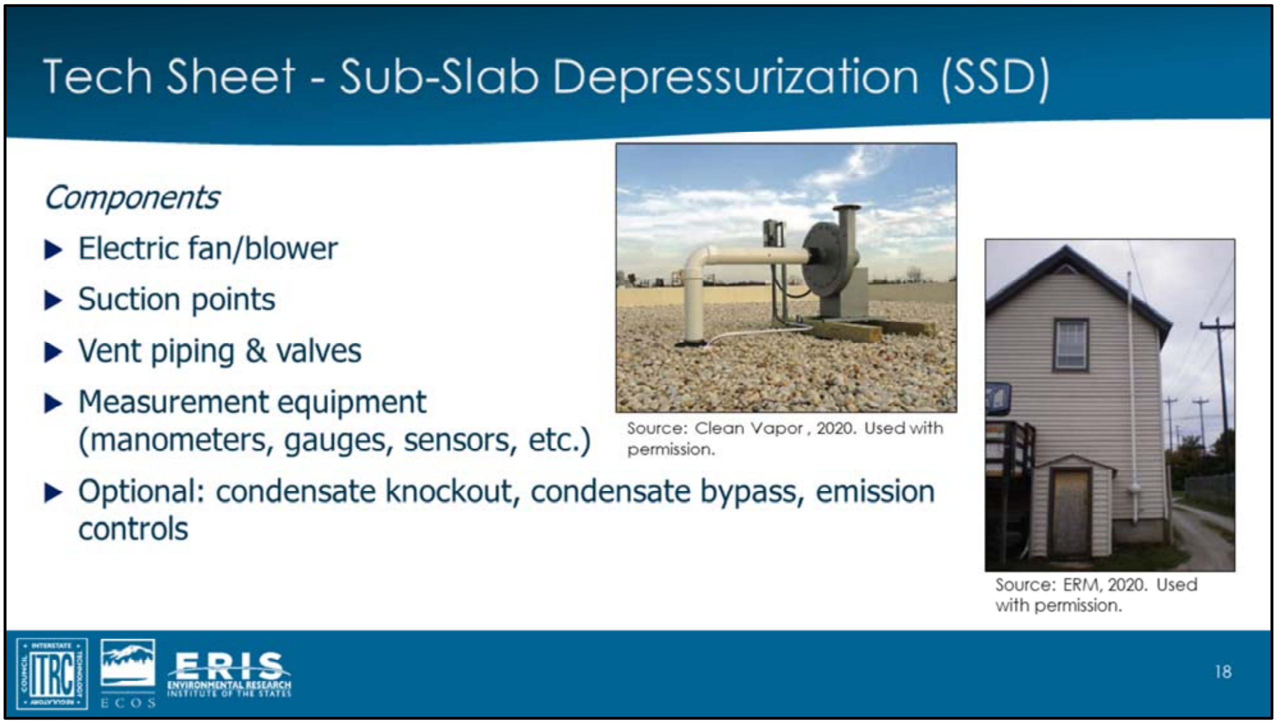
- Active mitigation is the **continuous** diversion of vapors from under the building to the atmosphere outside using mechanical means like a fan or blower.
- The mechanized feature is what defines it as active.
- Active systems can be measured with, physical measurements, so it is **easy to determine effectiveness**
- Some of the measurement types are listed here on the slide for example vacuum and flow within the piping or differential pressure which measures vacuum under the slab relative to the indoor air space



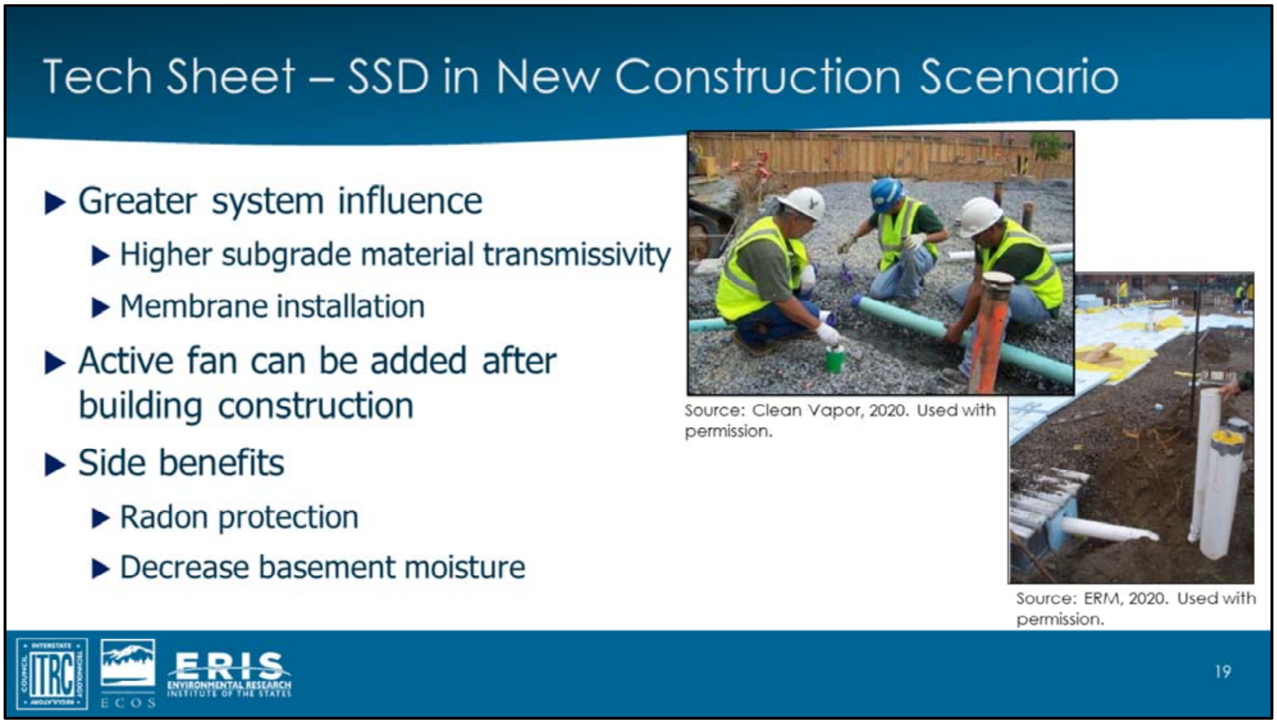
- Fact sheet is laid out as a **summary guide** to the content in various other Active work products
- Note quick summaries on the technologies that were common enough that we created Tech Sheets
- but also has quick descriptions of other lesser common technologies that may be encountered
- Numerous references to previous ITRC documents (2007 and 2014)
- References to updated ANSI/AASRT standards if you are looking for details to actually design a system



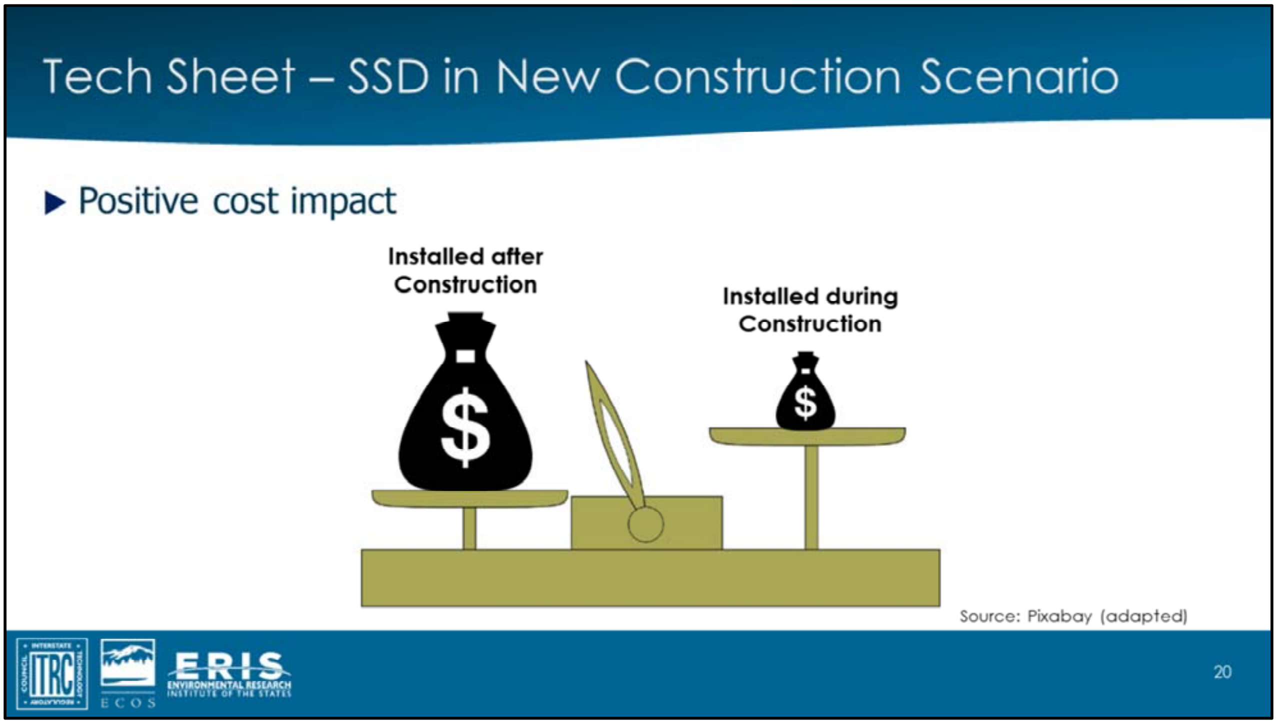
- Next we will go into more details of what the four most common types of active mitigation systems look like.
- VIMT created technology information sheets for each of the common active approaches
- Each goes through their general design, components, pros and cons and possible cost implications.
- Here is the first one - Sub-Slab Depressurization (PRESENTER: DO NOT SAY "S-S-D", TOO HART TO UNDERSTAND OVER IBT)
- Draws air from beneath the slab to collection point, through riser pipe, vented to the atmosphere
- Notice fan placement both outside or, if inside it is outside the occupiable building space
- Typically thought of as a retro fit of an existing building but can be used during building construction
- Often coupled with crack sealing to increase effectiveness and efficiency
- **Most common** and **most conservative** mitigation method
- Has been **shown to be very effective**



- Components listed on slide
- Measurement equipment includes (u-tube manometer, vacuum gauge, pressure sensor, etc.)
- Emission controls usually not needed for vent stacks but need to check your state's regs
- Large systems may need emission controls, condensate knockout
- There **are adv and limitations** to this technology and they are in the tech sheet, talk about some in the course of this presentation but **not specifically listed in this presentation**



- SSD is most often thought of in existing buildings but I want to just mention quickly that it can also be considered in New construction
- Most control on the materials in the subgrade
- **Membranes may not need to be as robust if going straight to active** versus trying passive first.
- If not sure system is needed can be "roughed in" for later use

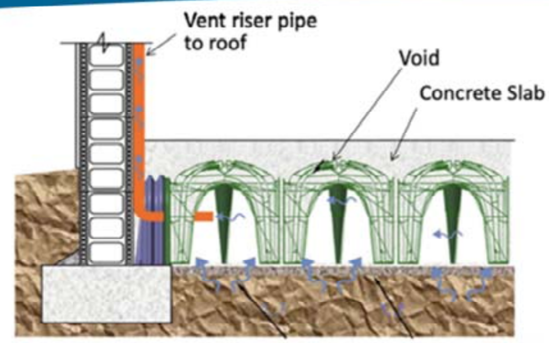


- Ultimately lead to a **positive cost impact**
- A roughed in system will be cheaper than a system put in later as a retrofit.
- With the increased influence of the system (as compared to a retrofit)
- It may eliminate the need for a larger fan or multiple extraction points to obtain adequate coverage.
- Able to plan the location of the vent stack (e.g. placing in utility closet rather than center of basement)
- If installed after construction will need to access building and potentially disrupt ongoing operations.

Tech Sheet – Sub-Slab Venting (SSV)

General Design

- Similar to SSD
- Air flow reduces sub-slab vapor concentrations
- High-permeability soils or void spaces
- Relatively low vapor concentrations
- Performance measurements include air velocity, system vacuum, vapor concentrations, mass flux



Source: Pontarolo Engineering, Inc.

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- Next tech sheet is sub-slab venting (PRESENTER – SAY FULL WORD, DON'T SAY "S-S-V", TOO HARD TO UNDERSTAND OVER AUDIO)
- **Variant of SSD**
- Similar to depressurization in that it draws vapor out from under the slab
- As you see in the pic through these vapors are drawn out from either a very permeable layer like a gravel or from a void space
- Drawing out vapors **reduces conc below slab** and mitigates VI
- **Due to relative ease in drawing out air, and the potential for dilution air to be introduced in some cases less vacuum may be generated**, performance **metrics could be slightly different** than SSD and include those listed
- Typically used when high permeability is already present (or new construction when you can create that layer)

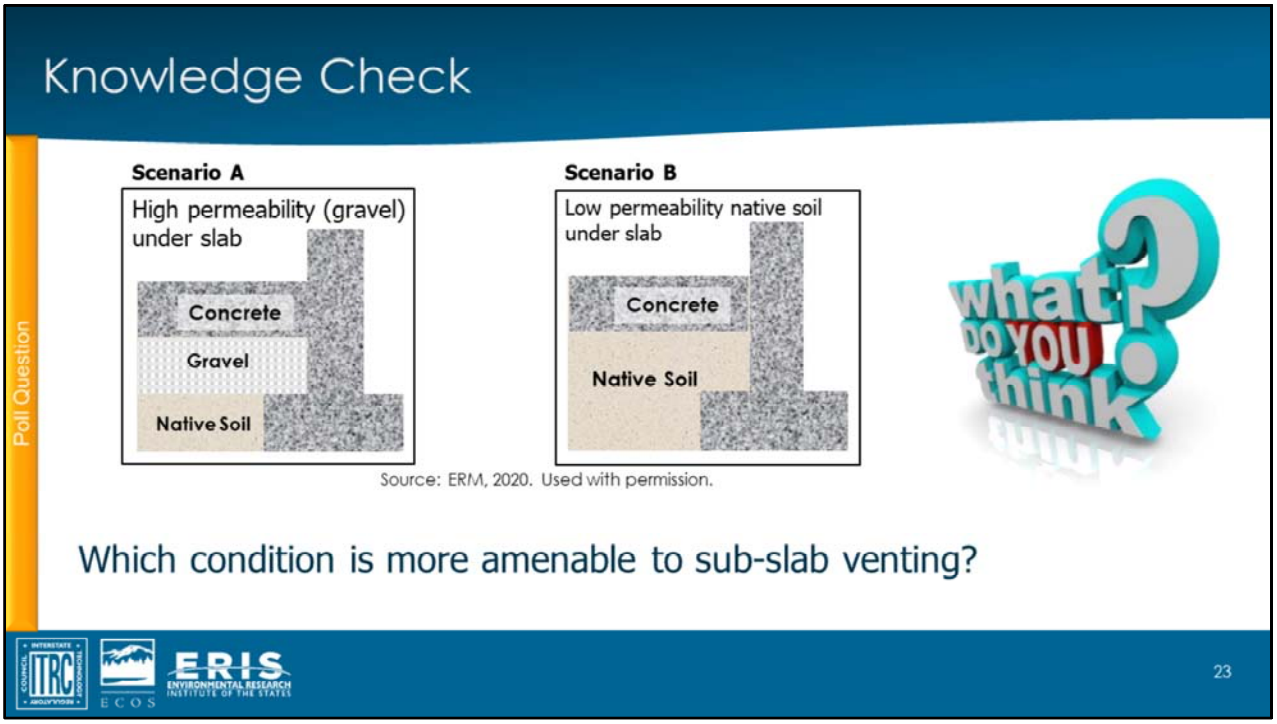
Tech Sheet – Sub-Slab Venting (SSV)

Components

- Components same as SSD
- May incorporate aerated floor system (void spaces)
- May include inlets for sub-slab dilution air

Source: Clean Vapor, 2020. Used with permission.

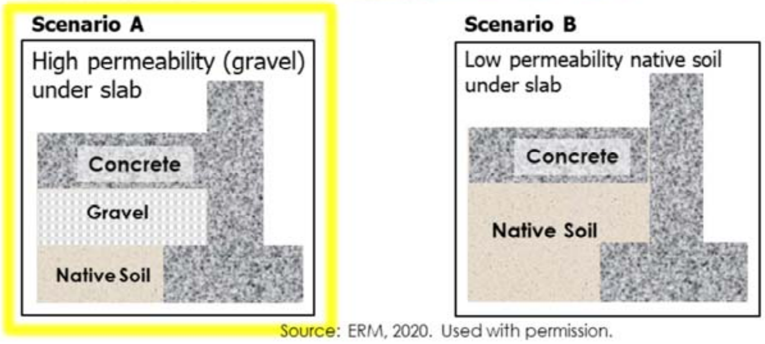
- As mentioned, almost exact same components to SSD
- Void spaces more common with SSV and more common when added to new construction (see picture) although a new floor in a retrofit or adding a floor on top of an existing floor could also allow for an aerated floor system
- Some systems may intentionally incorporate dilution inlets that allow fresh air to circulate in the surface as the fan draws out the vapors or leakage may occur naturally into the subsurface creating that same dilution.



- A knowledge check based on what we just learned

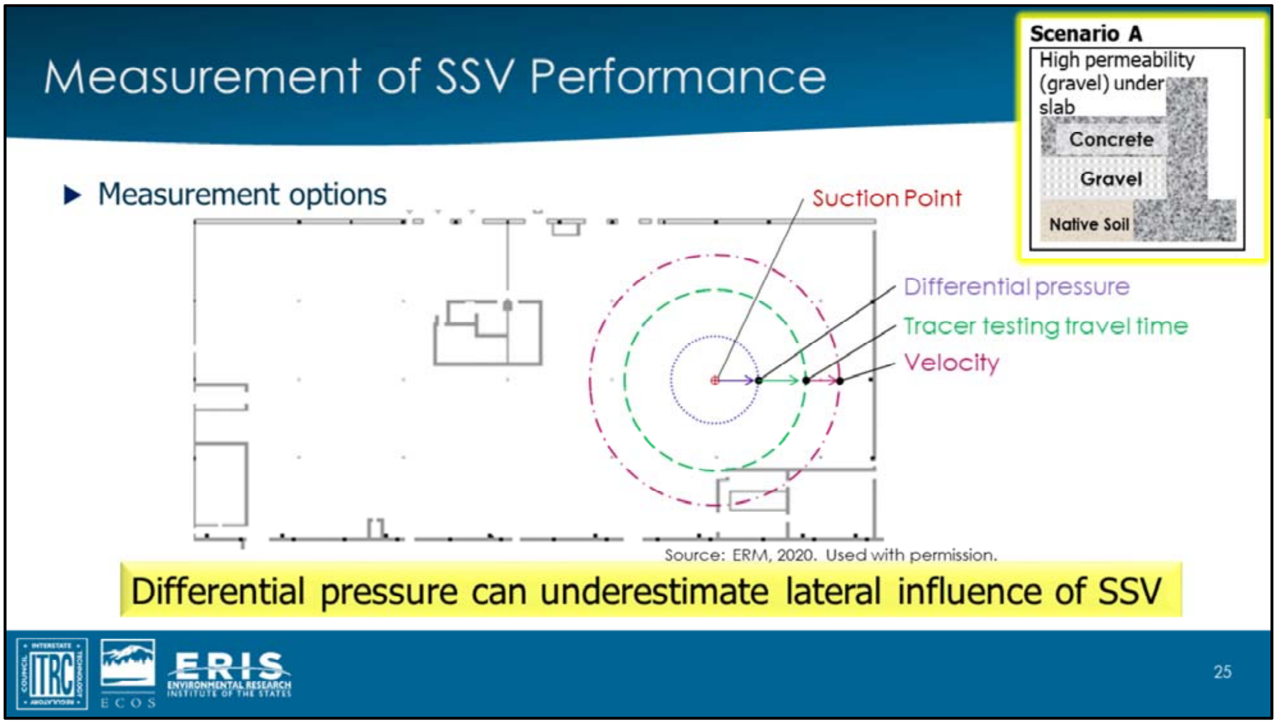
Knowledge Check

Poll Question

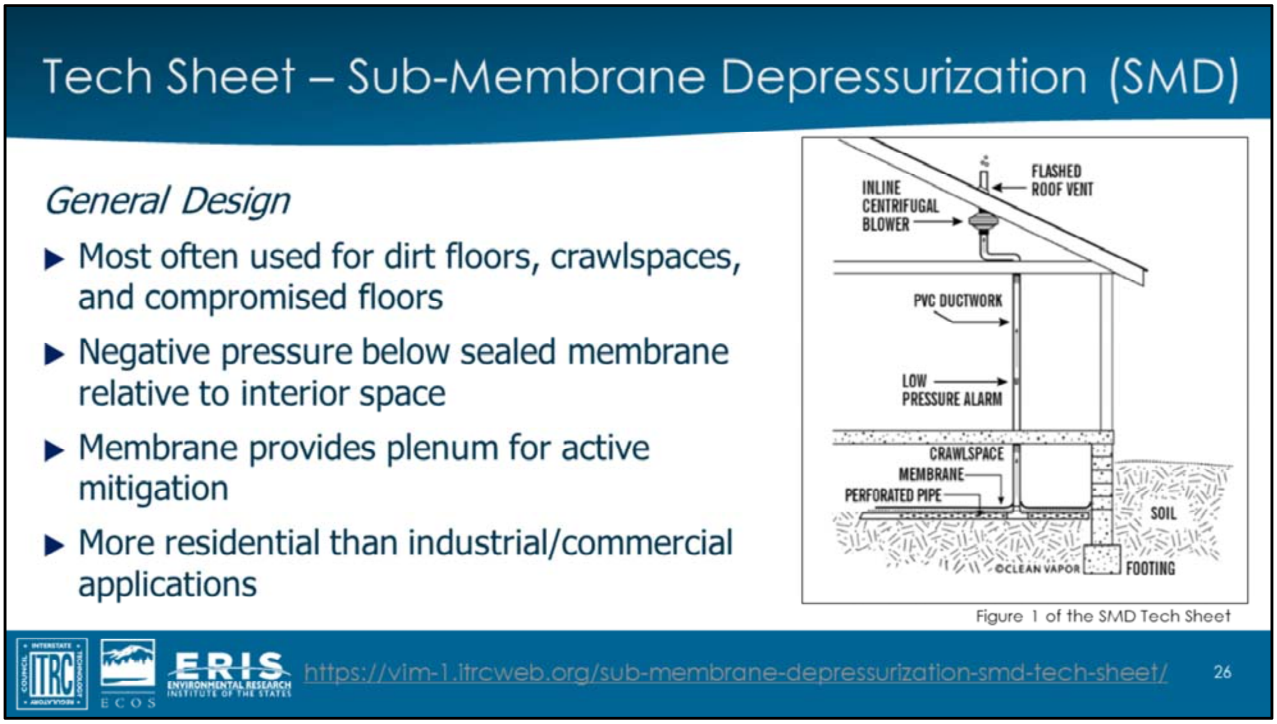


Source: ERM, 2020. Used with permission.

Which condition is more amenable to sub-slab venting?



- Dig deeper into scenario A where there is high permeability material under the slab and how we would want to evaluate the performance of an SSV system.
- So if you have a suction point here and if you were to just measure the induced vacuum as differential pressure, you may see the influence of the system to here CLICK
- But if we use the metrics discussed earlier like a tracer test we could show that the SSV system actually has an influence much greater to say here CLICK
- and if we measured velocity under the slab you may see evidence of air movement to here CLICK
- CLICK This is all to say that differential pressure as a performance metric may underestimate SSV systems because of the conditions where SSV system operate.



- Next Tech sheet is Sub-Membrane Depressurization
- Very similar to SSD except for locations where there is no slab, this system installed a membrane and then vapors are drawn from underneath to create the depressurization.
- **Preferred method for crawlspace mitigation, intercepts vapors before entering crawlspace**
- Draws air from beneath the sealed membrane to collection point, through riser pipe, vented to the atmosphere
- Fan put outside occupiable living area or outside
- Membrane provides sealed space for active mitigation consideration when impermeable surface is not present
- Best used with crawlspaces or earthen floor exposures
- Typically installed more in residential homes as usually this dirt floor occurs in a crawlspace but could be used in other types of buildings.

Tech Sheet – Sub-Membrane Depressurization (SMD)

Components

- Electric fan/blower
- Vent piping & valves
- Membrane sealed to walls and around pipe penetrations
- Vapor collection piping/plenum under membrane
- Measurement equipment (manometers, gauges, sensors, etc.)
- Optional: condensate bypass, emission controls

Source: Arcadis, 2020. Used with permission.

