

Vapor Intrusion Mitigation of Non-Residential Buildings by Sub-Slab Depressurization

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Vapor Intrusion in Commercial and Industrial Buildings: Assessment and Mitigation

NEWMOA & Brown University
Westford MA September 23, 2008
Providence, RI September 24, 2008



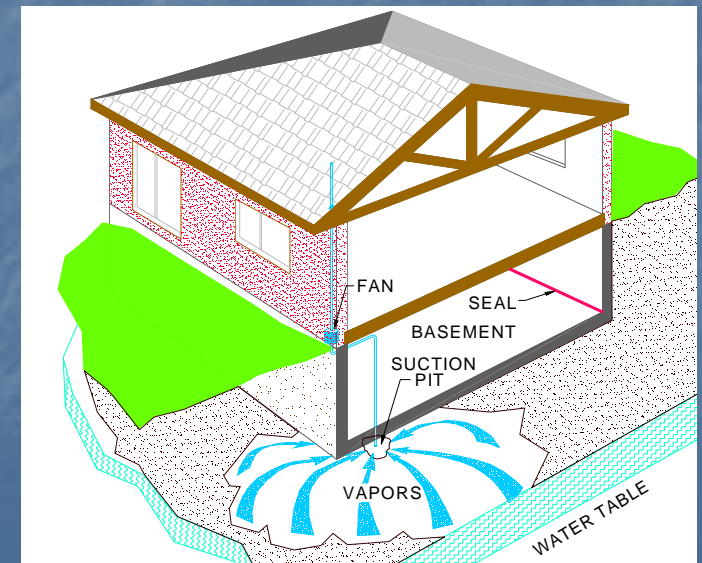
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Vapor Intrusion Solutions

Commercial/Industrial Building Mitigation

- Institutional controls
- Source removal
- Building positive pressurization
- Passive barriers (new buildings)
- Sub-slab depressurization (SSD)

Sub-Slab Depressurization

- Originally developed for radon control
- Residential Homes
 - Highly effective (99.5% + reduction)
 - Typically low cost
 - \$1500 - \$3000 (install only)



Sub-Slab Depressurization

- Commercial Buildings
 - More challenging
 - Barriers often included
 - Higher cost
 - 1-5 \$/sf + (ITRC, 2007)



SSD Case Histories

- Manufacturing Building, CO
- Dance Studio, CO
- Recreation Center, NY
- Warehouse, NY
- Charter School, CO
- Office Building, WY
- Law Office, KS
- Vocational School, KS
- Condominium Complex, CO
- Toronto Ferry Terminal, Canada