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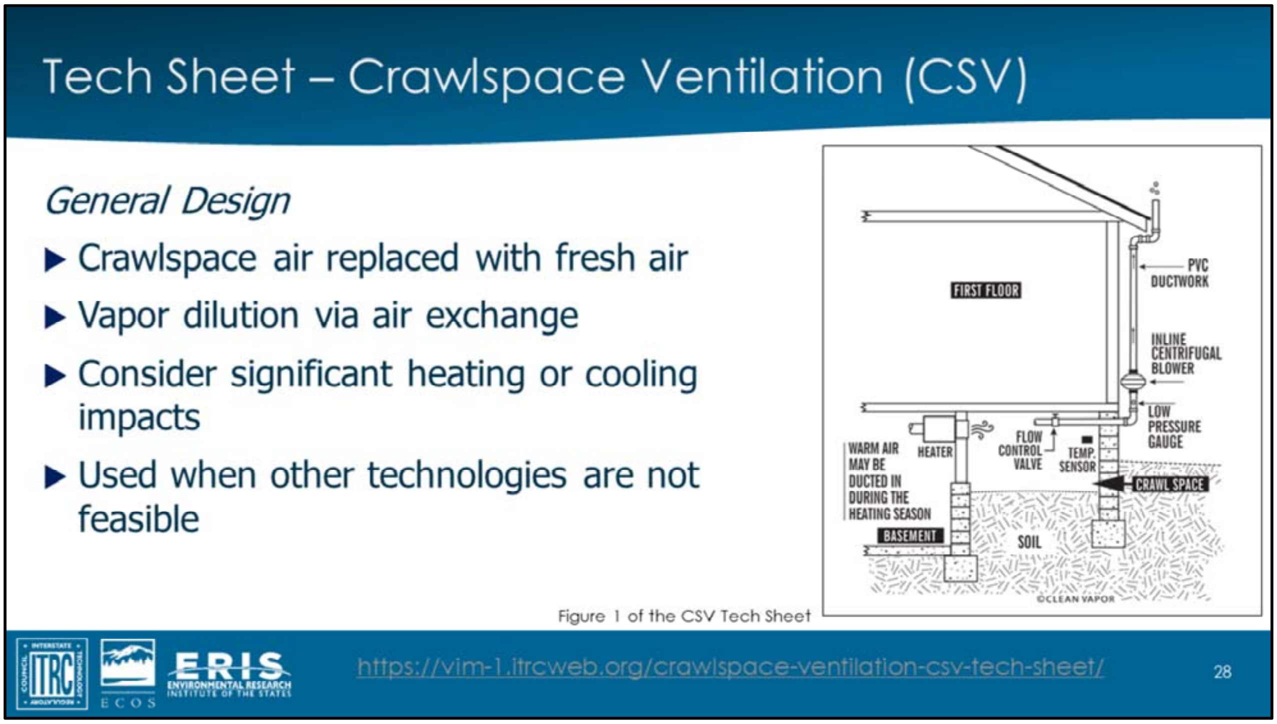
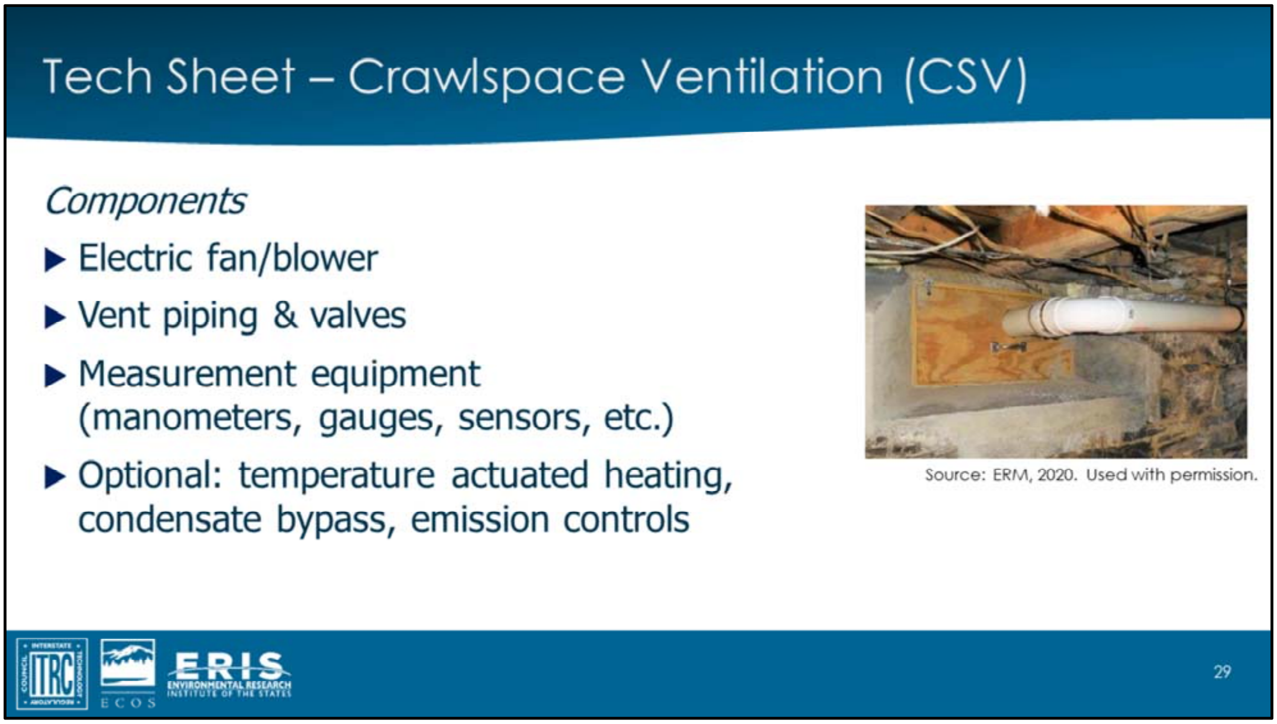
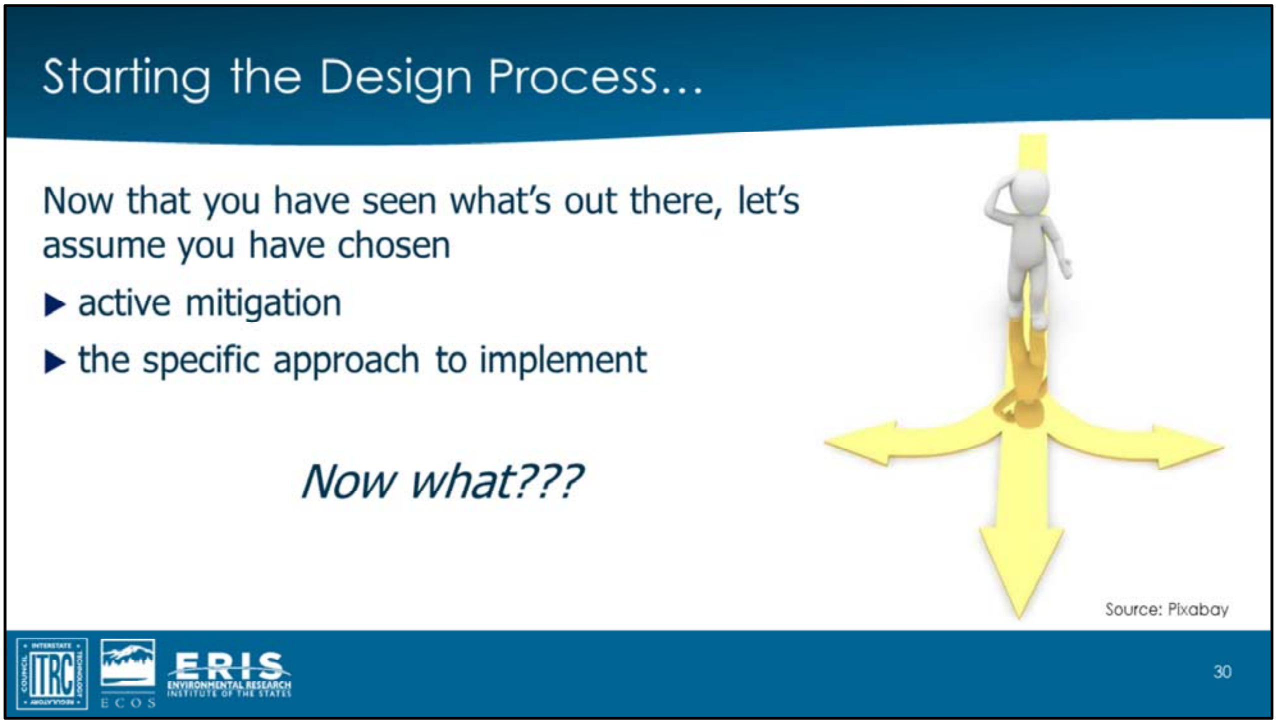
- Components mostly the same as an SSD include the fan/blower, vent piping, stack, balancing valves, measurement equipment such as manometers, vacuum gauges.
- Biggest difference is the membrane that is needed to create the plenum and the place where vapor can be drawn from.
- See the membrane in the picture with batting to seal it to the walls of the crawlspace



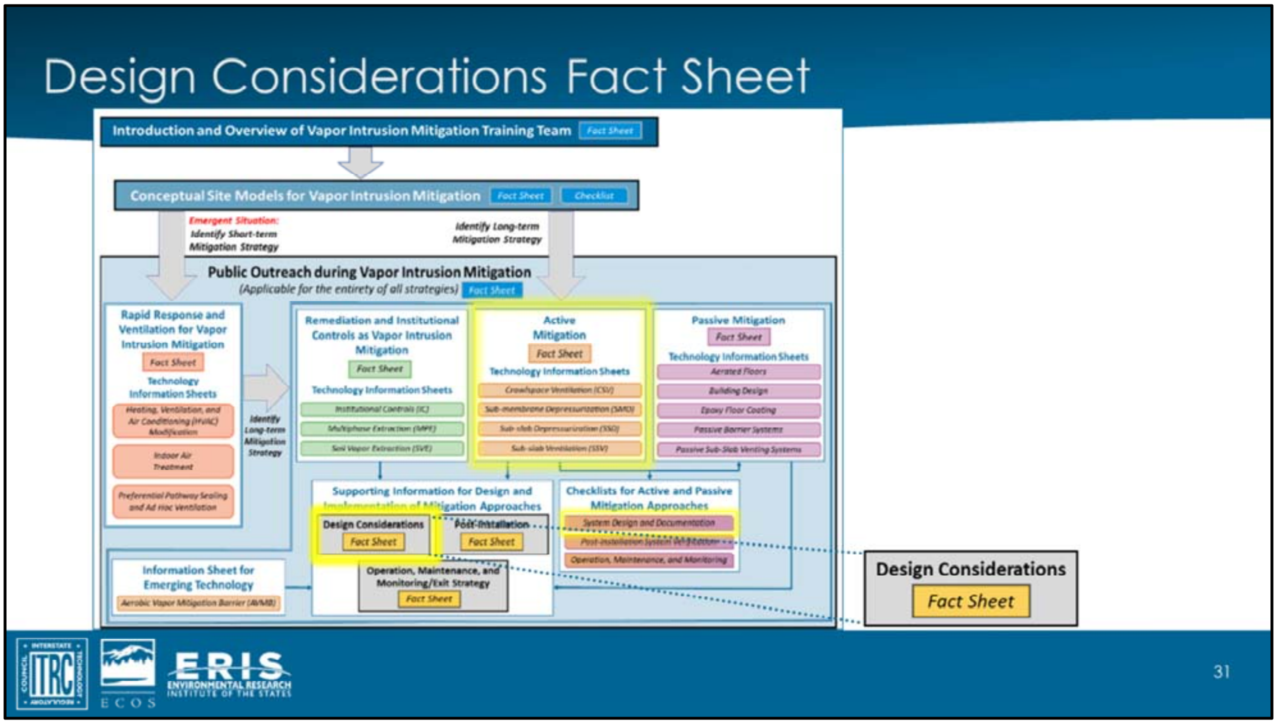
- Last tech sheet is Crawlspace Ventilation
- Typically **a last option** for crawlspaces that you are not able to access to put in a membrane
- **Does not prevent vapors from entering**/traveling through the crawlspace
- Should not be used unless unable to enter crawlspace to install barrier
- Draws air out of the vent space and out to the atmosphere
- Used to dilute the vapors in the crawlspace
- However, heating or cooling may impact the vapors beneath the slab
- Frozen pipes that are in the crawlspace could be a concern if living in a cold climate
- Not as common for crawlspace mitigation as other technological options will be more effective and efficient



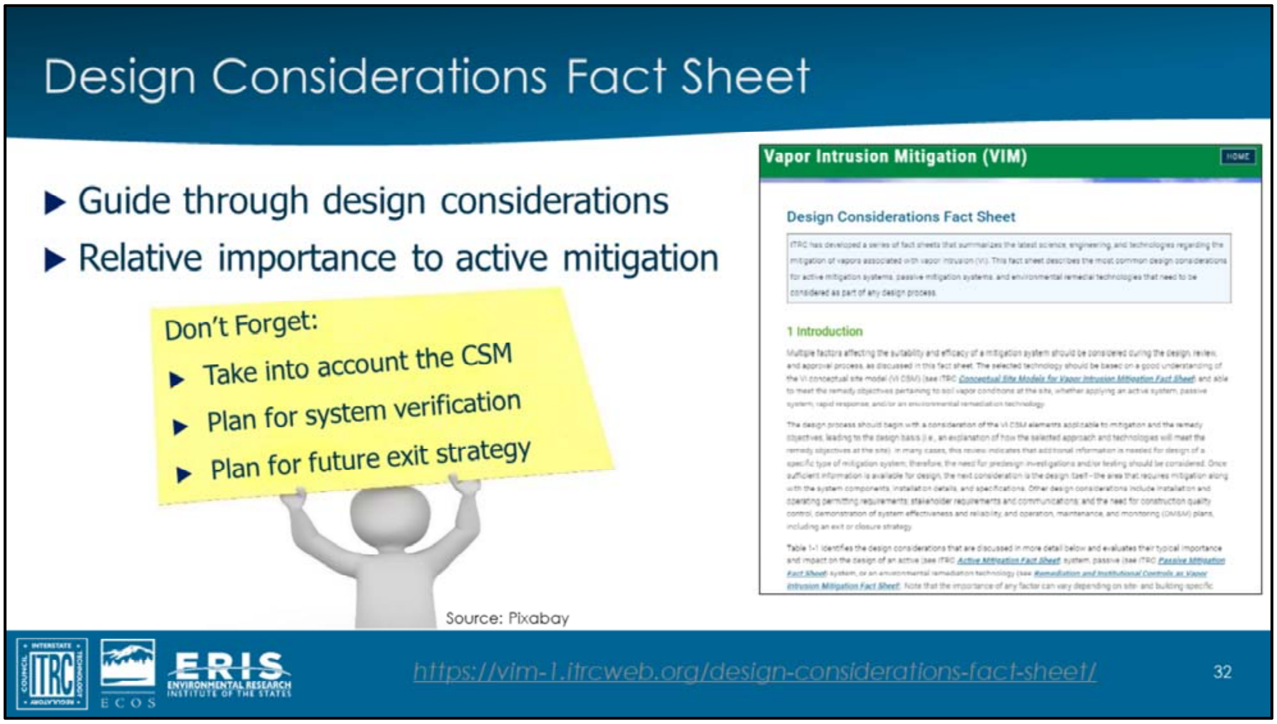
- Again Construction components similar to SSD with venting including piping to the atmosphere and a fan
- May not have enough flow to measure vacuum with a manometer but can **measure flow** and also may need sensors for temperature control.



- Those were the end results…..
- How do we get there?
- ITRC created the process fact sheets to summarize the considerations to be though about when planning the design of vi mitigation including active mitigation



- Location of design considerations fact sheets in the document map
- Started at the Active mitigation fact sheet and the associated tech sheets and not moved down to the process of designing a mitigation.
- Here we will talk about design process considerations for active mitigation.
- Couple other process steps you see here after design but those are covered in another module.



- Design Considerations Fact Sheet is a guide through many of the considerations to be thought about for various VI mitigation approaches .
- Documents then discusses the relative importance of different considerations as they pertain to the various types of mitigation approaches (like active, passive, rapid response....)
- The process fact sheet does not help you choose a technology, it assumes you have chosen your technology already
- Points out the major considerations for each technology for each step of the way.
- As discussed before don't forget that during the design process you are still taking into account CSM, how you will verify system operates to your objectives and how you will plan to turn it off someday.
- Important for designs to both look backwards and to look forwards
- **Fact sheet written for all types of mitigation approaches. We are going to go through some factors to take into consideration in the design that are particularly important and in some cases unique to the Active approach. Other considerations particularly important to Passive approaches will be covered later in the session.**

Design Considerations – Building Conditions
New Construction

- Different components will be considered versus existing buildings
- Typically combined with passive mitigation technologies
- May be designed and installed but not activated

Source: Clean Vapor, 2020. Used with permission.

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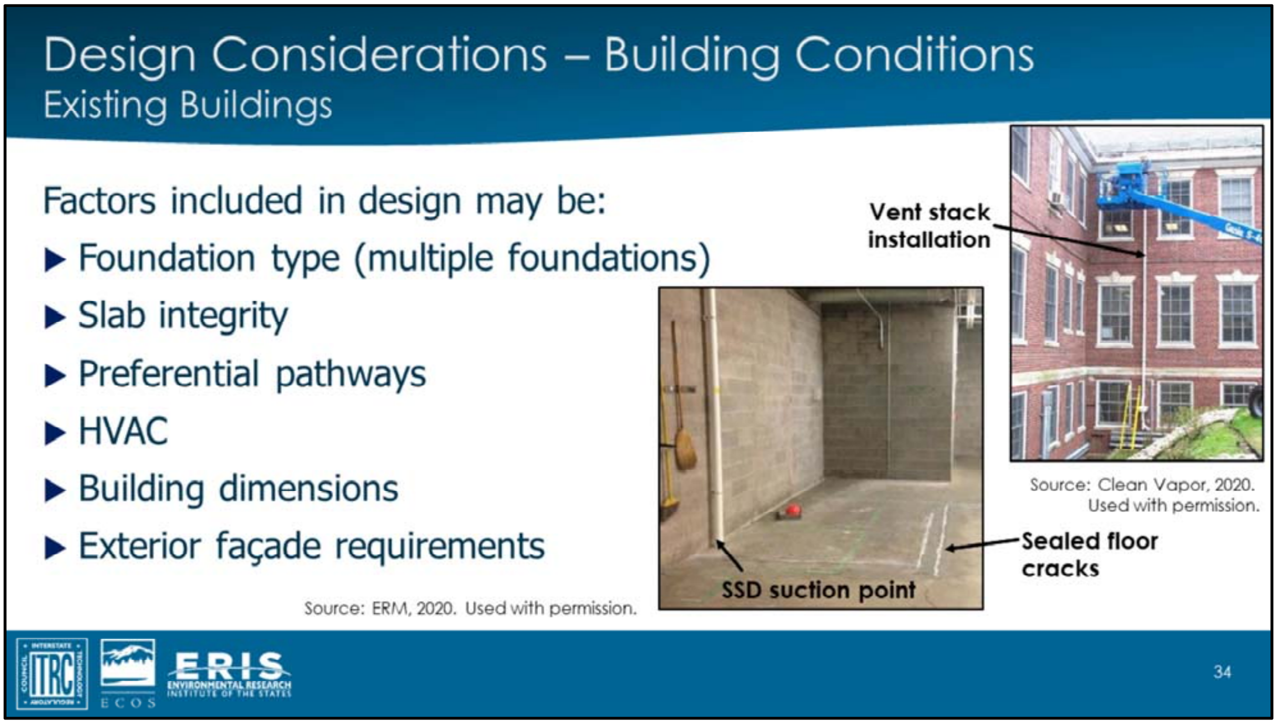
- Some of the more important design considerations for active mitigation are the building type
- Is the building for example new construction
- Whether a building is new, about to be constructed, or existing will have a major impact on an active mitigation design strategy
- Components will be considered differently for new construction than for existing buildings and will most likely be combined with passive mitigation technologies
- If passive is going to be the primary approach, active systems may be designed and installed but not “turned on” in new construction
- Activated at a later date when it is determined if they are needed.



- If the building condition is that it is an existing building then design considerations may focus on the items listed for example here
- Basic foundation type or multiple foundation types and locations due to building additions over time
- Slab integrity and if sealing is needed like in the photo
- HVAC systems present and how they need to be incorporated or overcome within the Active system design.
- Working with the exterior façade requests of the building owner (picture far right).
- Soil permeability and DTW will significantly impact the design
- Also important to determine feasible pipe routing and identify discharge locations that meet separation requirement from openings into the building

Design Considerations – Sub-slab Diagnostics

- Diagnostics used to determine
  - Suction point configuration
  - Number and size of fan(s)
- Pressure field extension (PFE) testing
- Differential pressure measurements
- Other diagnostics like tracer testing may also be used

Source: ERM, 2020. Used with permission.

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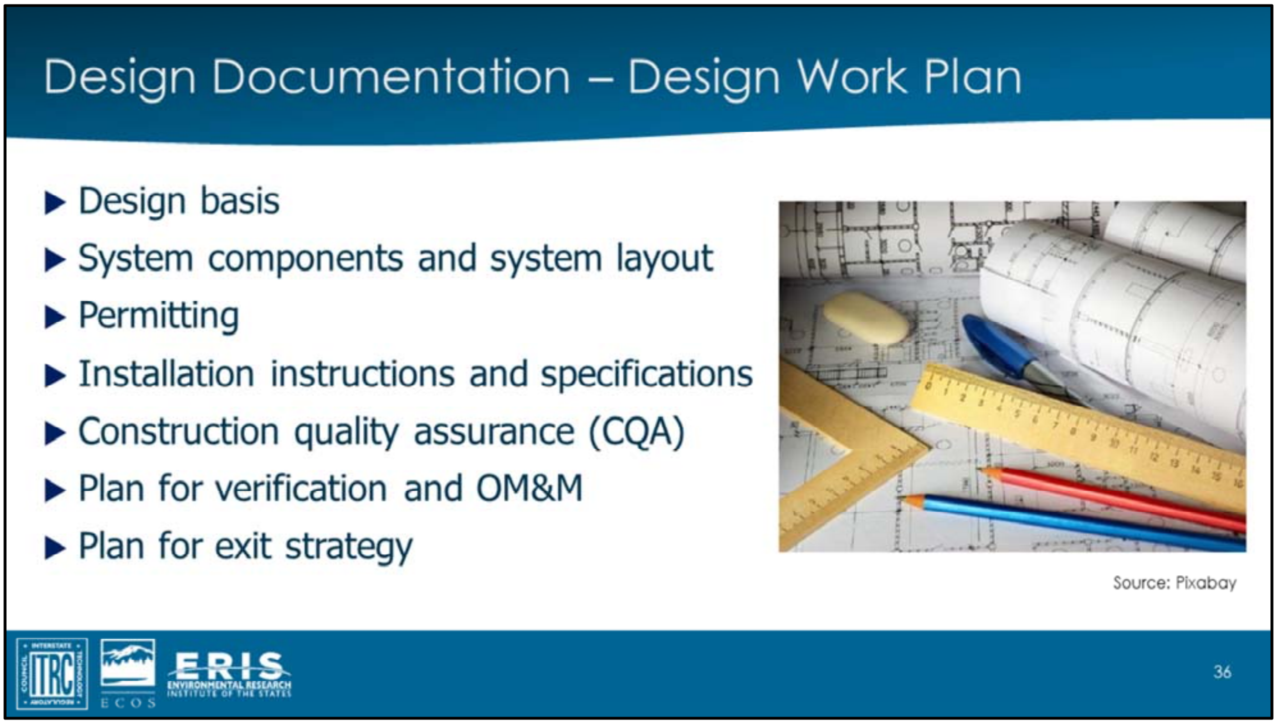
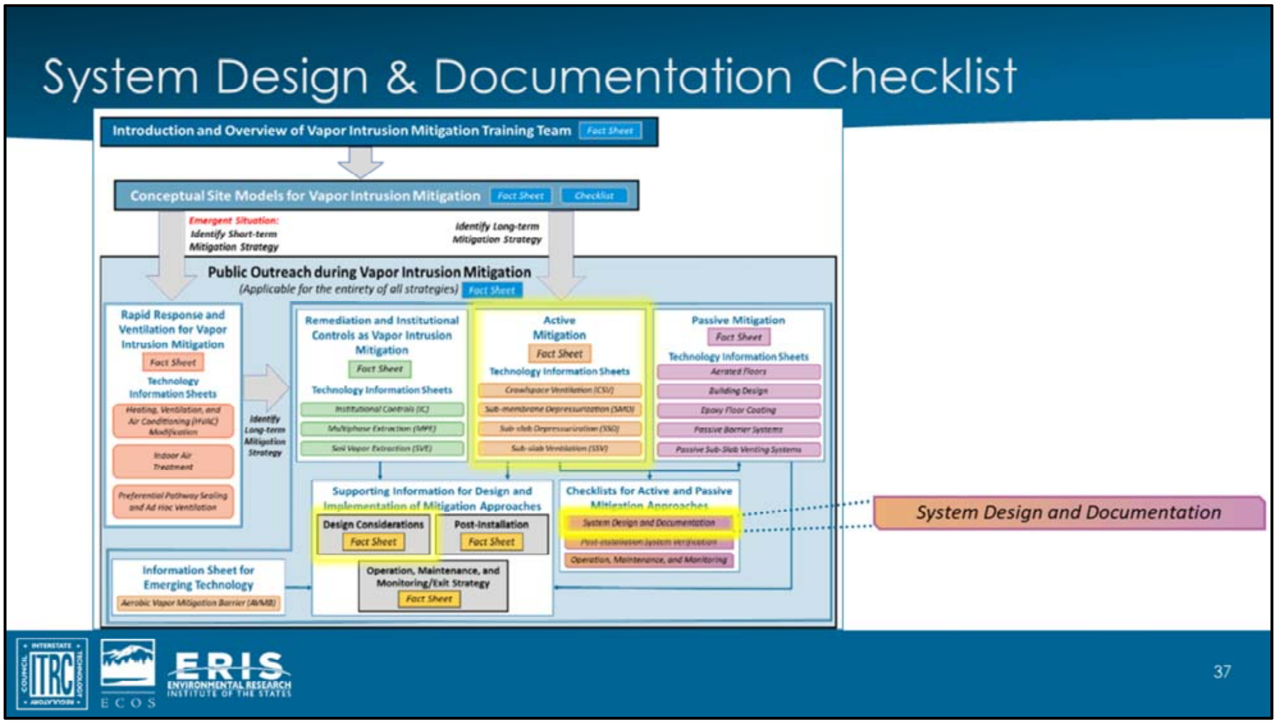
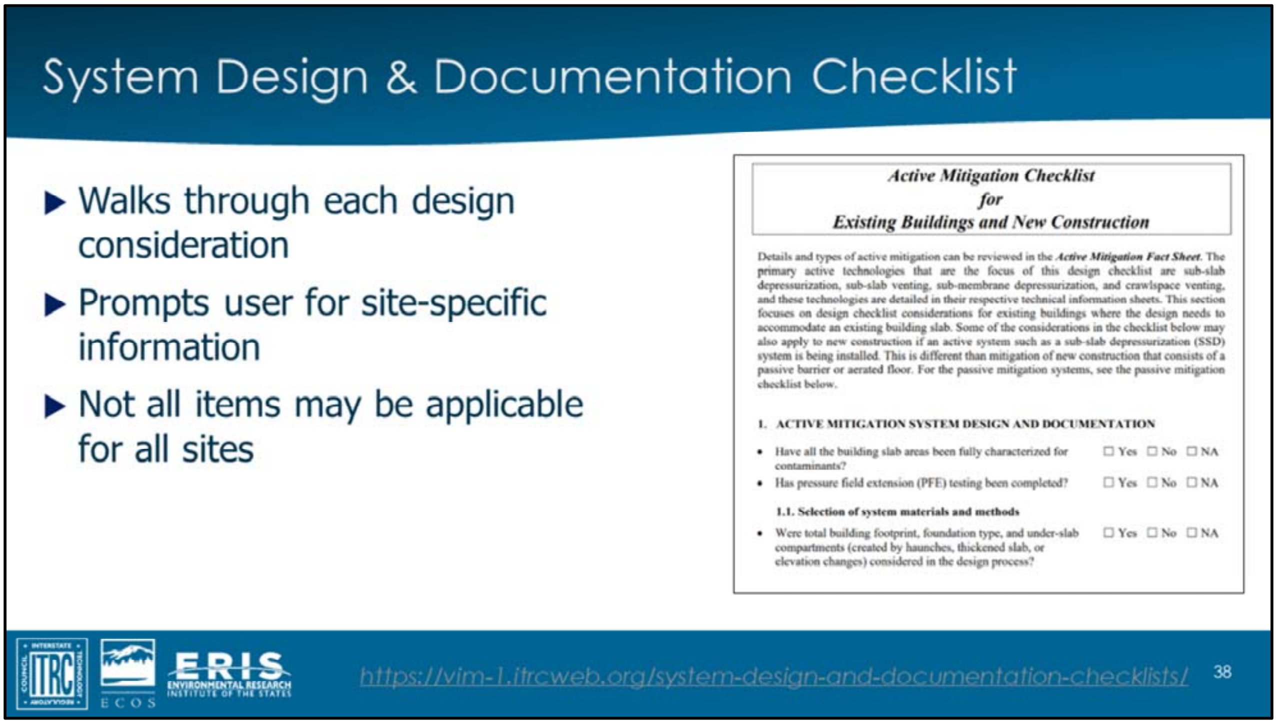
- Sub-slab diagnostics are an important design consideration for an existing building
- The most common sub-slab diagnostic tests conducted in existing buildings are pressure field extension (PFE) testing and measurement of differential pressures across the slab.
- Using diagnostics may be dependent on building size (smaller building or residential homes may not need them if sufficient information is available to be reasonably confident in the mitigation system design or there is an expectation to modify system design during system construction as effectiveness is tested (i.e. a design-build method).
- used to understand sub-slab conditions to select the number and locations of suction points, fan sizes, etc.



- Design work plan is also an important consideration for active mitigation
- design work plan is where you will gather all of your important information like your design basis and reason for mitigation
- Design basis that explains how vapor intrusion is occurring (or could occur in new buildings) and how the mitigation approach and technologies selected will control vapor intrusion sufficiently to meet the design objectives.
- Work plan will commonly include one or more layout sheets, showing where the various components of the system, design specs, piping layouts, suction point locations, vent stack location, etc.
- Mitigation system designs must consider building codes, and other permits that need to be addressed, highly variable to cities and towns) and in some states an emissions permit and/or emissions controls
- You should plan out what you plan to use as the metrics to show that your system, once installed and operating, is meeting your design objectives as well as a plan to make sure construction quality is maintained during installation with a quality assurance plan.
- You can also lay out in the design how you intend to do routine OM&M and how to eventually plan for turning off the system.
- Communication with the property owner, tenants, other stakeholder key at the design stage (so they know what you are doing and if they agree with where you are doing it



- Along with the Design Considerations Fact Sheet is the companion check list
- here it is listed in the document map



- Checklist is not just for active mitigation, it is for passive as well
- This checklist provides information necessary to proceed through the design process
- Checklist focuses on system design and documentation items (I.e., are certain aspects and components included in the design package)
- The checklist is a template out there to aid in the design. The checklist can be used to help prompt the user to think about each of these aspects of the design. Not all items will be applicable to all situations. Depending on the complexity of the design, it may be appropriate to identify why certain items are NOT applicable to your site scenario.
- Some designs will be very different or will be very basic depending on complexity of the building (e.g., small residential home, design-build situations)
- Some buildings may not need almost any part of the design checklist if they are very simple

Summary

- Definition of active mitigation
- Common active mitigation approaches for new construction and existing buildings
- Considerations for designing an active mitigation technology
- Key elements in active mitigation system design
- Design documentation

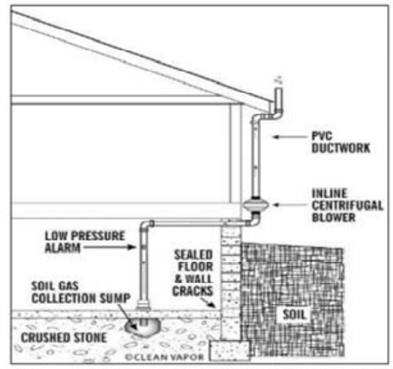


Figure 1 of the Sub-slab Depressurization (SSD) Technology Information Sheet.

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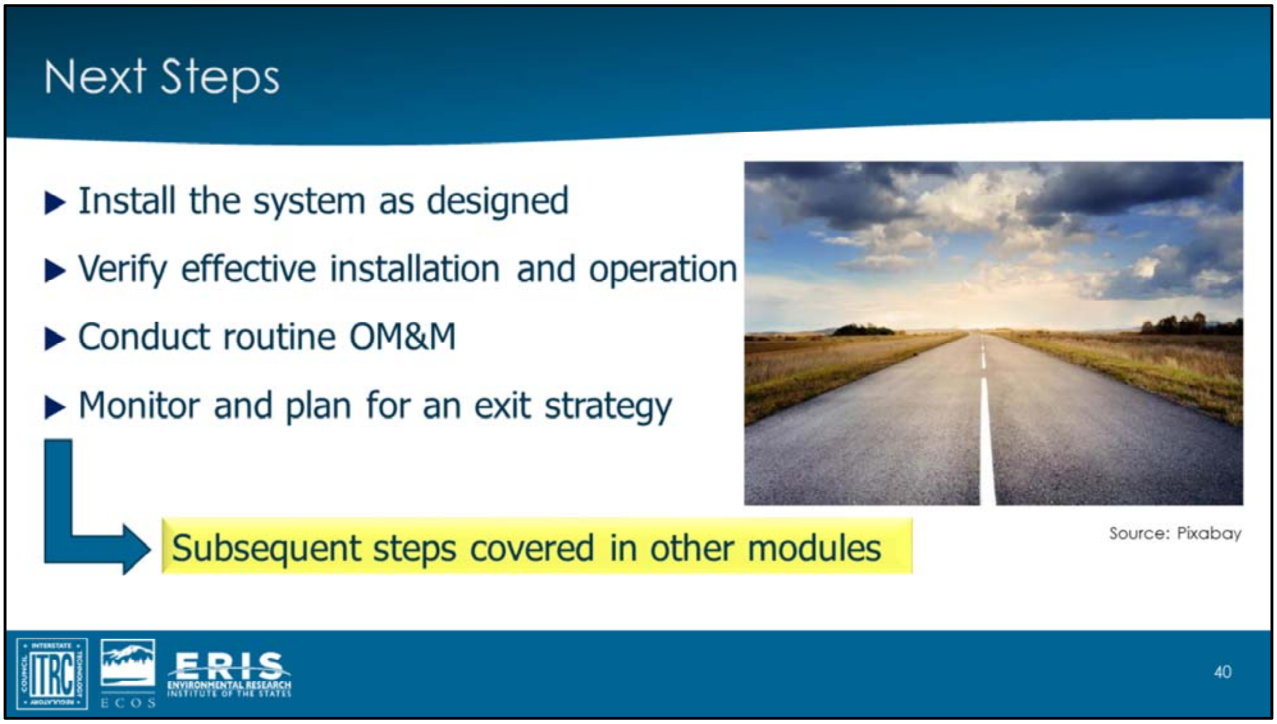
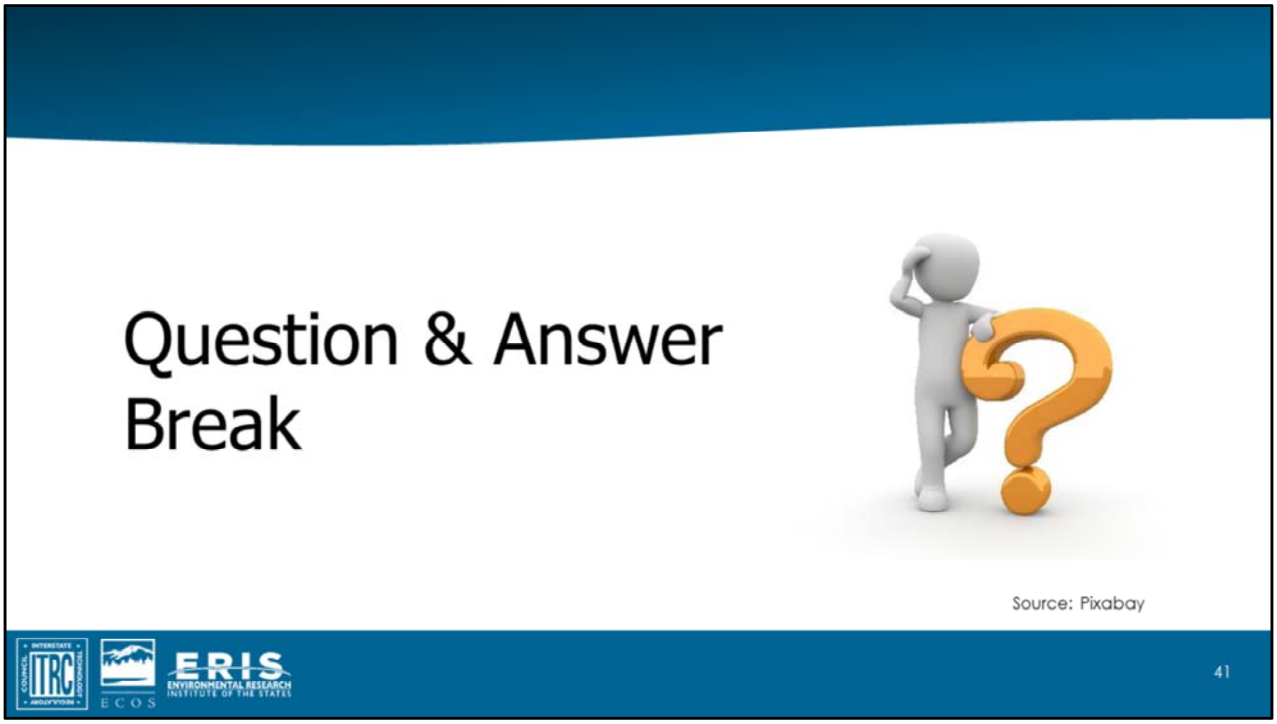
- In summary....
- We have reviewed what definition the ITRC used to define an active mitigation
- What we consider to be the 4 most common types of active mitigation approaches
- Some of the most relevant design considerations for active and the tools that ITRC has developed to help you through the design process or reviewing a design work plan.
- And we have highlighted where in the document map you can find all of the active mitigation information for you to review on your own



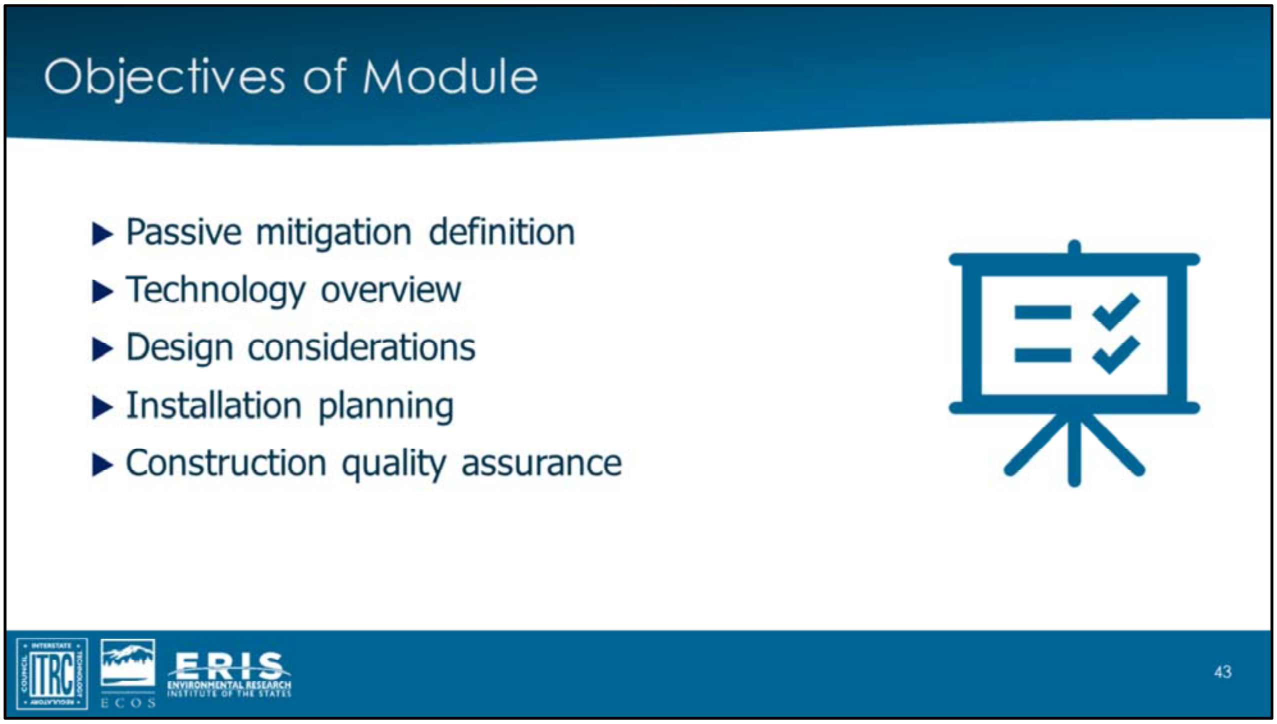
- So where do we go from here
- The next logical step in the path of this system is that the design is approved and the system is installed as designed.
- The installation and operation of the system would be verified and then the system would be operated and monitoring for some period of time
- Eventually the system, based on data, may be shutdown
- All of these steps will be discussed in subsequent modules.



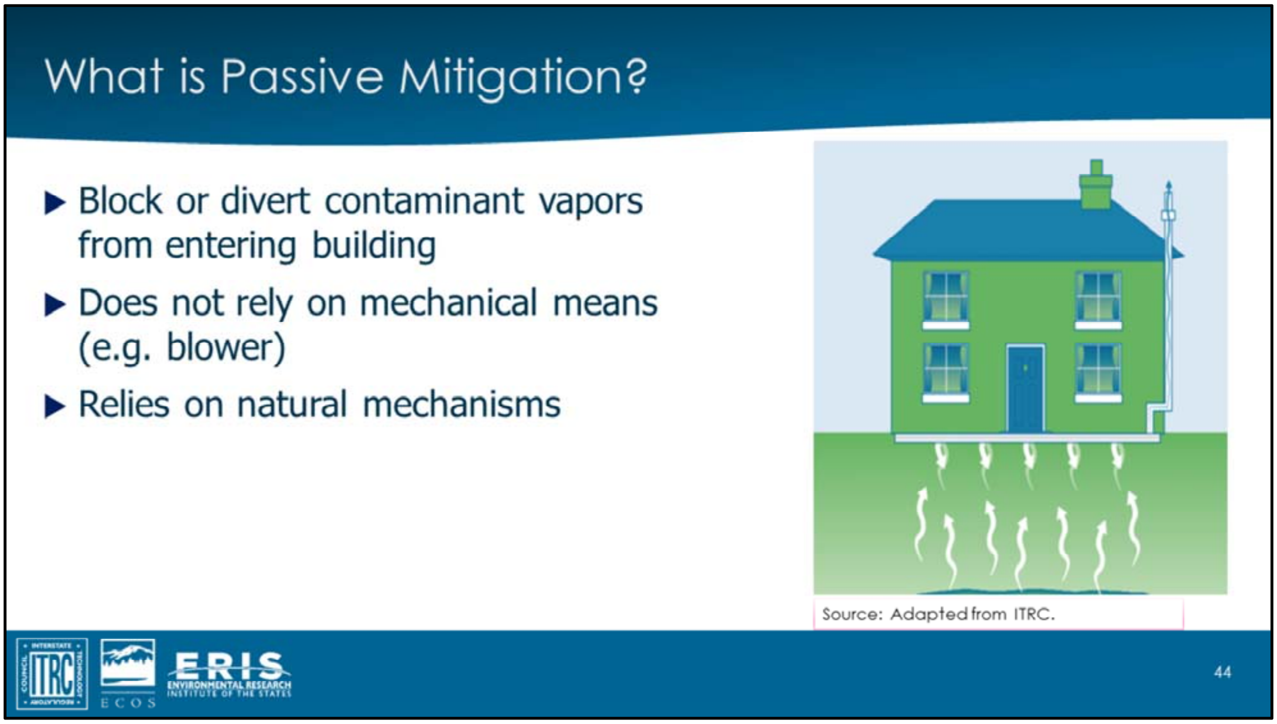
At this time we will open the questions and answers portion of our training.

- Transition slide from Active group
- Introduction of speakers (both)
- General welcome

- Welcome to the passive mitigation approaches training module.

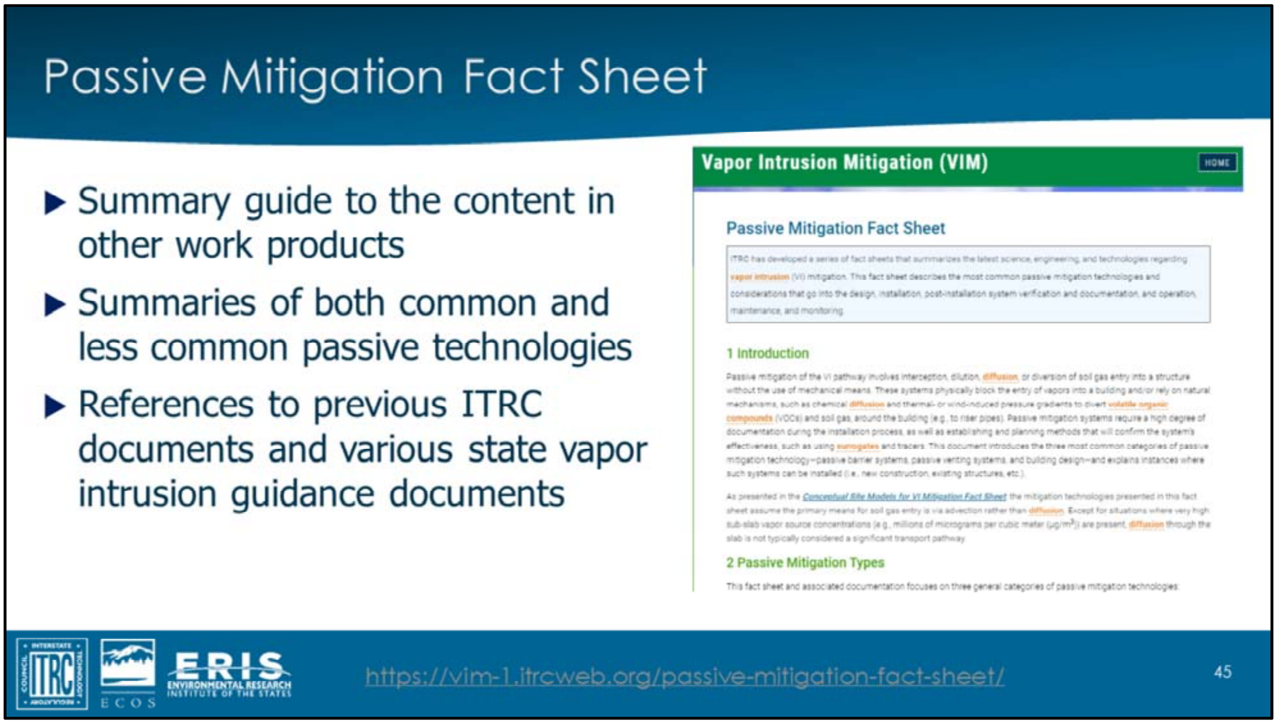


- During the 1st half of the presentation, I will:
  - Define passive mitigation
  - Introduce documents
  - Discuss common technologies
- During the 2nd half of the presentation, [CO-PRESENTER'S NAME] will introduce:
  - Key considerations for system design, installation, and planning
  - End with construction quality control measures

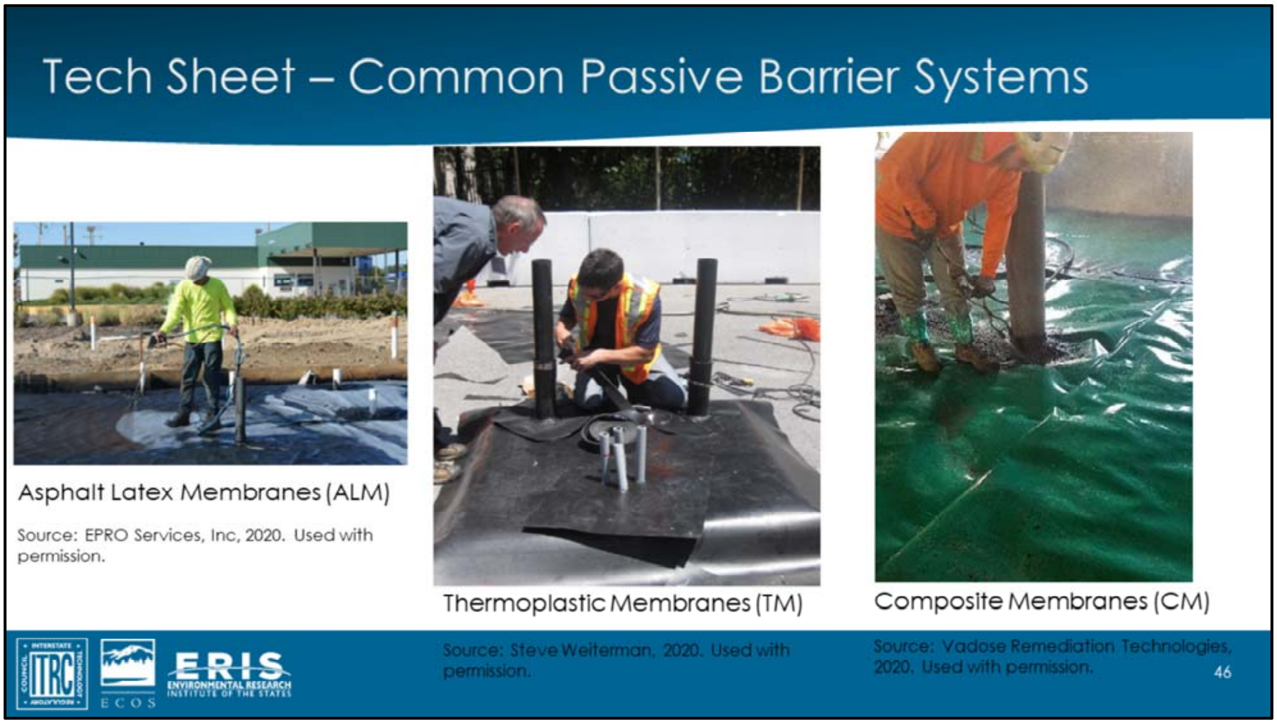


- Define passive mitigation
  - No mechanical means
  - Blocks VI pathways and relies on natural mechanisms
  - Most commonly used in new construction