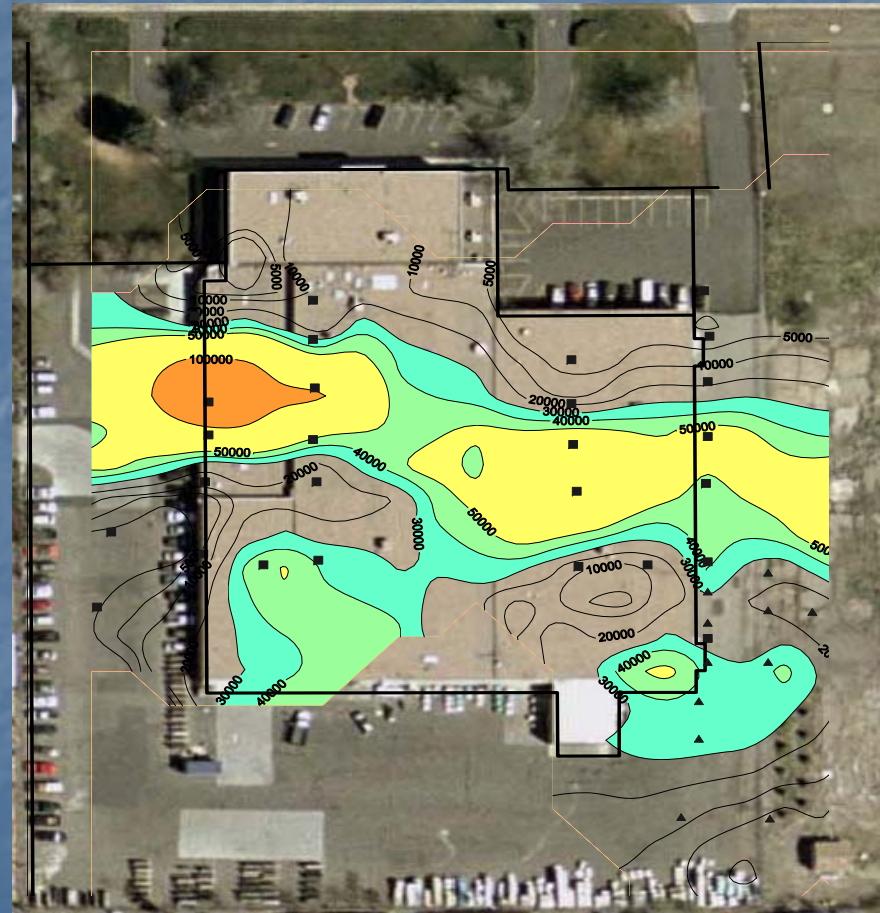
Manufacturing Building, CO

- 70,000 sf warehouse & manufacturing space (single story)
- 15,000 sf office space (two story)



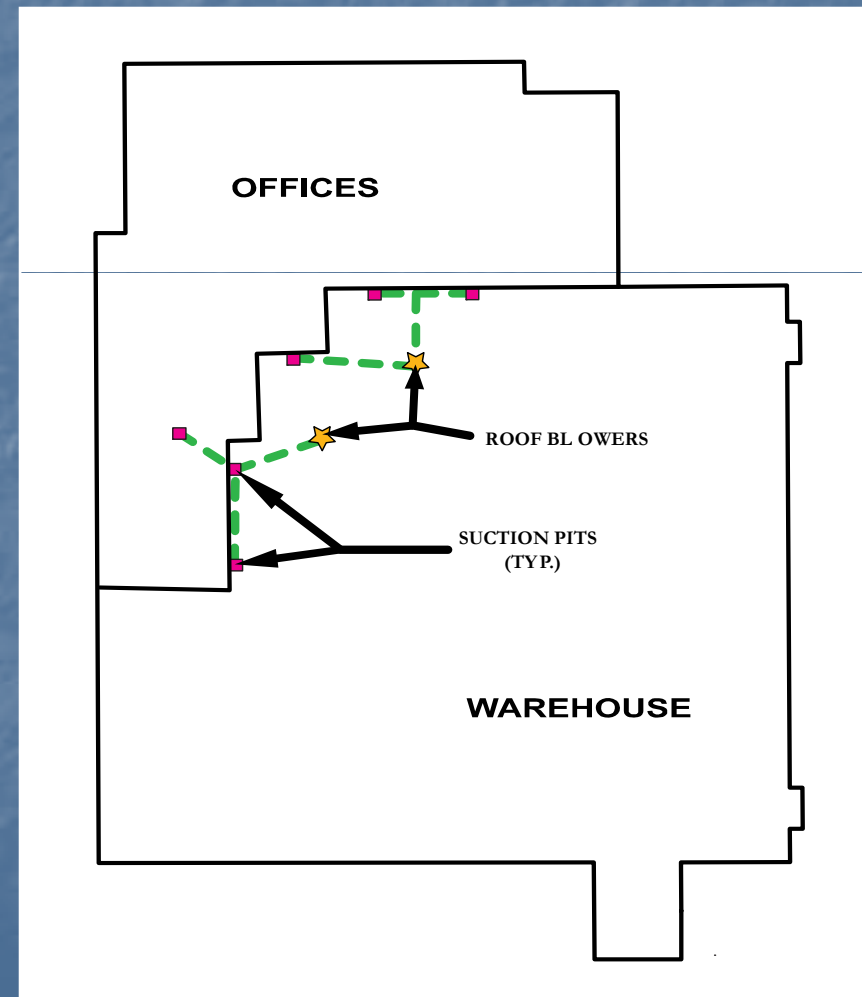
Manufacturing Building, CO

- Chlorinated solvents in soil and groundwater below building
- Highest soil vapor levels near office area