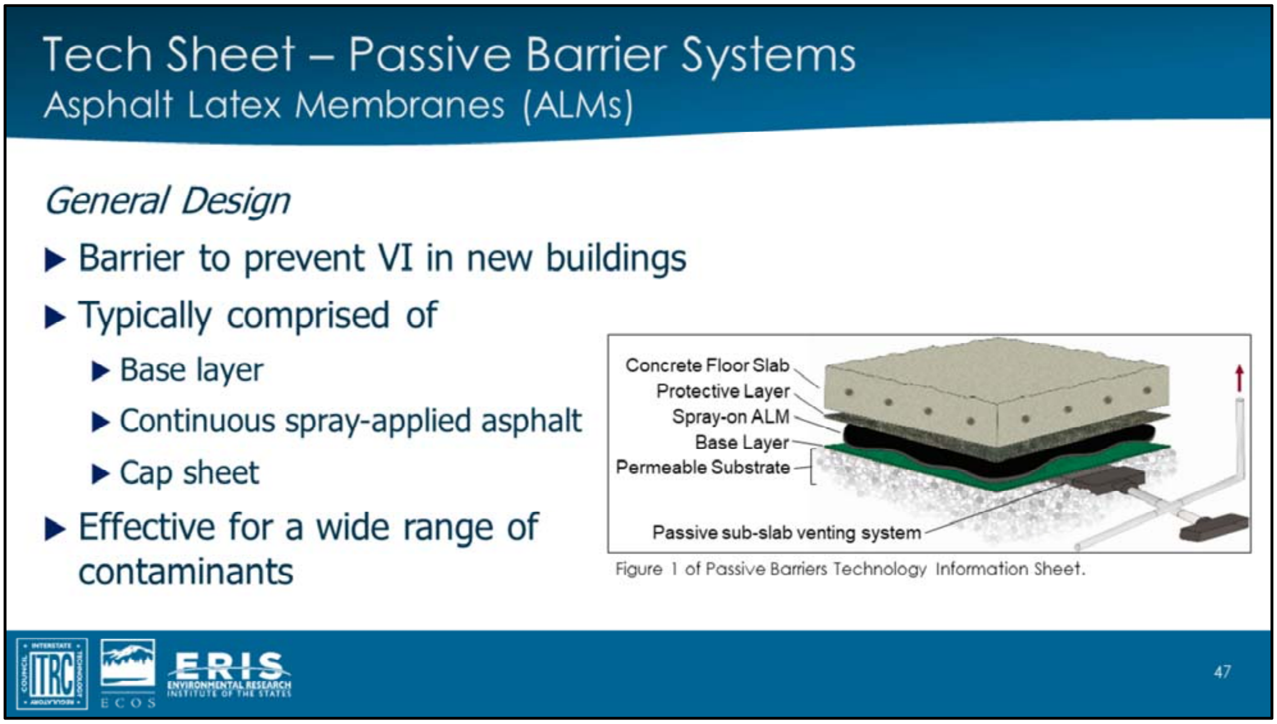
- Remember to review and update the CSM often
  - Evaluate whether current site conditions warrant mitigation
  - Ensure appropriate mitigation approach
- Public outreach - Any time mitigation is necessary
  - Ensures the mitigation systems installed are understood and not compromised in the future



- The information we're covering today is based on the Passive Mitigation Fact Sheet
    - Walks reader through the mitigation process from start to finish
    - Direct reader to additional resources
    - Includes links to five Technology Information Sheets



- Introduce passive barrier systems:
  - Asphalt Latex Membranes
  - Thermoplastic Membranes
  - Composite Membranes
- Subtle differences - Materials and installation methods
- All seal foundation and block preferential pathways
- Site conditions may dictate which barrier you use



- Asphalt Latex Membranes
  - Base layer, asphalt latex core, and a cap sheet
  - Base and cap materials vary
    - Usually consists of a thin plastic membrane backed with geotextile fabric
  - Base provides surface for spray-applied asphalt latex
  - Cap provides protection to barrier system

Tech Sheet – Passive Barrier Systems
Asphalt Latex Membranes (ALMs)

Installation

- ALM application to Thermoplastic Membrane
- Manufacturers provide specific installation instructions

Source: EPRO Services, Inc, 2020. Used with permission.

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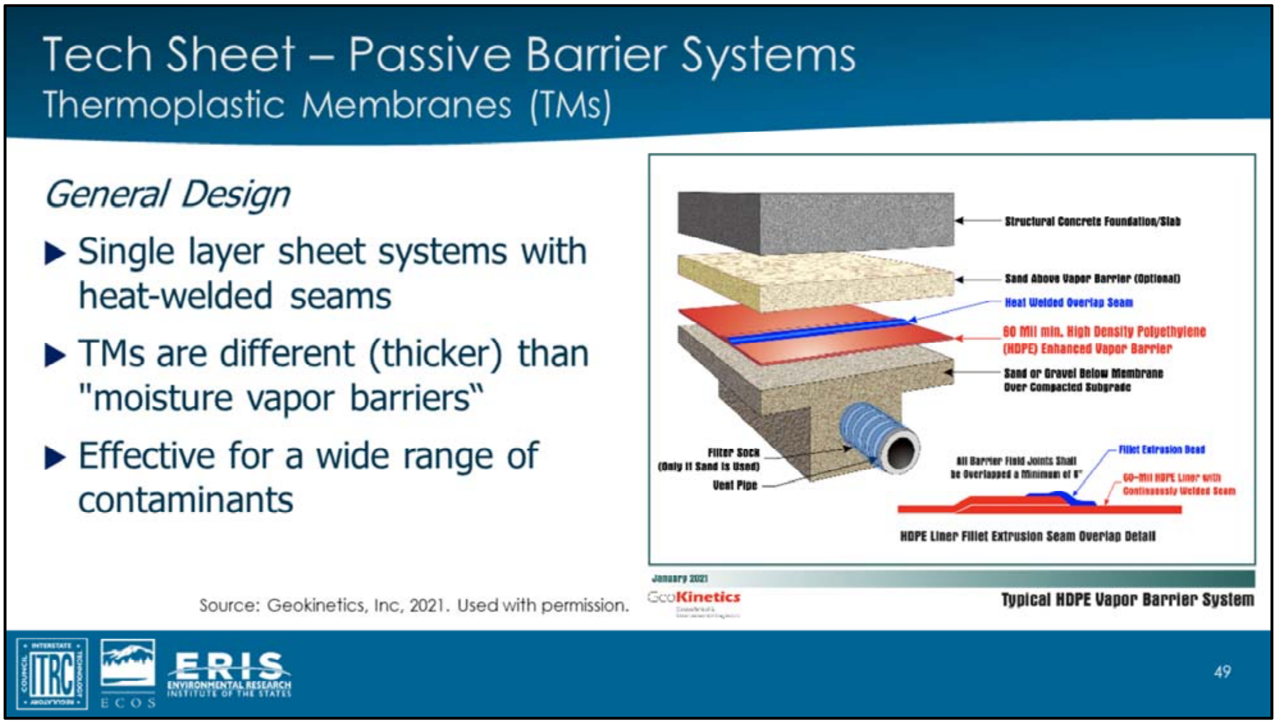
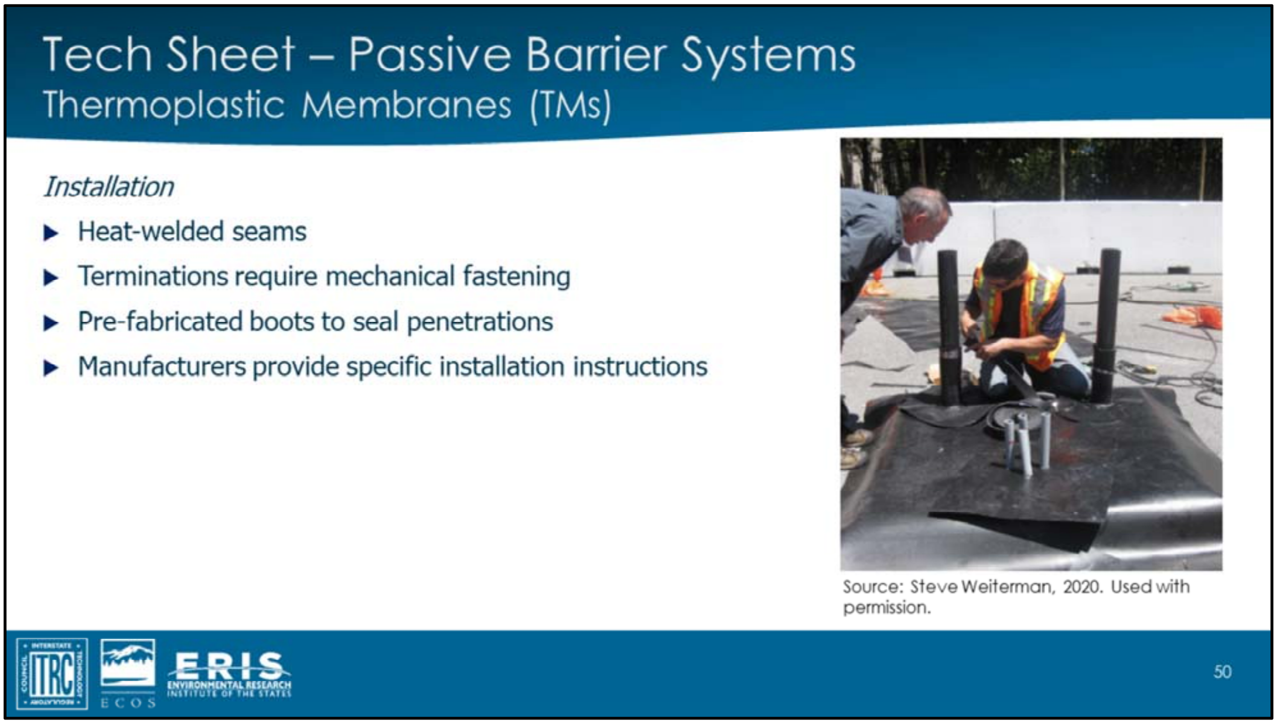
- Core is spray applied and cures in place
  - Provides a seamless layer of protection
- Cap sheet creates bond between barrier and slab
  - No mechanical fasteners or caulking at penetrations
- Mil thickness specified by the manufacturer



- Thermoplastic Membranes
  - Typically are single layer systems comprised of HDPE
    - May consists of other materials such as LLDPE
  - Thicker and more rigid
  - Thickness affects installation procedures

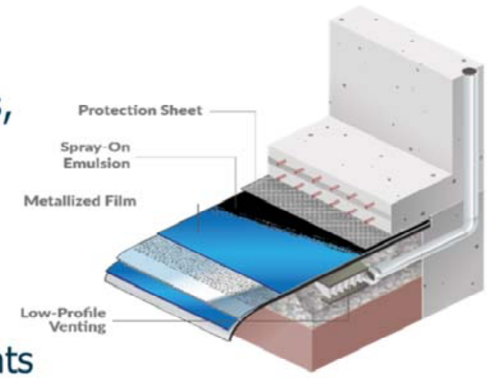


- During installation
  - Sheet overlapped and heat welded
  - Prefabricated boots to seal penetrations
  - Mechanical fasteners secure terminations
  - Often used in conjunction with a vapor collection system
- More puncture resistant
- Offer high level of chemical resistance
- Materials costs are low, but installation process is more difficult
- Typically used for new construction

Tech Sheet – Passive Barrier Systems
Composite Membranes (CMs)

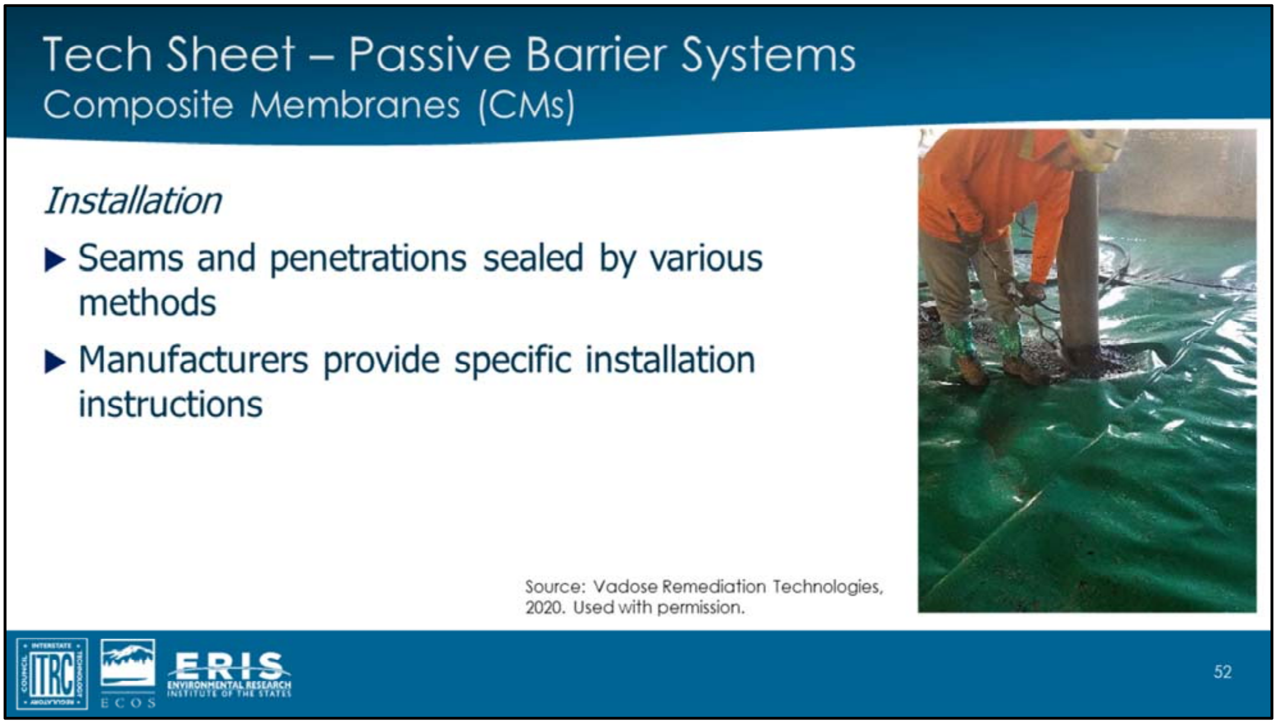
General Design

- Typically comprised of multiple materials, such as
  - EVOH
  - Metallized films
  - Spray-on emulsion/ALM
- Effective for a wide range of contaminants

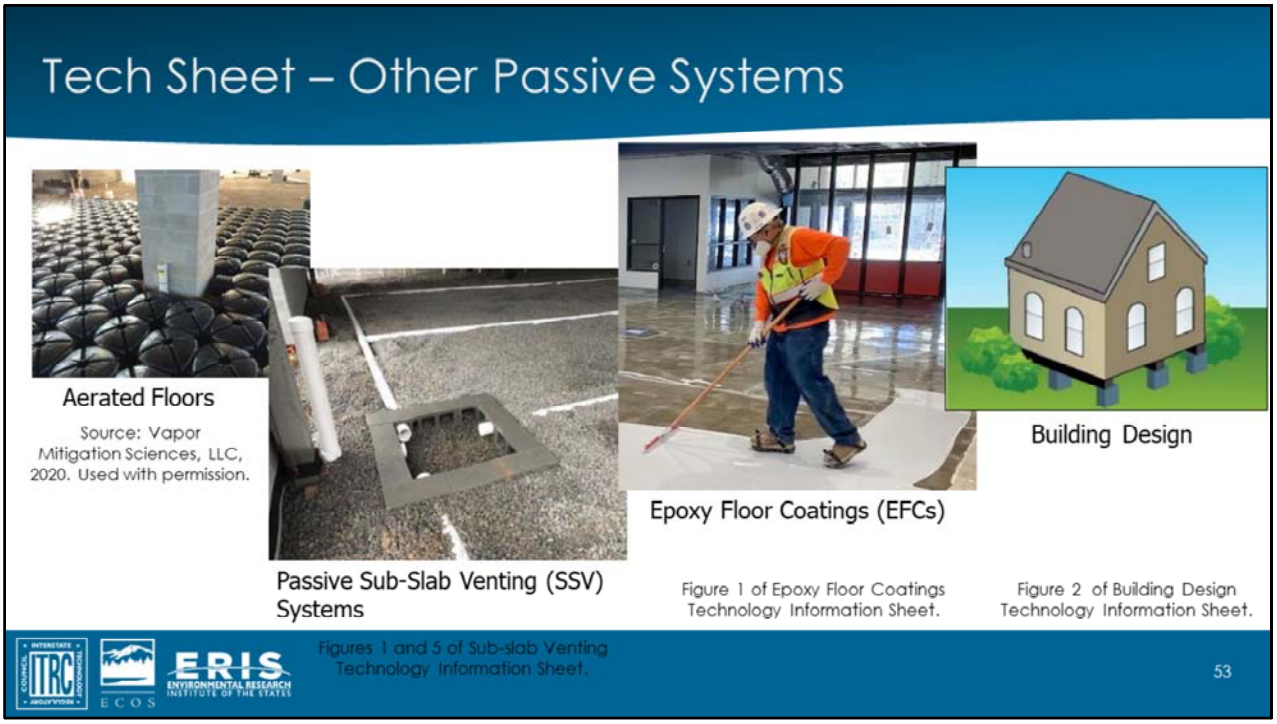


Source: Land Science, 2020. Used with permission.

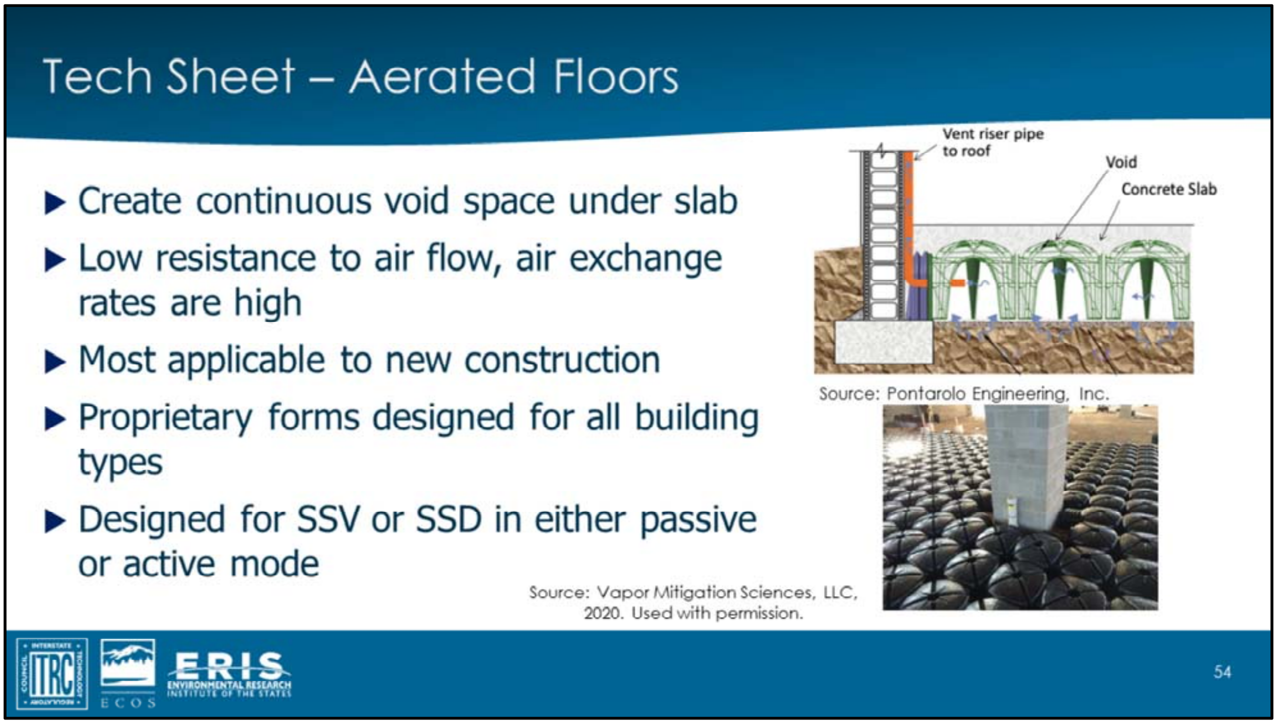
- Composite Membranes
  - Multi-layered system
  - Materials can improve chemical resistance, constructability, and durability
  - Sum of the whole is greater than the sum of the parts
- Gray area between CMs and other barriers
  - Example: CMs and ALMs both use multiple materials that can reduce diffusion rates



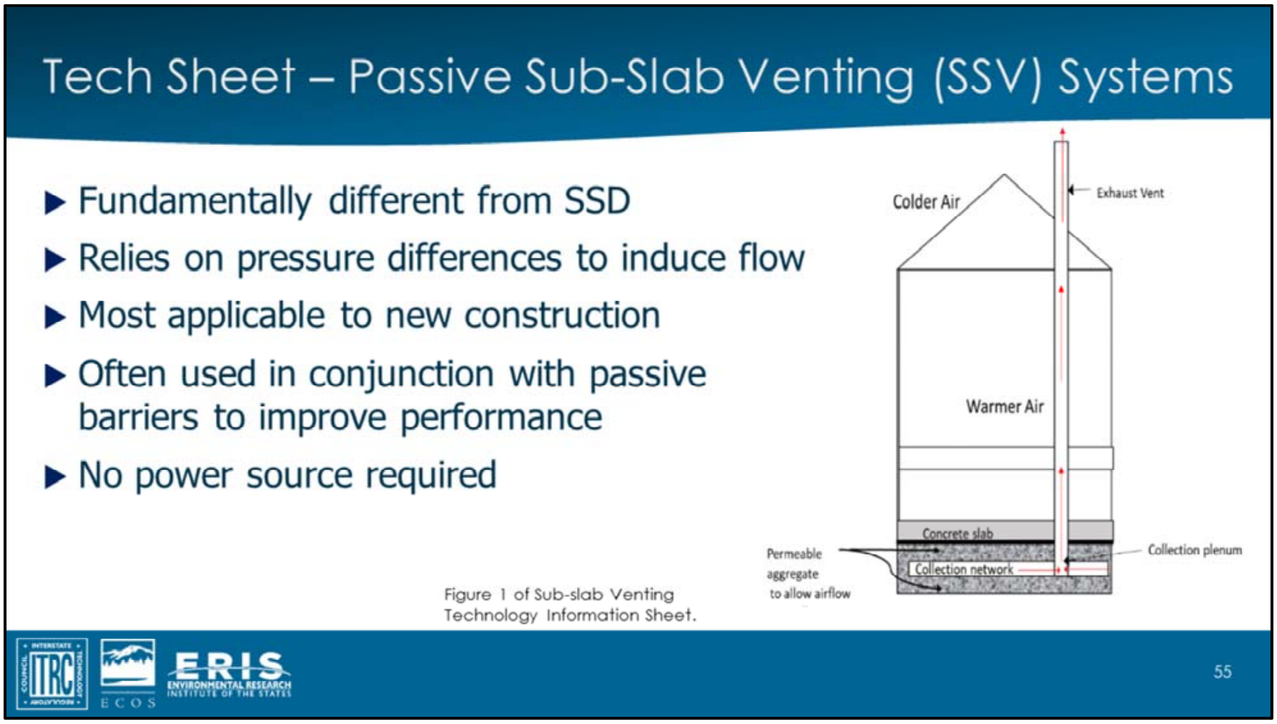
- Installation methods vary depending upon materials used
- Depending upon materials used, may offer greater protection using thinner mil systems
- Some use tape-based seams that may delaminate
- Smooth materials may not adhere to slab
- Some states require minimum mil thickness and/or regulatory approval for new technologies



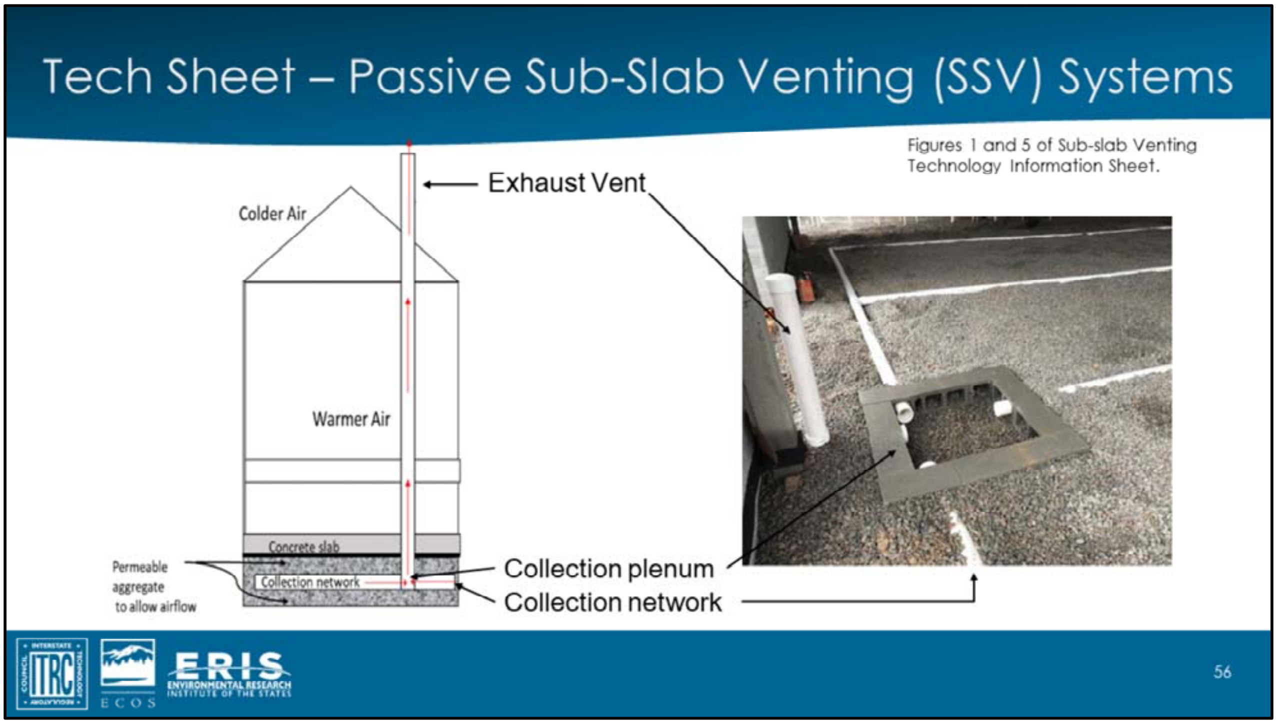
- Other approaches are effective against a variety of contaminants
  - Aerated Floors
  - Passive sub-slab venting
  - Epoxy floor coverings
  - Building Designs
    - Raised foundations or vented crawl spaces



- Aerated Floor Void Space Systems
  - Uses forms to create a void space beneath slab
  - Very low resistance to air flow
  - Allows high vacuum levels and air exchange rates
  - Forms connect to vent risers that discharge vapors above the roof
  - Can rely on passive venting, but often use active depressurization

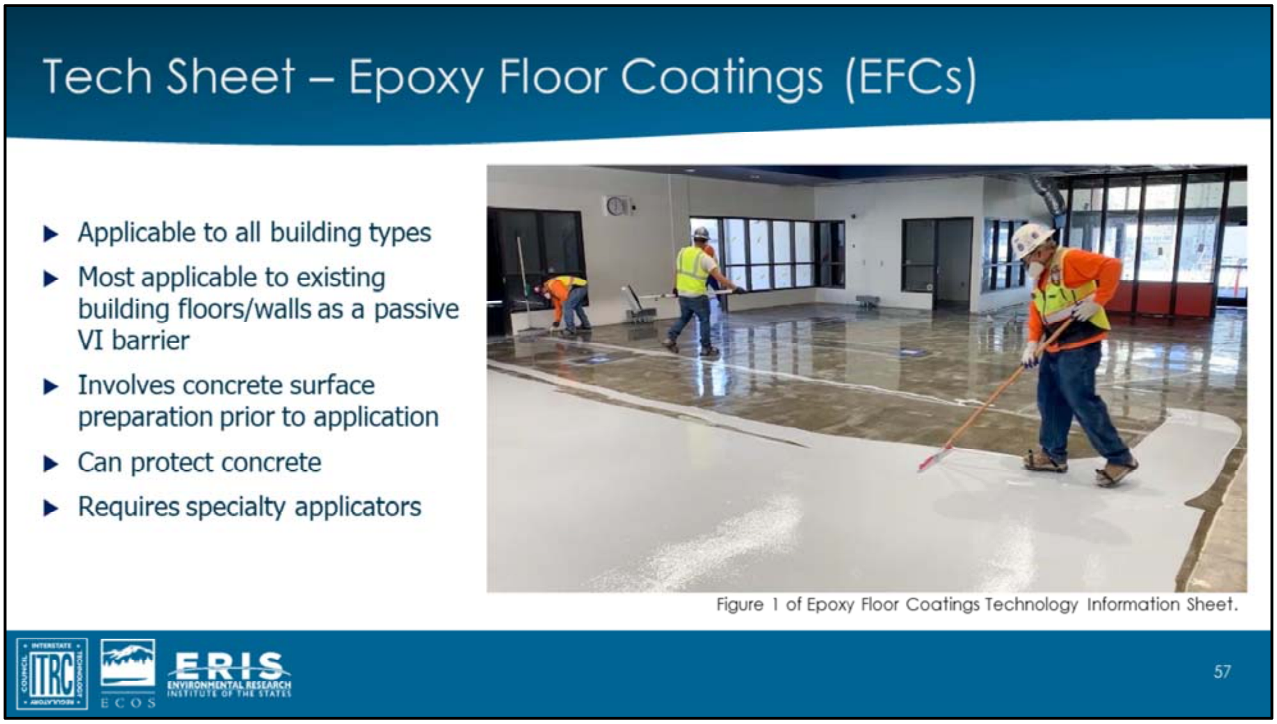


- Passive Sub-Slab Venting Systems
  - Horizontal vent piping installed in a permeable layer
  - Perforated pipe or permeable geotextile mating connected to vent risers
  - Vapors beath building travel through piping and are discharged above the roof
  - Relies on pressure differences to induce air flow
  - Almost always used in combination with a passive barrier



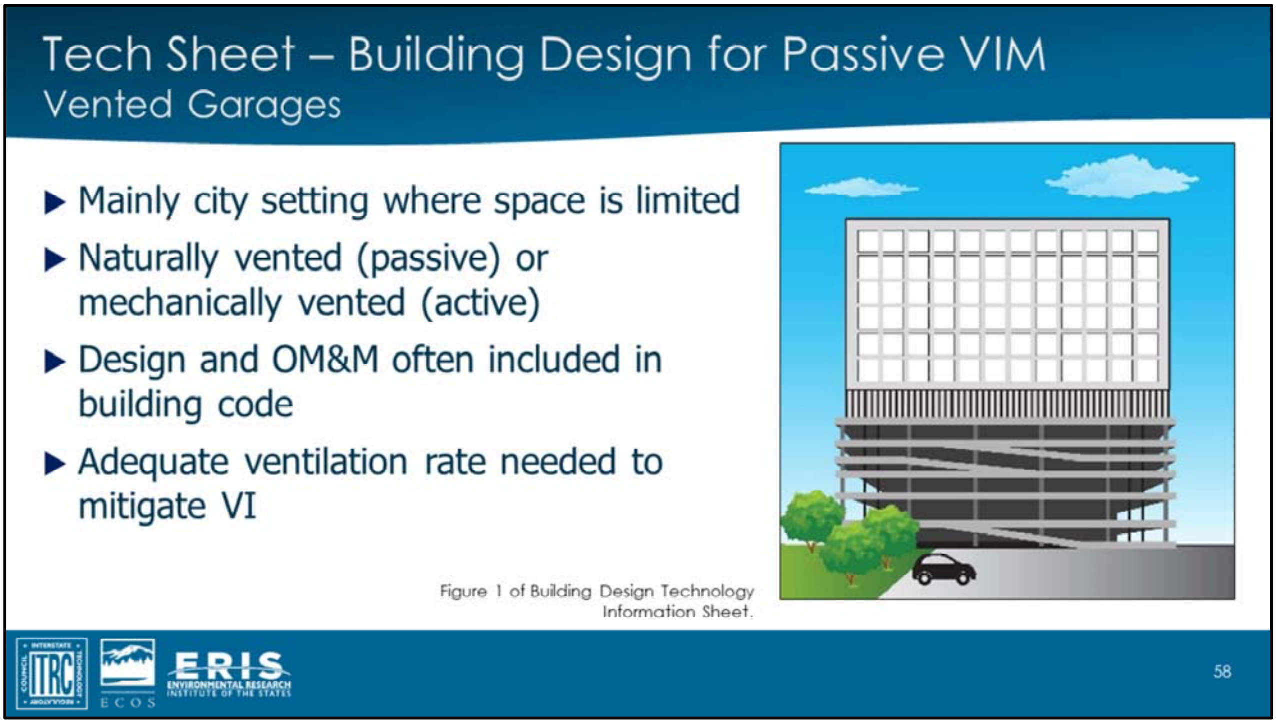
- Discuss photo of passive sub-slab venting system
  - Click 1 – Horizontal vent piping (aka collection network)
  - Click 2 – Void space (aka collection plenum) where horizontal vent piping connects to vent risers
  - Click 3 – Vent riser (aka exhaust vent). The exhaust vent is capped.

- Under the right conditions can capture vapors over a large area
- Simple design avoids need for long term OM&M
- Compared to an active venting system
  - May require more vent risers
  - Has reduced performance
- Almost always used in combination with a passive barrier

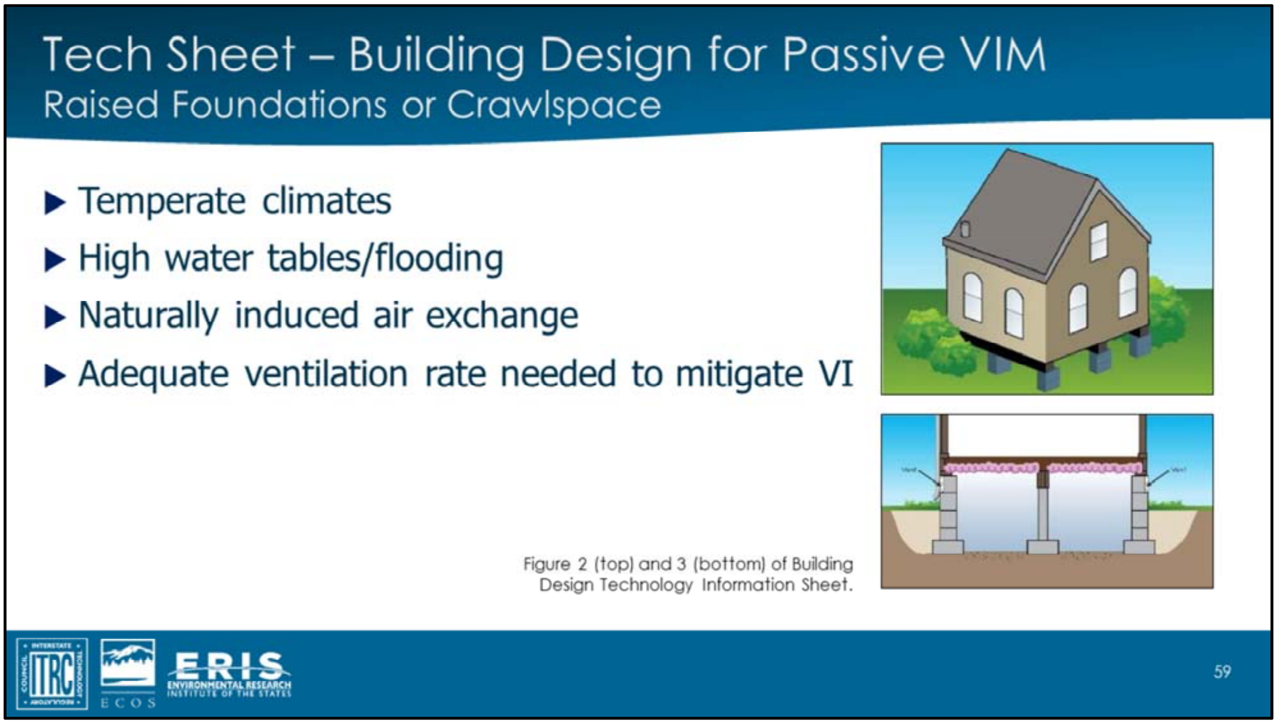


- Epoxy Floor Coatings
  - Can be applied to an existing floor slab
  - Floor slab condition and surface preparation affect overall quality of the EFC
  - Concrete must be clean and dry, and the surface must be scarified

- Provides a strong, durable, chemically resistance barrier
- Easy to clean, maintain, and repair
- Easy to customize (color/finish)
- Require special preparation to control moisture content and scarify the concrete to precent delamination



- Building Design
  - Building design can be used to prevent VI from occurring or mitigate the VI pathway
  - Parking garage example
    - Designed to prevent the build up of vehicle exhaust by increasing air flow
    - In some locations air exchange rates are specified by building code
    - Documenting the air exchange rates are being maintained may address the VI risk



- Raised Foundations
  - Other forms of building design, such as raised foundations and vented crawlspaces can address VI concerns for smaller buildings
  - Raised foundations usually found in warm climates and areas prone to flooding
  - Block and beam construction raises a building, separates the building from the vapor source, and cuts off the VI pathway

Knowledge Check

Poll Question

Which mitigation technology is commonly used in combination with a passive barrier system?

A. Aerated Floors
B. Epoxy Floor Coatings
C. Passive Sub-Slab Venting Systems
D. None of these

Source: Pixabay

Knowledge Check

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Which mitigation technology is commonly used in combination with a passive barrier system?

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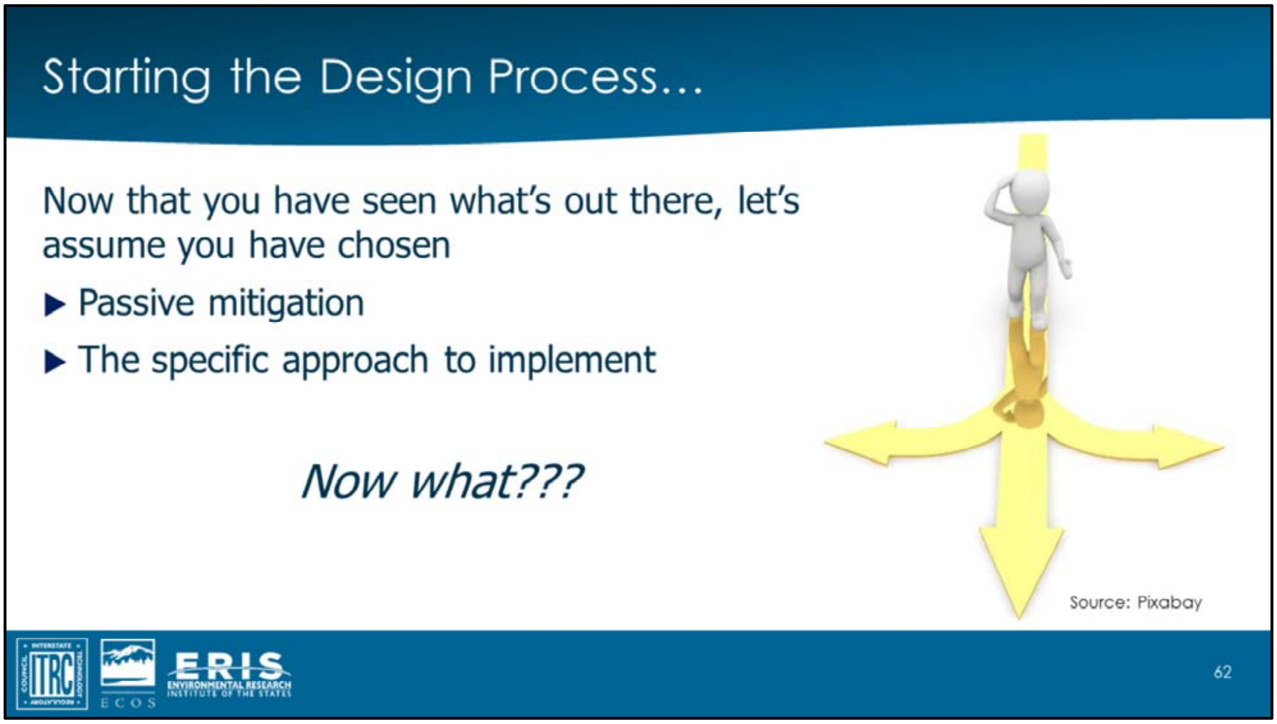
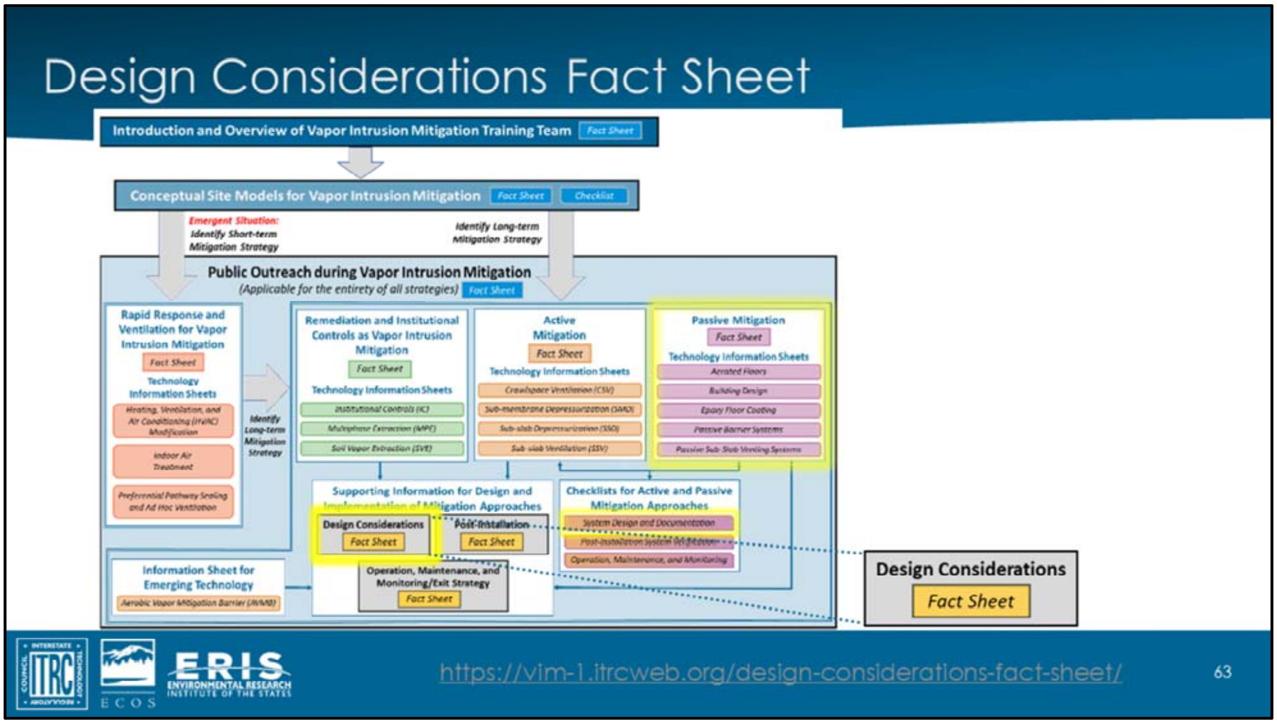


Segue:

- During the second half of this training module, [PRESENTER NAME] will discuss mitigation system design and installation.
- So let's turn things over to [PRESENTER NAME].

------------------------- TRANSITION TO NEXT PRESENTER -------------------------

- Hi, I am [PRESENTER NAME].
- During the second half of this training module…. (I will introduce key considerations for mitigation system design and installation planning and include a discussion of construction quality assurance measures.)
- Now that we've covered the common passive mitigation approaches, let's discuss the mitigation system design process.

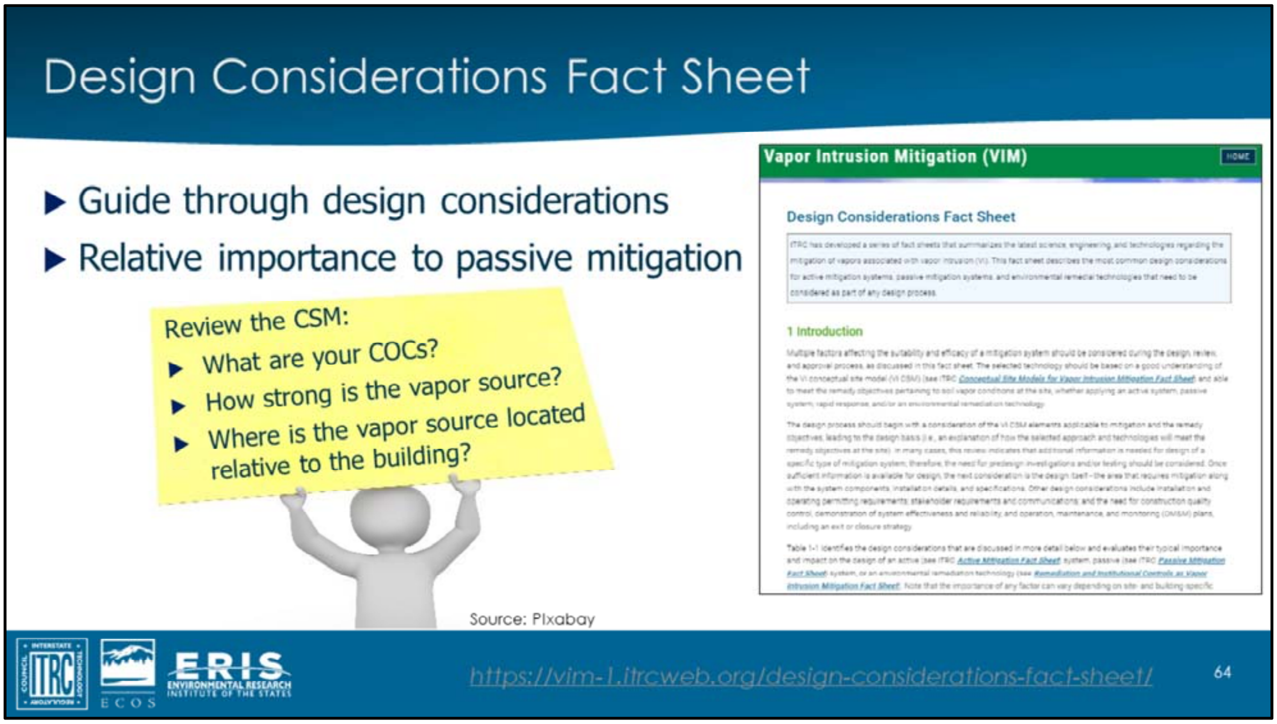


ITRC created the process fact sheets to summarize the considerations that may need to be incorporated into implementation of a project from design to install to verification to OM&M and finally exit.

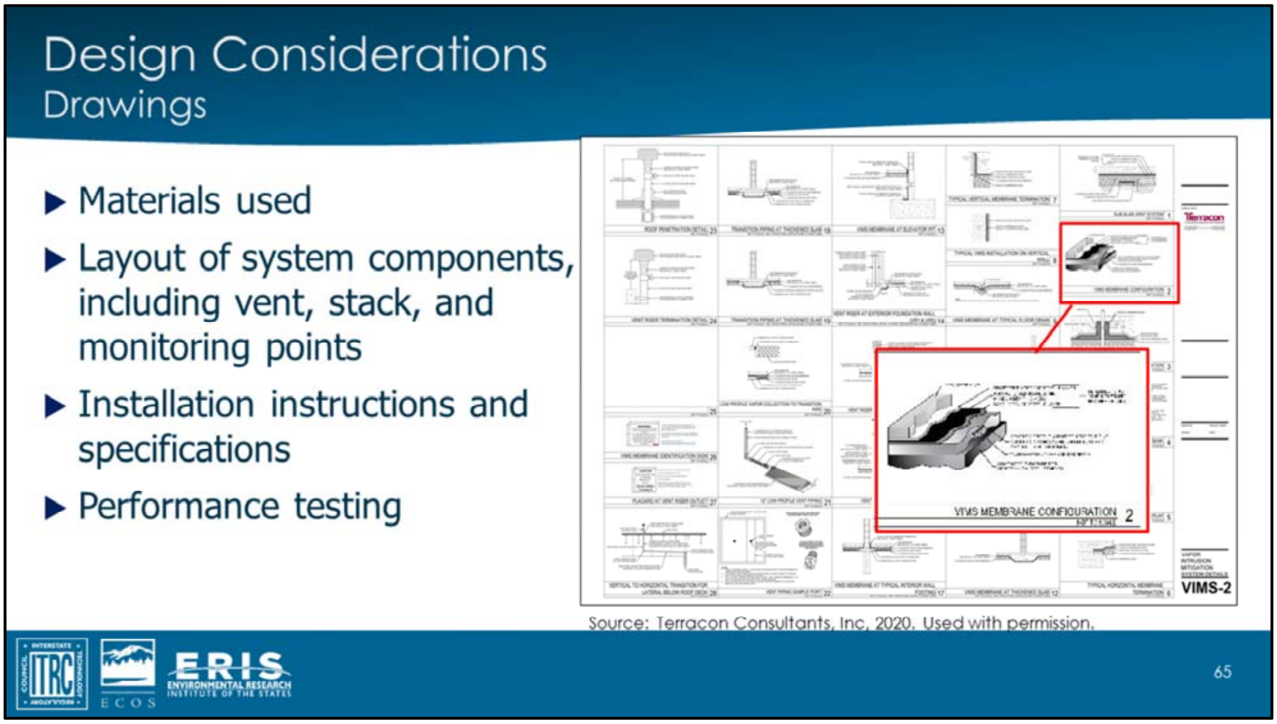
The process fact sheets assume you have chosen your technology already (if you haven't, go back to the CSM section) and point out the major considerations for each technology for each step of the way.

Here we will talk about design process considerations for passive mitigation.

The post installation and OM&M will be covered in another module.



- Establish a basis for design
  - The mitigation system design should include a design basis document that explains how vapor intrusion is occurring (or could occur in new buildings) based on the VI CSM (see ITRC CSM Technology Sheet) and how the mitigation approach and technologies selected will control vapor intrusion sufficiently to meet the mitigation objectives.



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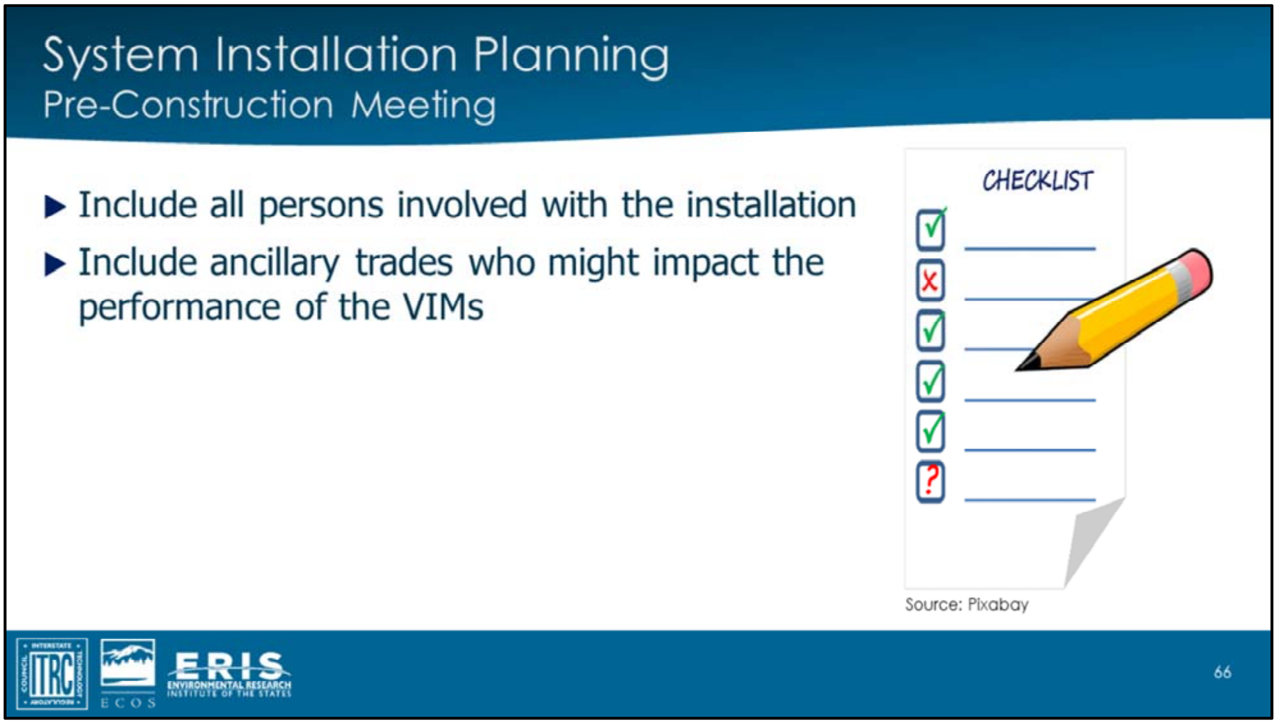
- Design Documentation:
  - Mitigation system designs will commonly include one or more layout sheets, that identify and locate system components in relation to the building. Detail drawings should also include how system components will be configured in specific areas; and the components dimensions, materials, and other specifications.
  - For designs with ventilation systems, documentation of vent layout and stack placement is critical to ensuring effluent vapors do not enter adjacent buildings.

Installation Instructions.

Performance Testing

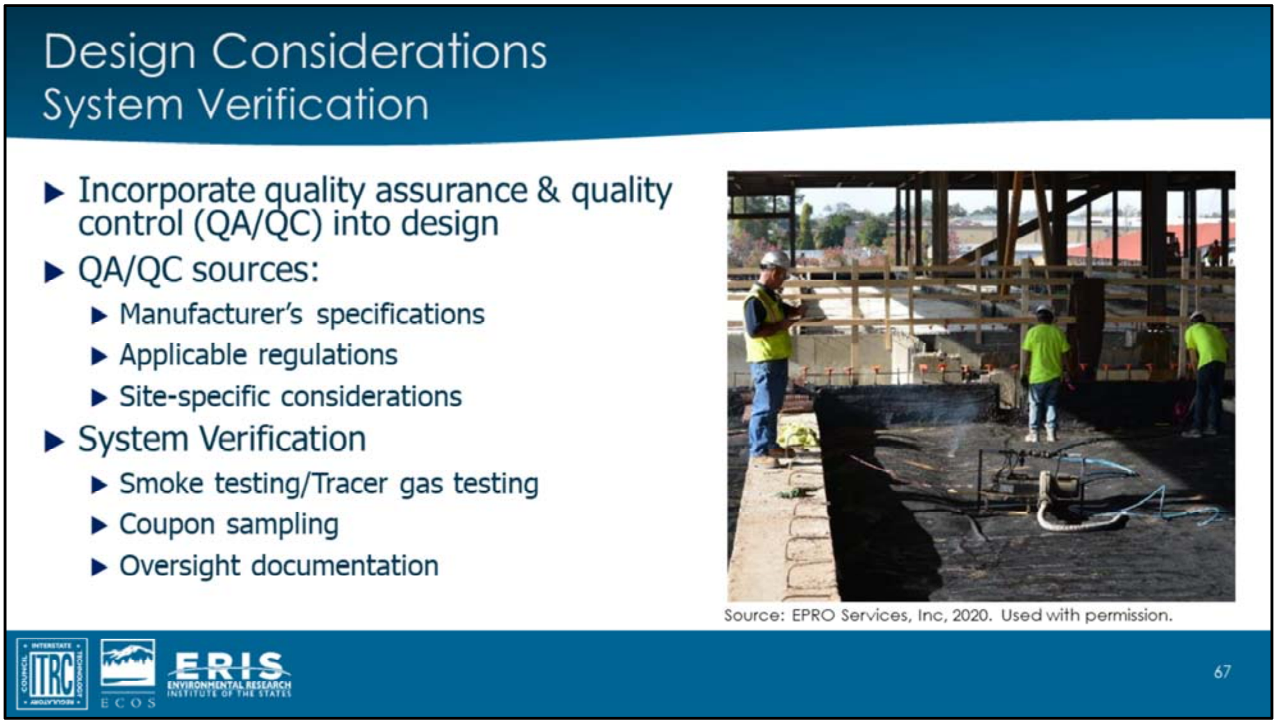
- For example,

- <u>Diffusion Coefficients</u>
  - More nuanced testing methods have been developed to more accurately calculate diffusion coefficients for passive barriers.
  - Diffusion coefficients can be a good indicator of a product’s ability to be protective against chemicals of concern and, if available, should be included within the mitigation system design documentation



- Pre-Construction and Installation Oversight
  - After the vapor mitigation system design has been developed and documented, the engineer of record (or equivalent) should confirm that a preconstruction meeting is planned with all persons involved wit the installation of the mitigation system as well as any sub-contractors who's work may affect the performance of the mitigation system during and following the installation process.
  - During this meeting, all parties should review the vapor mitigation system installation drawing set to confirm the details shown in the drawings match the project conditions.
    - This allows all contractors to review and confirm aspects of the mitigation system design such as:
      - Substrate specifications
      - Vent layout
      - Locations of vent risers and utility penetrations
      - And allows the general contractor to clarify the construction and installation sequence with all trades
  - Frequency and duration of the installation oversight should be specified in the vapor mitigation system plan.
    - Providing oversight prior to, as well as during installation, will increase the likelihood that the system has been installed in accordance with the

system design.



First and foremost, QA/QC procedures should be selected during the design phase of a mitigation system to ensure these procedures will be incorporated during the construction process.

Quality Control:

- Quality control and assurance procedures should be selected during the design phase of a mitigation system to ensure these procedures will be incorporated during the construction process.
- The manufacturer's requirements, regulatory requirements, and site-specific needs should be considered when selecting which system integrity testing methods to utilize.

Common approaches include:

- Smoke or tracer gas testing
- Coupon Sampling

Passive barriers are constructed in the field and applied prior to placing a concrete slab.

Each barrier system should have installation specifications along with quality control procedures to test the integrity of seams, seals around penetrations, system termination points, and overall field membrane integrity.

Considerations for new vs. existing structures. (Insert chart showing which passive technologies are generally used for each)

- New buildings – Mitigation system design is incorporated d during building construction process.
- Existing buildings – Mitigation system design must work around existing building conditions.

Some situations may require rapid mitigation of the vapor intrusion pathway.

Please see **ITRC Rapid Response and Ventilation Fact Sheet** when these situations arise.

Design Considerations - New Construction

- Building-specific customization of mitigation system
- Coordination with multiple construction trades required
- VIMS design drawings aid in successful installation
- Able to combine mitigation approaches

Source: Kelly Johnson, 2020. Used with permission.

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Clean slate provide for proper planning and evaluation of mitigation approaches. Regardless of what type of system is utilized, planning and construction oversight is a very important step in the process and required to assure the systems are installed per design.

The planning and resulting design, should be used to help coordinate with the project team and subsequent trades. This design should become part of the building plans to aid in managing the system in the future.

A key advantage in new construction is the ability to combine multiple mitigation approaches to create redundancy. I.e. venting and barrier. Barrier and building control, etc.

Design Considerations - Existing Buildings

- Conditions may limit the passive technologies which can be used
- Foundation can impact system effectiveness
- Building modification may be necessary to accommodate mitigation system
- Planning and construction oversight required

Source: Land Science, 2020. Used with permission.

Existing buildings to do not provide the flexibility that comes with new construction. This may limit the use of passive mitigation technologies.

The key consideration in incorporating a mitigation system is having an understanding of existing foundation, unless as built drawings exist, it may take time to understand how the building foundation might impact any form of mitigation. Active group provides more details considerations for how to address these conditions.

Buildings may need to be modified, and the implementation of these systems also requires a high level of planning and construction oversight.

Regardless of passive or active, a design should be used to document how these systems are installed.

Knowledge Check

Poll Question

What is the most important element of good design?

A. Figuring it out as you go
B. Skipping the CSM
C. Letting the project team know you want passive mitigation
D. Proper site evaluation and planning

Image source: Pixabay

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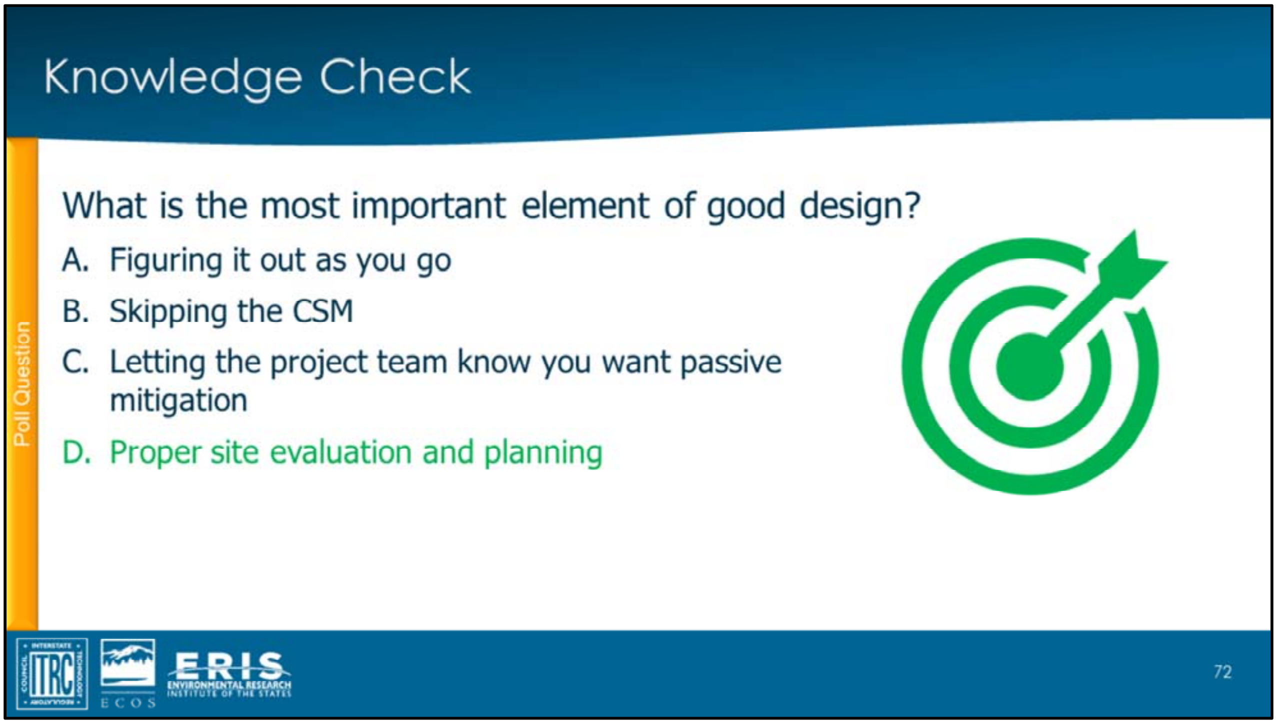

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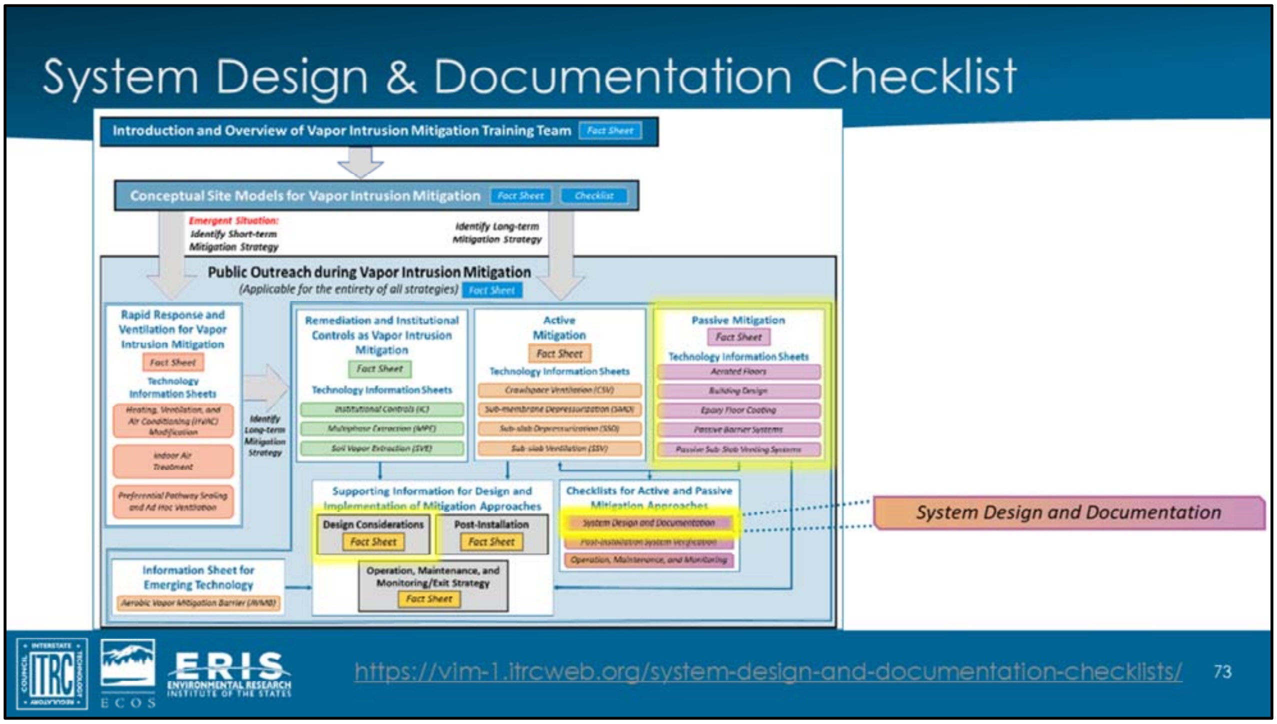


System Design and Documentation, more information can be found here. It is designed to prompt users to think about each aspect. Not everything will be applicable to all situations, but it is a great place to start for reviewing the many aspects of passive VI mitigation. The complexity of the site may dictate how applicable the check list is for your site.

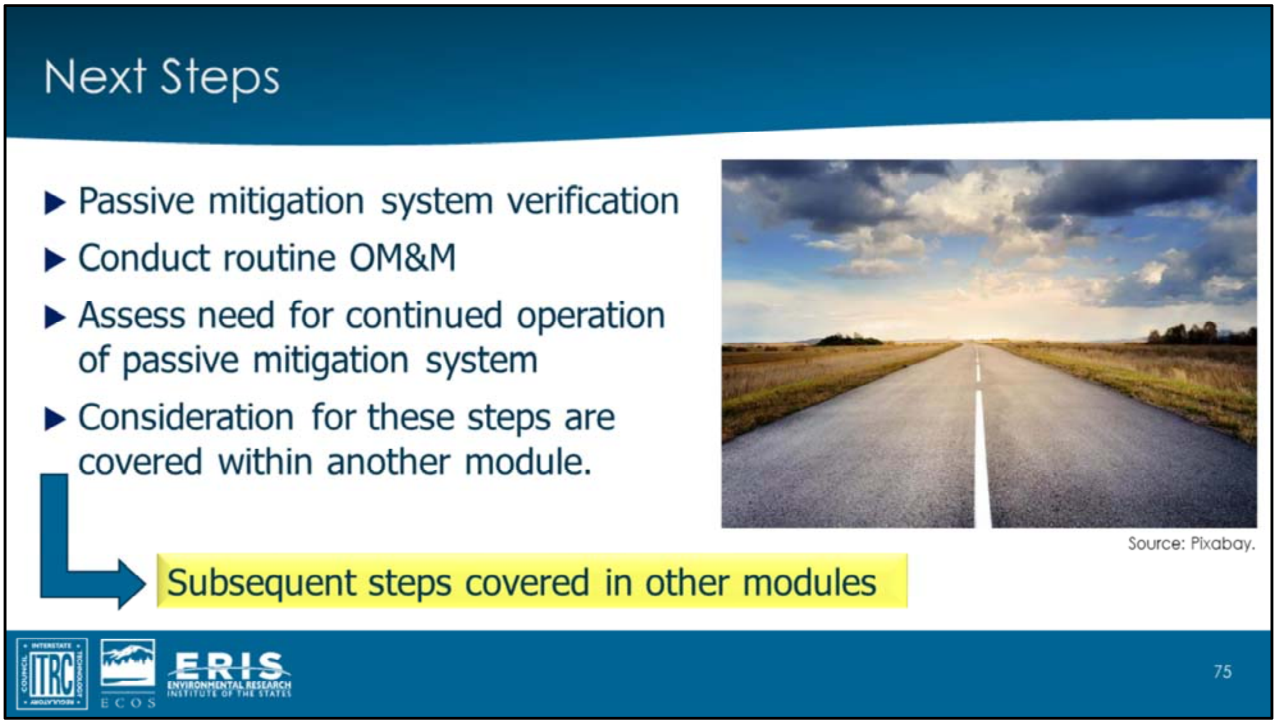
Depending on site conditions, it may be appropriate to provide information why certain items are NOT APPLICABLE rather than simply noting they are NOT APPLICABLE

Notes:

- The System Design and Documentation Checklist provides information to proceed though the pre-system installation process.
- The checklist is meant to prompt the user to think about each of these aspects of the system design.
- Not all items will be applicable to all situations.
- Sites with complex CSMs or system designs may utilize the checklist to a greater degree than less complex sites.
- Depending on site conditions, it may be appropriate to provide information why certain items are NOT APPLICABLE rather than simply noting they are NOT APPLICABLE.

So what did we learn during this module?

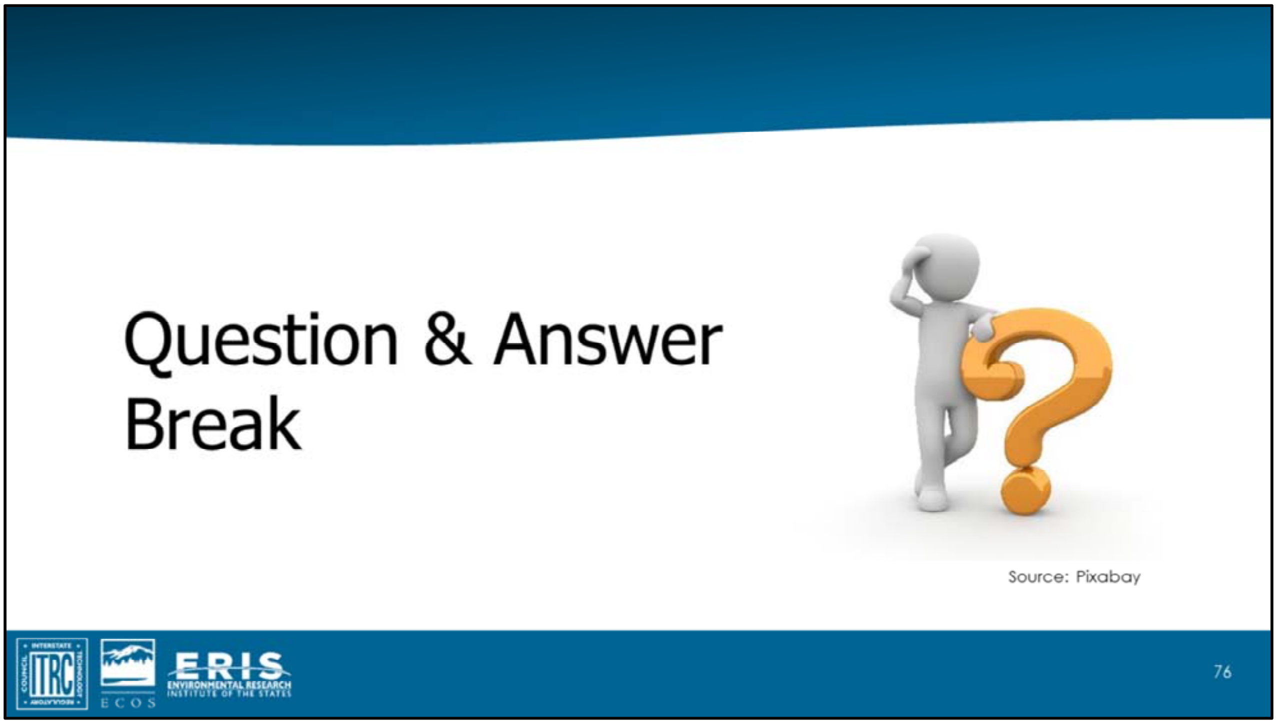
We covered:
- Why a system would be considered a passive mitigation system (vs an active mitigation system)
- The three major categories of passive mitigation systems
- Considerations for selecting appropriate passive mitigation technologies for new construction vs. existing buildings
- Major components to incorporate into passive mitigation system design, and finally
- The importance of construction quality assurance, installation oversight, and appropriate documentation



The next step in the process include:

- Verification that the passive mitigation system is functioning as designed
- Conducting routine Operation, Maintenance, & Monitoring, and
- Assessing the need for continued operation of the passive mitigation system

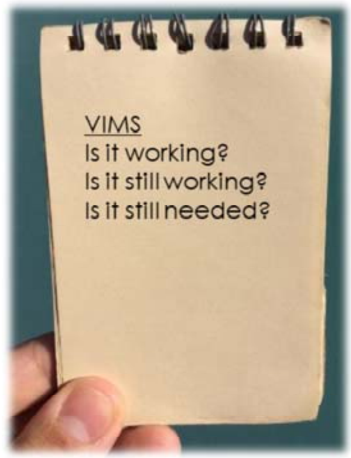
Consideration for each of these steps are covered within subsequent modules.



At this time we will open the questions and answers portion of our training.

Advancing Environmental Solutions

System Verification, Operation, Maintenance, and Monitoring, and Exit Strategy



Source: Pixabay (adapted)

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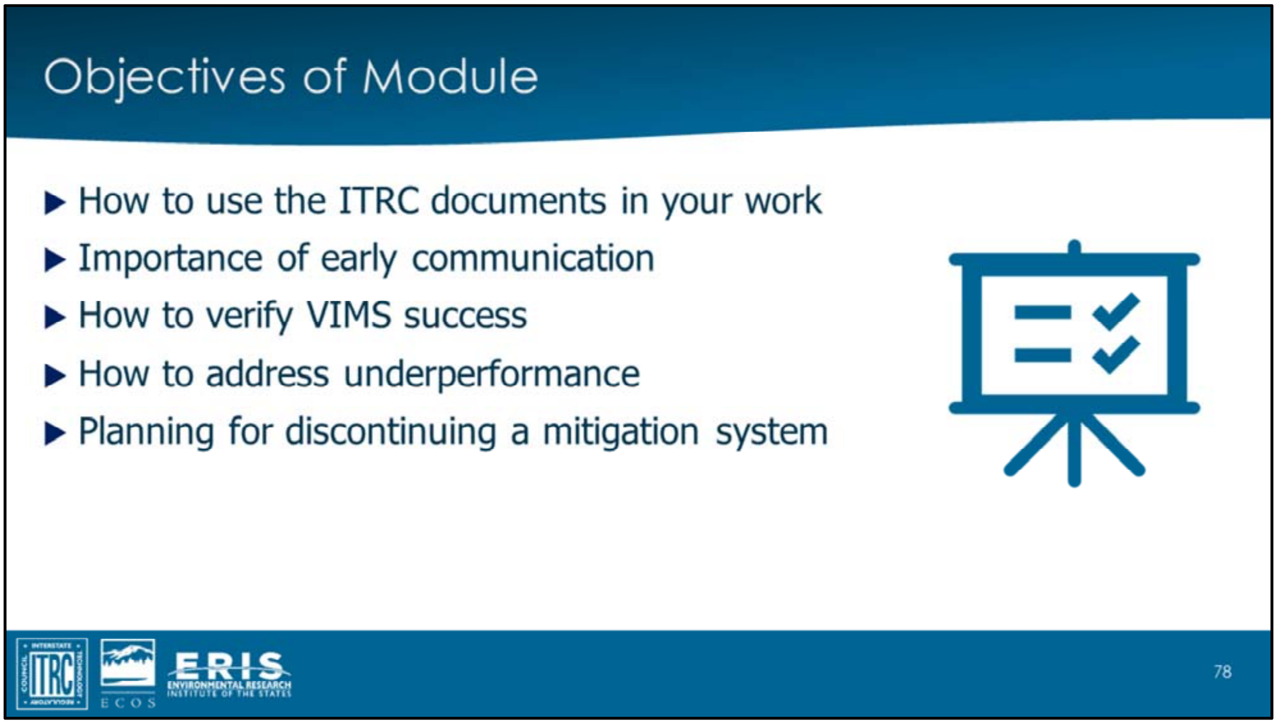
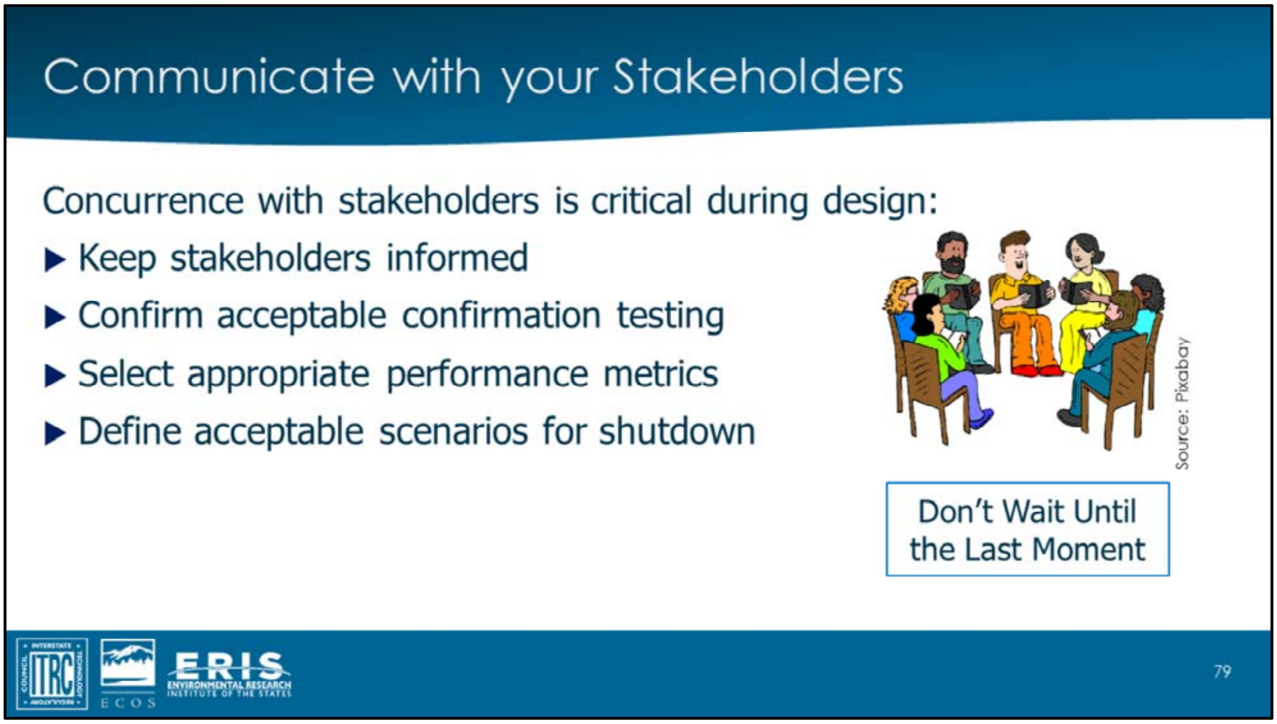
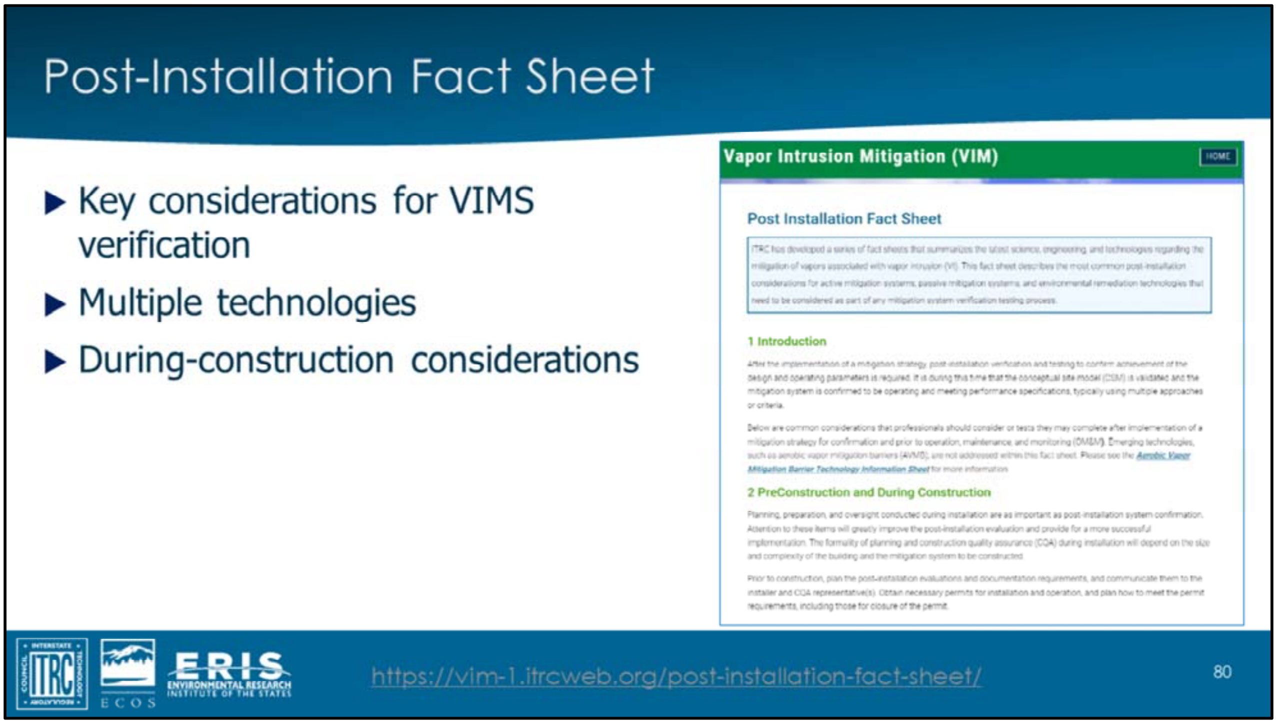


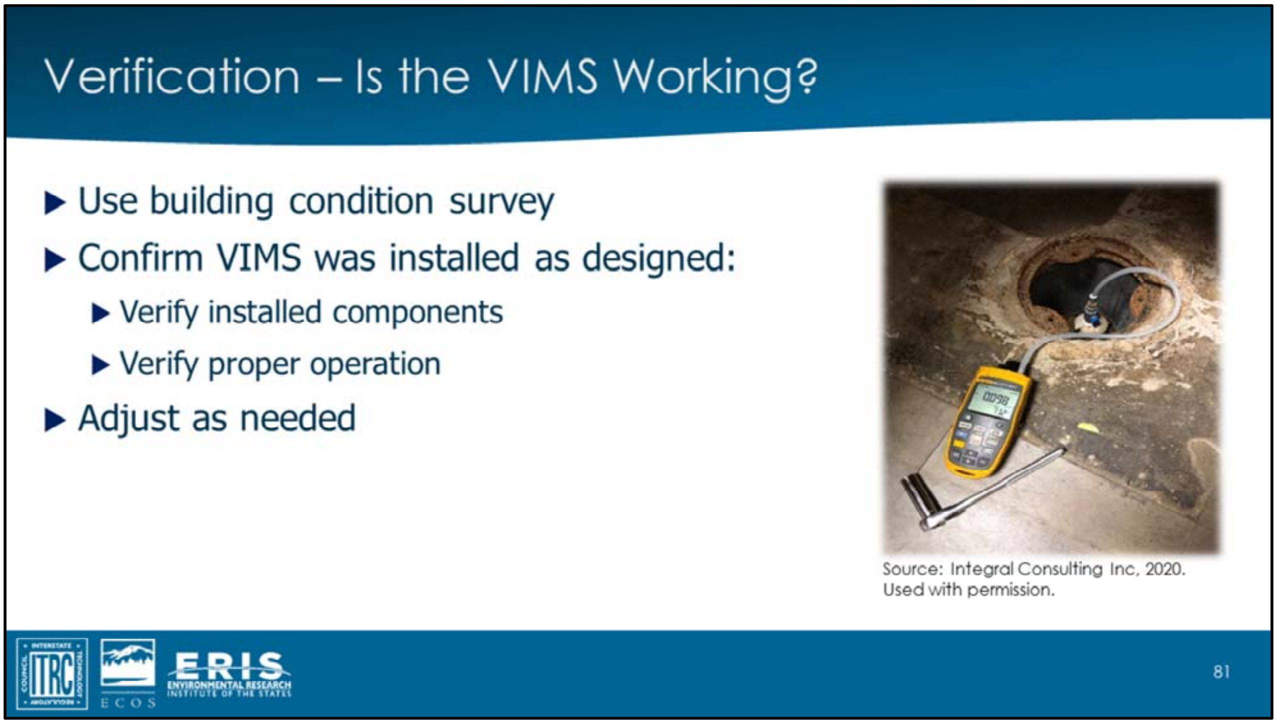
- How to verify VIMS success
- Proper system performance and how to address underperformance
- Significance of early communication and planning for discontinuing a mitigation system
- How to use the ITRC documents in your work



- You will see this theme repeated during the presentation: communication is key
- Keeping stakeholders informed includes regulators, consultants, property owners/tenants, responsible party
- We will touch on the role of community outreach in a subsequent slide
- We select appropriate performance metrics to establish baseline readings for subsequent OM&M inspections
- We want to communicate/confirm "acceptable scenarios for shutdown", such as: GW below VI screening levels; soil source removed;



Provides key considerations and testing for post-installation VIMS verification
Covers active, passive, remediation, and rapid response technologies
Describes elements that should be considered during construction



Is the VIMS working?

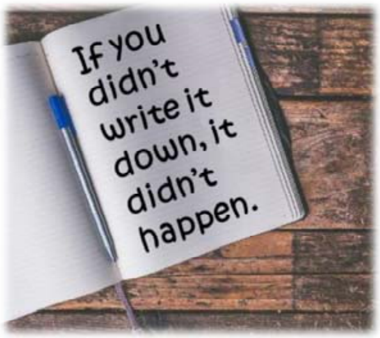
Building Survey / VIMS inspection

- Before beginning or concurrent to confirmation testing, conduct building survey and to inspect your system.
- It's important to evaluate building conditions (both pre-construction and post-construction) to understand how the building conditions may affect your mitigation system. The baseline survey conducted during the design (or pre-design) phase can be compared to the post-installation survey to identify changes that may affect the VIMS.
- For example, poor building foundations, unsealed utility penetrations, or incorrect piping can decrease the effectiveness of the VIMS.

Commissioning

- We tell that a system is working properly by commissioning, which is a series of tests (i.e. multiple forms of verification) to confirm that the system is operating properly and that we are meeting mitigation objectives (e.g., meeting vacuum level criteria for active systems and, ultimately, protecting indoor air quality).
- While not covered in detail in this module, it is important to confirm that the system is operating within the confines of issued permits, building codes, and industry standards. A VIMS can change during construction (from design), and it is important to verify that that the VIMS, once constructed, meets permit requirements and building codes. This should be evaluated as part of the building survey.
- Important to note that different VIMS may have different verification testing and parameters
- Perform a series of testing to verify systems works as designed and meet the agreed minimum requirements
- Adjust VIMS system as needed during construction or during commissioning
- Some system verification details are covered in the passive/active training modules
- More information in the Post-Installation Checklist

Documentation



Source: Pixabay

Critical foundation for future condition evaluation

- As-built drawings
- Verification performance data

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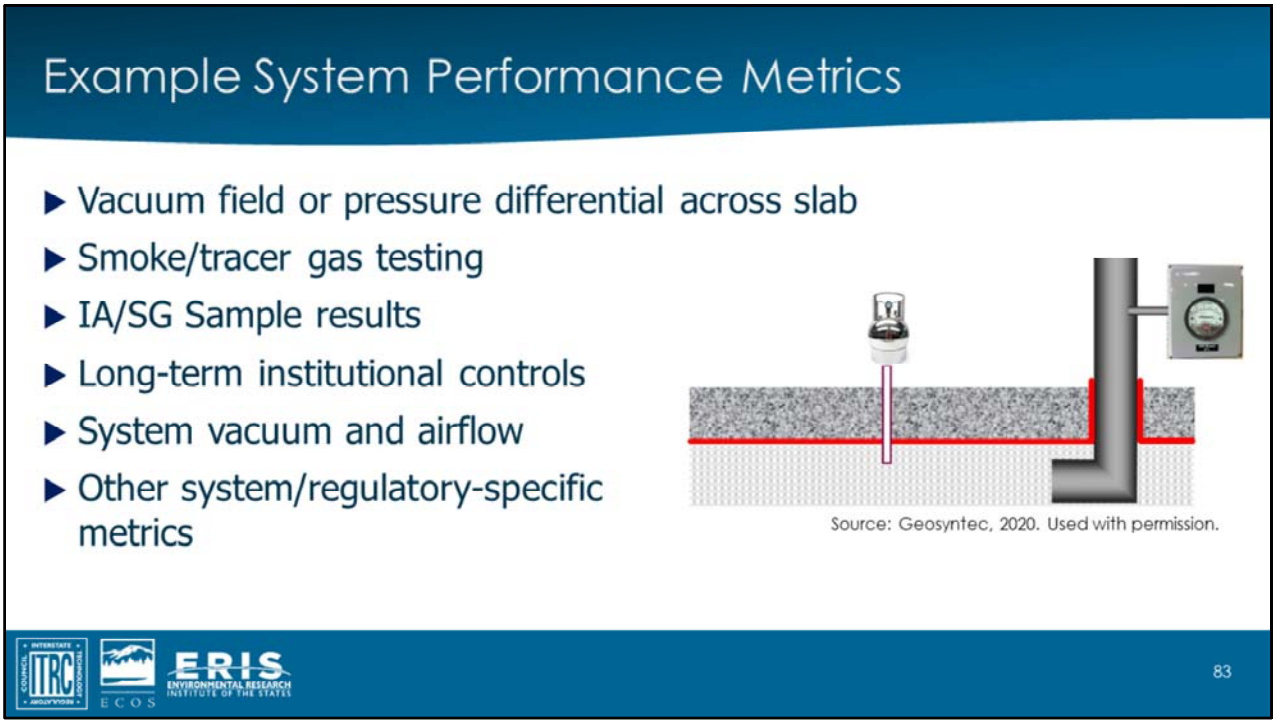
As-built drawings are important to prepare as the constructed system is often different than the design. As-built drawings may also be required for permits.

Verification performance data must be recorded and typically must be submitted to regulatory agencies. Further, it provides a baseline for comparison during the OM&M phase.

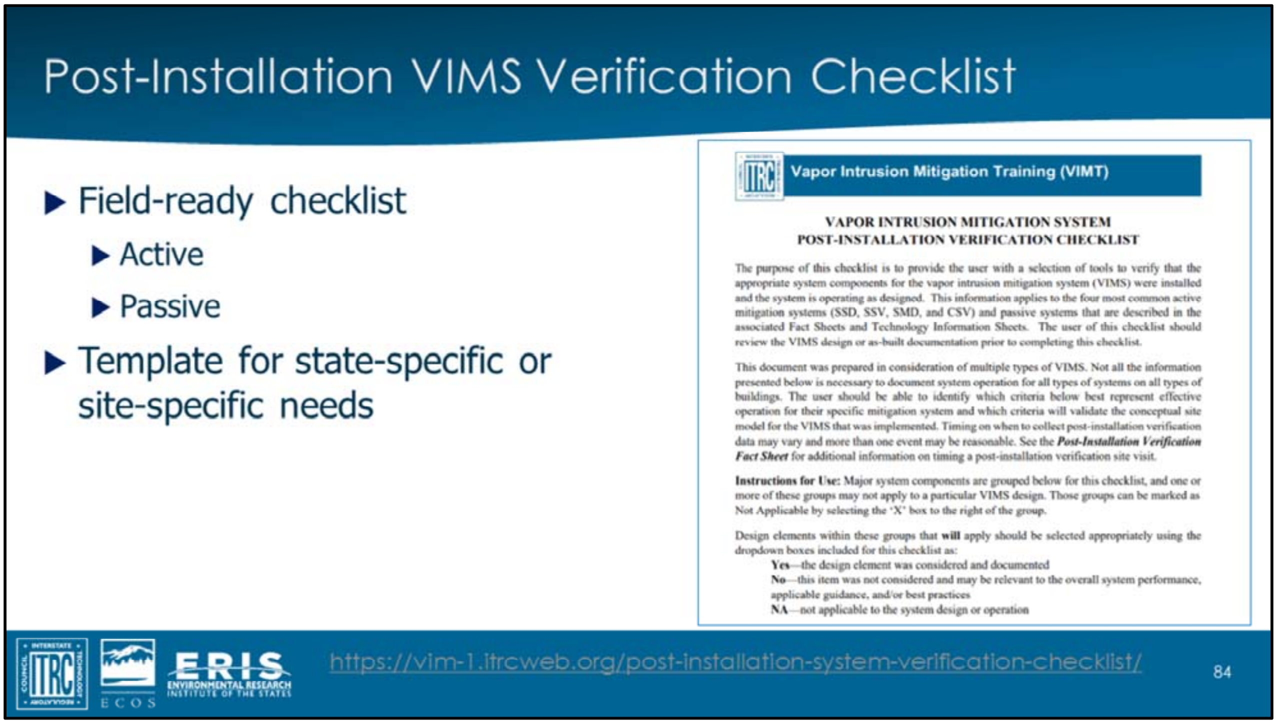


For IBT:

- Here are some example system performance metrics (not all performance metrics will be used at all sites or for all technologies; some of these look familiar because they were covered earlier in this module for active and passive):
    - If rapid response… IA/SG Sample results
    - If remediation… pressure differential across slab
- This is not a definitive list
- See the specific tech sheets for performance metrics specific to your system

For Individual Module:

- Here are some example system performance metrics (not all performance metrics will be used at all sites or for all technologies):
    - If SSD…. Vacuum field or pressure differential across slab; System vacuum and airflow
    - If passive barrier… Smoke/tracer gas testing
    - If rapid response… IA/SG Sample results
    - Active and passive VIMS can both require long-term institutional controls
- This is not a definitive list
- See the specific tech sheets for performance metrics specific to your system



We can't stress documentation enough.

Knowledge Check

Poll Question

When is it most important to develop verification procedures and an exit strategy?

- ▶ During VI investigation
- ▶ During mitigation design and planning
- ▶ At the time of mitigation implementation
- ▶ After construction
- ▶ Never

Source: Pixabay

Knowledge Check

Poll Question

When is it most important to develop verification procedures and an exit strategy?

- During VI investigation
- ☑ During mitigation design and planning
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- Never

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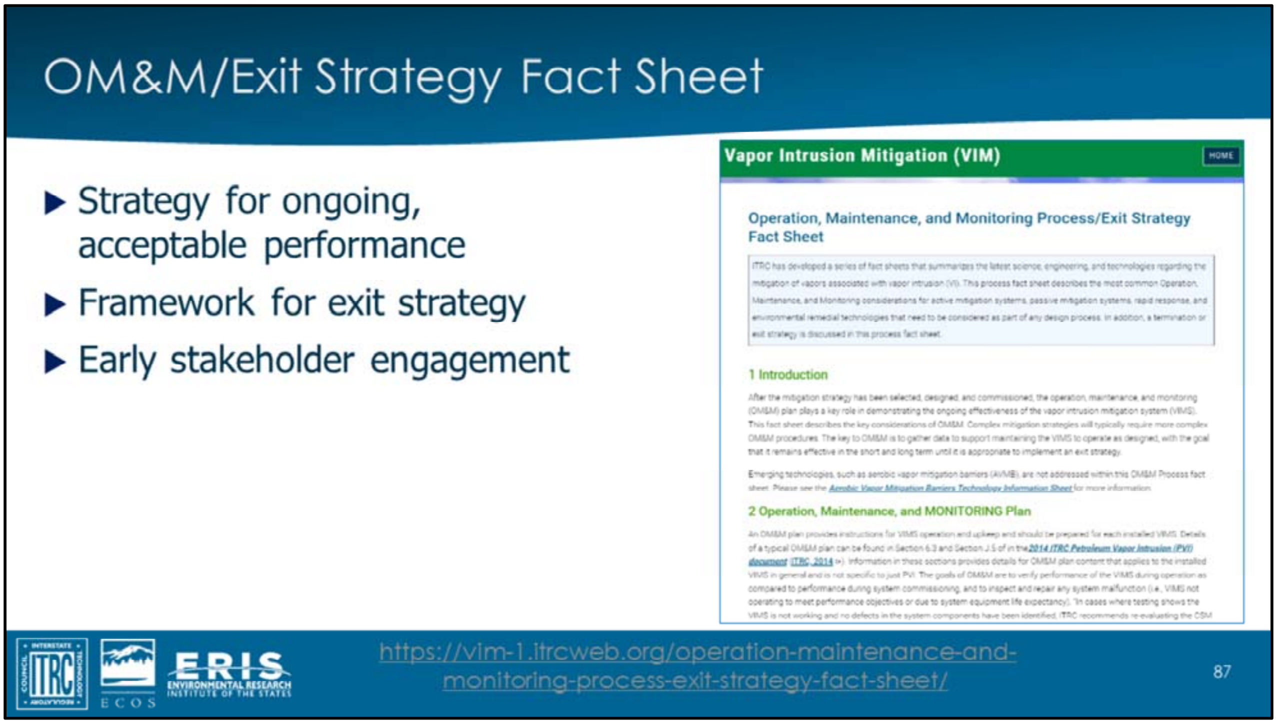
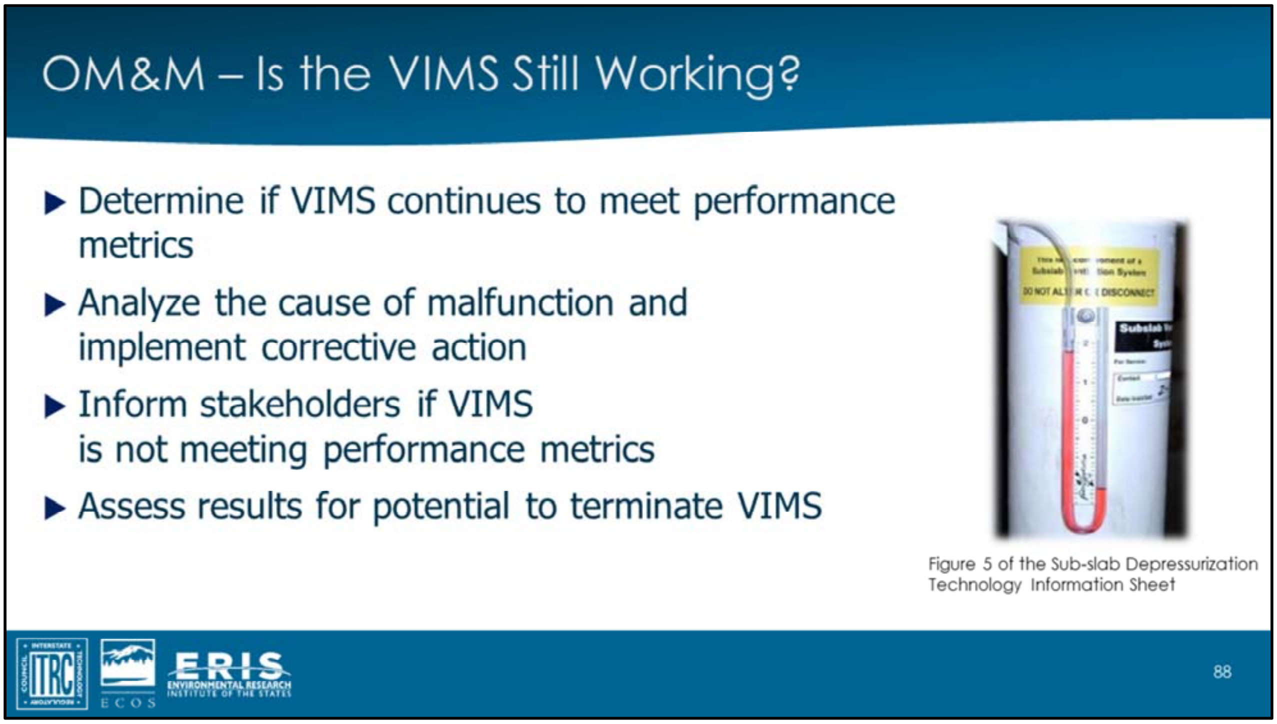


OM&M/Exit Strategy Fact Sheet

- Provides a strategy to confirm ongoing, acceptable VIMS performance as designed
- Presents a framework for exit strategy development
- Advocates for early stakeholder engagement of VIMS termination criteria and actions
- There may be additional state-specific and system-specific requirements



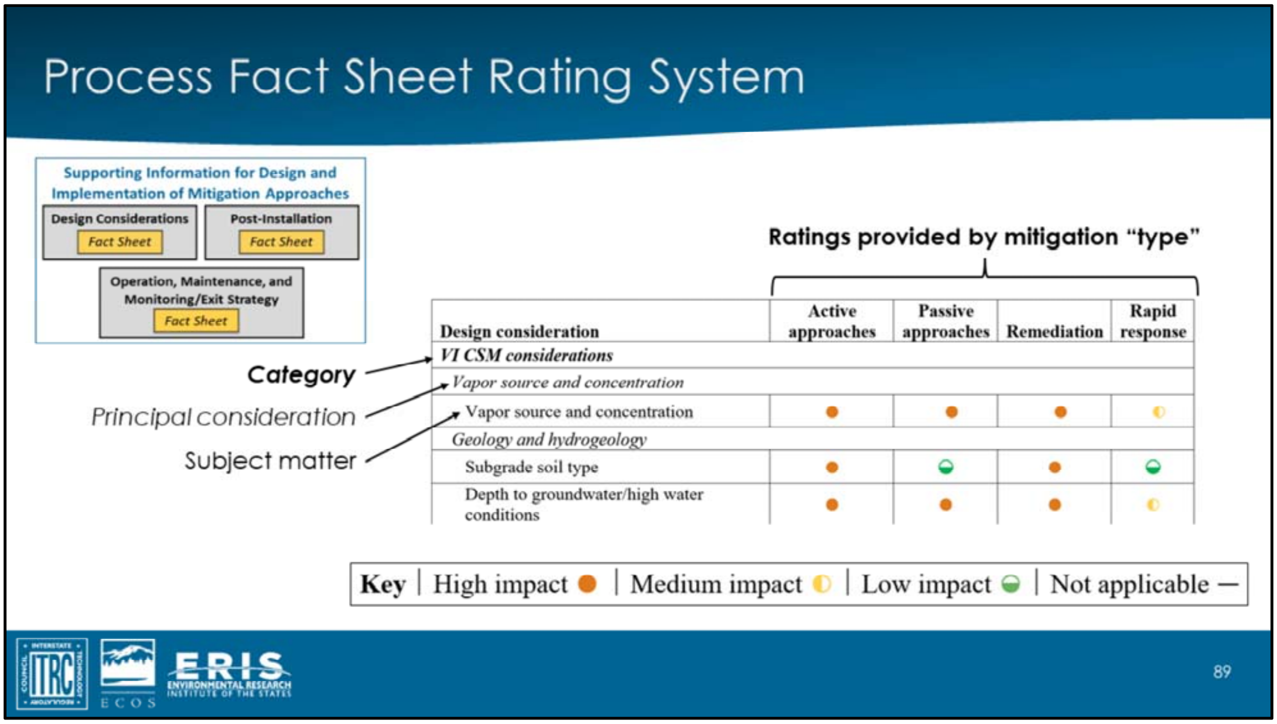
Is the VIMS continuing to meet performance metrics?

- Use the OM&M checklist to assist with periodic system inspection and to measure operational parameters
- Evaluate performance and potential for implementing exit strategy

What if the VIMS is not meeting performance metrics?

- Analyze data for cause of VIMS malfunction
- Inform stakeholders
- Repair/replace malfunctioning equipment, if applicable
- Manage changes in site or building conditions, as applicable
- Consider upgrading system or installing additional VIMS

Assess the OM&M results to see if you have a potential for terminating the VIMS



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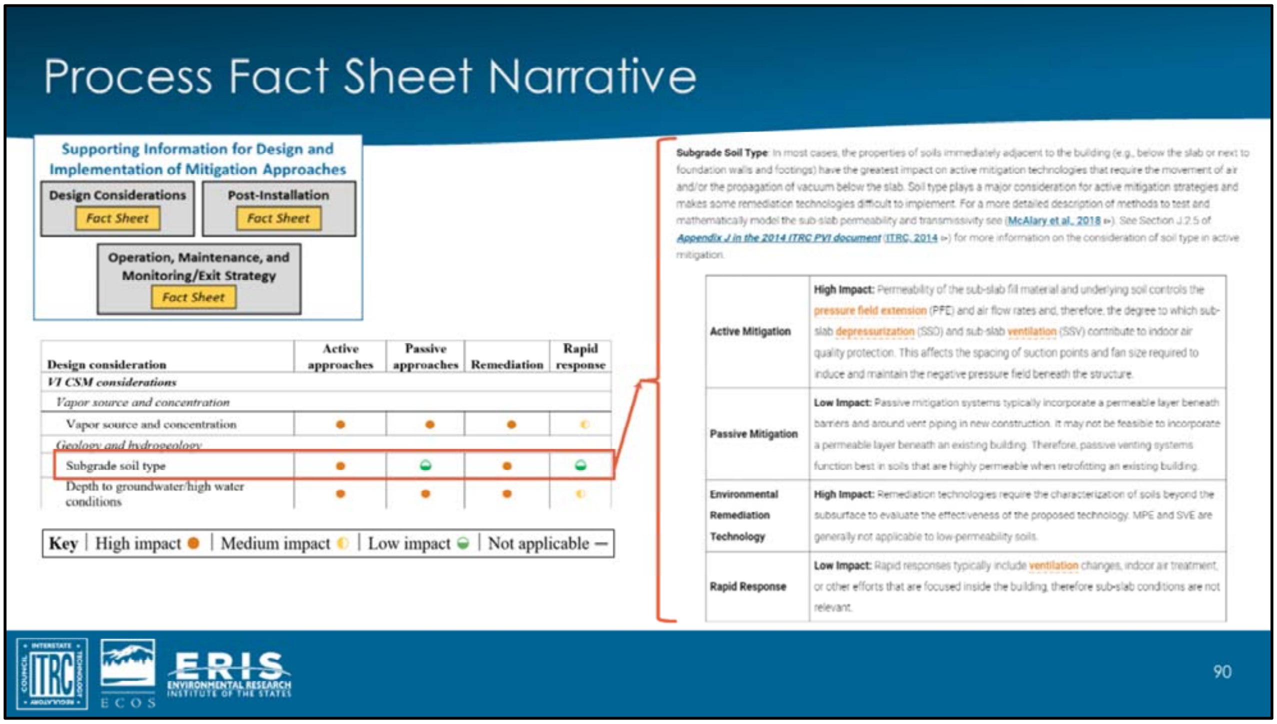

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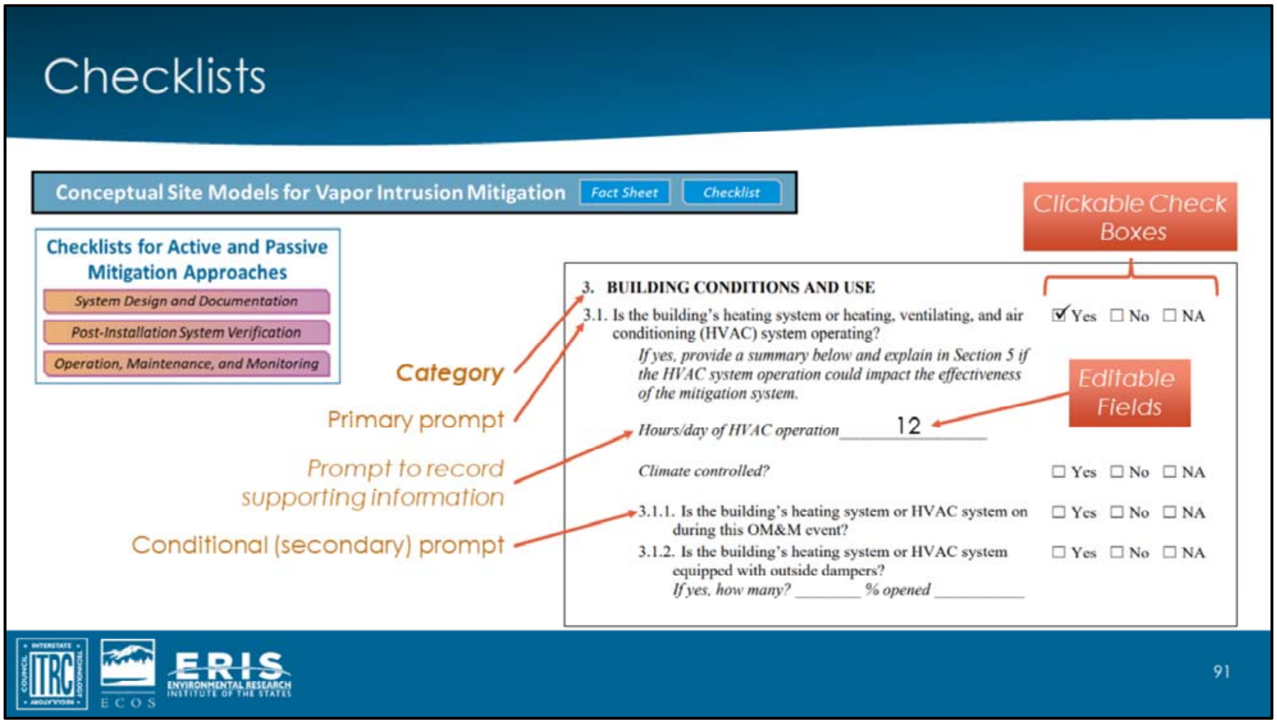
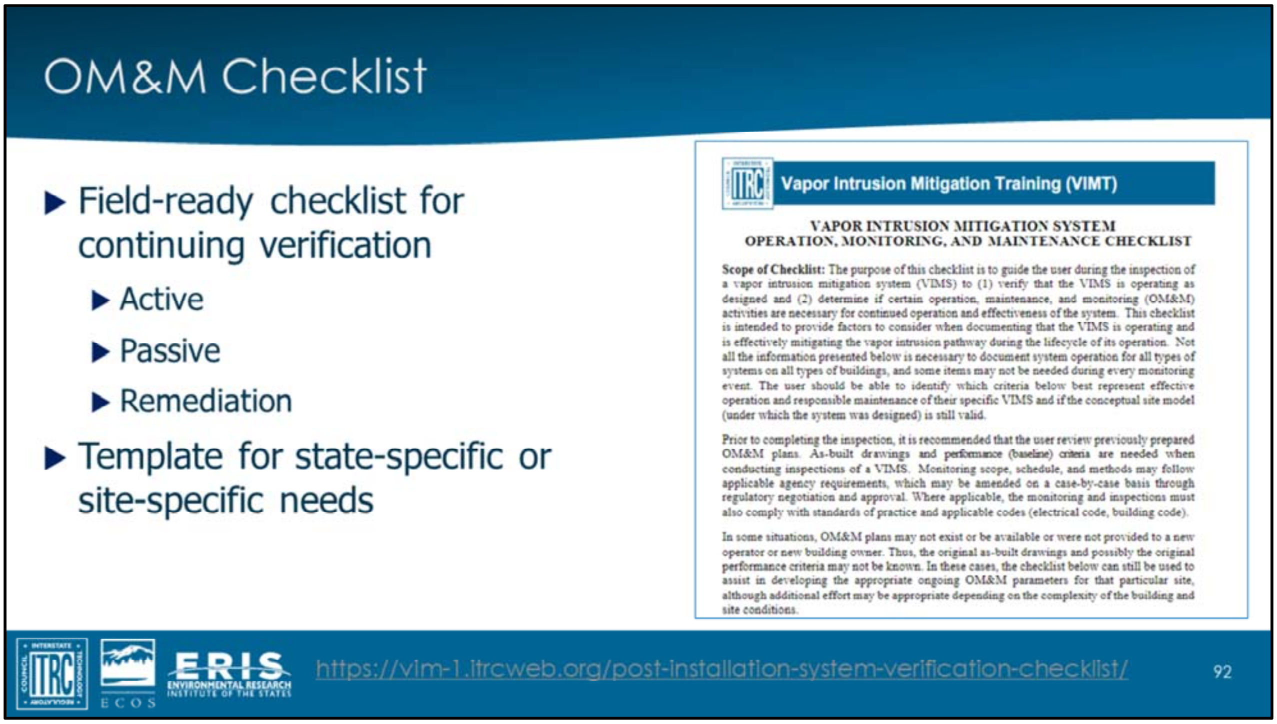
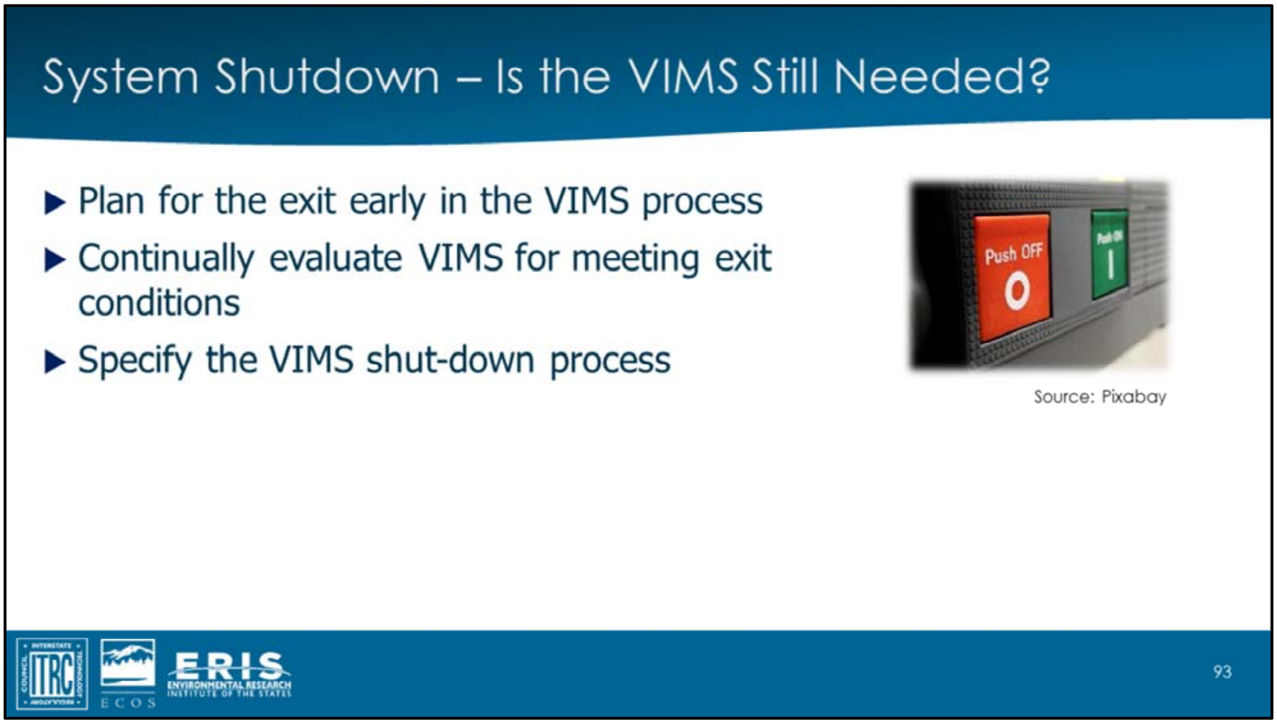


<clicks walk through checklist steps>



- Field-ready checklist for active, passive, and remediation system continuing operation verification
- Users can modify the checklist to meet state-specific or site-specific needs



Exit Strategy

- Plan for this upfront: Refer to the Active & Passive Mitigation Modules for a discussion of the Design Process Fact Sheet and its role in Planning

- All stakeholders should agree on post-installation, monitoring, and termination procedures as part of the original design process.

Continually evaluate VIMS for meeting exit conditions

- Evaluate shutdown parameters during OM&M events
- Assess if shutdown criteria is met after significant site condition changes (e.g., remediation)

Specify the VIMS shut-down process

- How will the system be decommissioned?
- May be specified in a regulatory document
- We understand that, for some sites, these systems will never be shut down

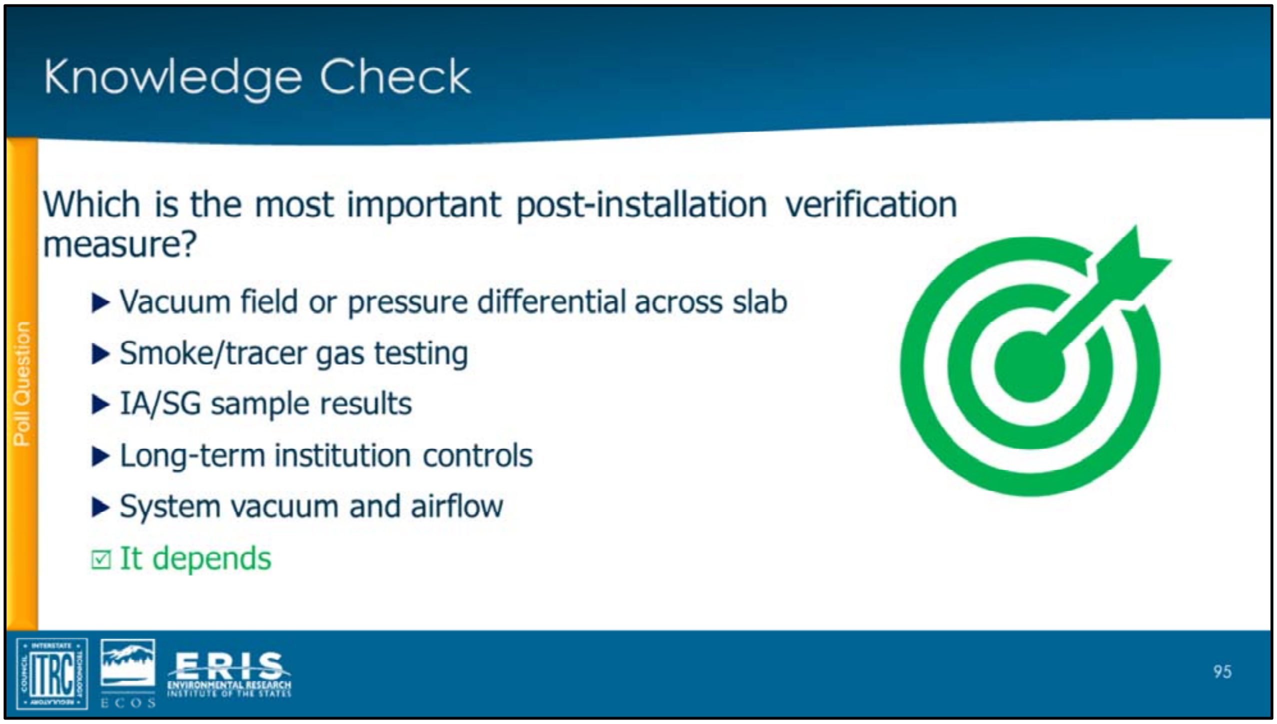
Knowledge Check

Poll Question

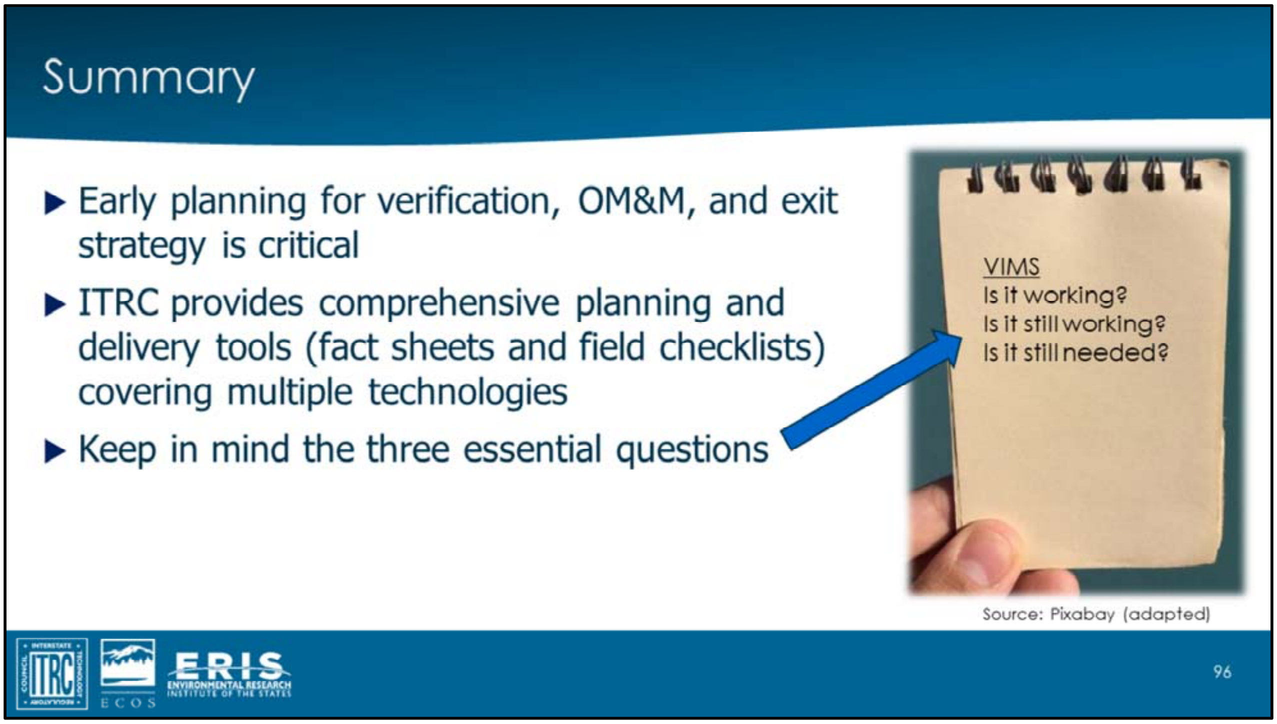
Which is the most important post-installation verification measure?

- Vacuum field or pressure differential across slab
- Smoke/tracer gas testing
- IA/SG sample results
- Long-term institution controls
- System vacuum and airflow
- It depends

Source: Pixabay



It depends… on the system and regulatory requirements



In this training module, we discussed the key concepts from the Post-Installation and OM&M Process/Exit Strategy Fact Sheets and Checklists:

- We stressed planning / Exit Strategy development up front and continuing through post-installation and OM&M
    - Begin with the end in mind
- Commissioning
    - We discussed confirming that the VIMS is operating as intended and meeting mitigation objectives using multiple forms of validation (testing)
- Monitoring
    - We discussed continually evaluating if the VIMS is operating as intended and determining when the exit strategy can be implemented
- Exit Strategy
    - As part of monitoring, ask yourself if you've reached the point of turning off or discontinuing monitoring of the VIMS
    - If needed, reevaluate the exit strategy with stakeholders.

Consider the three simple questions

Is it working (after installation)?

Is it still working during OM&M?

Is it still needed? (Exit strategy)

We would like to hear back from you today so please be sure to fill out the online feedback form that's linked on this last slide. You can also access the feedback form by clicking Feedback in the related links section and then clicking browse to. Filling out the feedback form and certifying that you participated will allow you to receive a certificate of completion.

If you need further clarification on the answers or would like to ask more questions, feel free to email us at training@itrcweb.org and we will follow up with our trainers to get your questions answered. Or you are welcome to follow up with our trainers directly.

Special thanks to our participants today. We appreciate you taking the time out of your busy schedules to join us today. Thank you to our expert trainers for being here today and for their contribution to the ITRC document.

As a reminder, ITRC archives all its training classes, so if you find that you have additional time or looking for additional training opportunities, please visit Clu-In and the archived trainings to see if there are other courses that might interest you.