Manufacturing Building, CO

- Solution
 - Focused system
 - Suction points between offices & plume
 - Suction points in unfinished areas
 - Pipe runs in single story warehouse



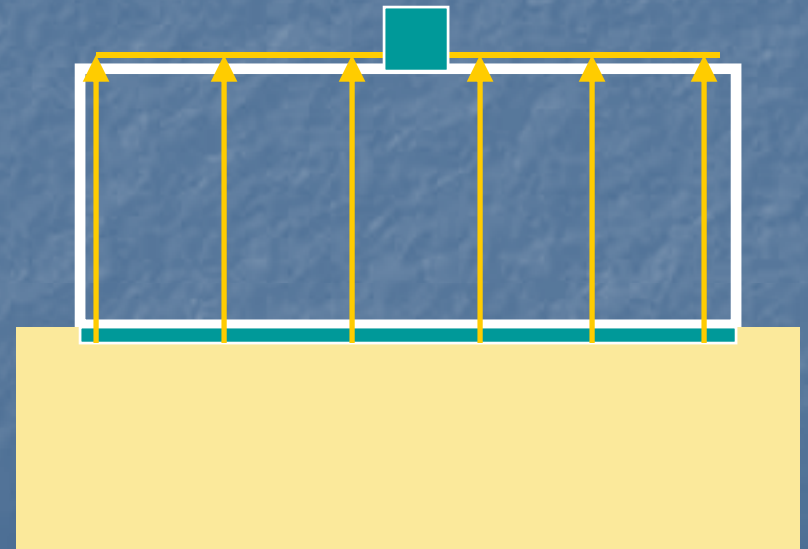
Manufacturing Building, CO

- Solution
 - Suction points in unfinished areas
 - Pipes run to ceiling in single story warehouse



Manufacturing Building, CO

- Multiple suction points manifolded to one blower on roof
- \$40,000 total cost
 - ~\$0.50 sf total building
 - ~\$2 sf mitigated



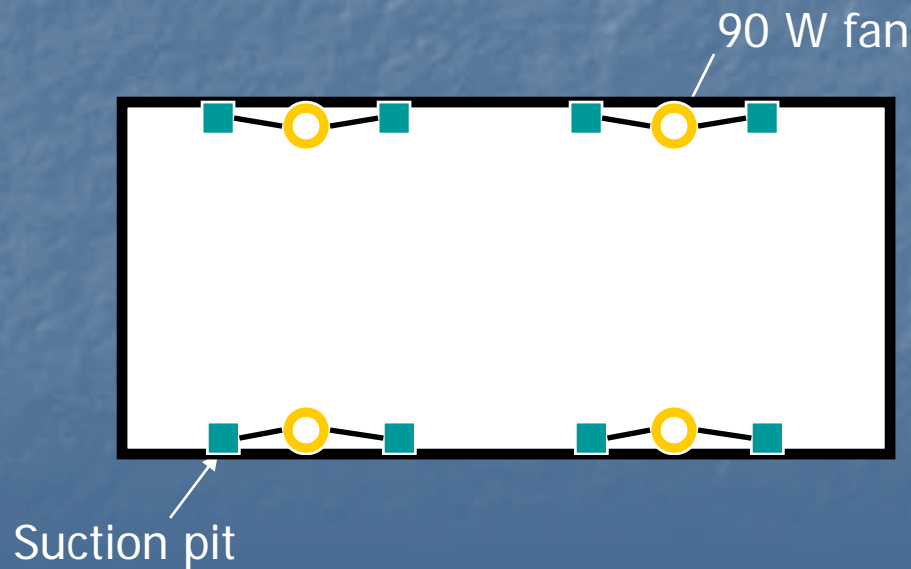
Dance Studio, CO

- Chlorinated solvents in groundwater
- Small single story building
- Roof unable to support large blower
- Large open room, no interior columns



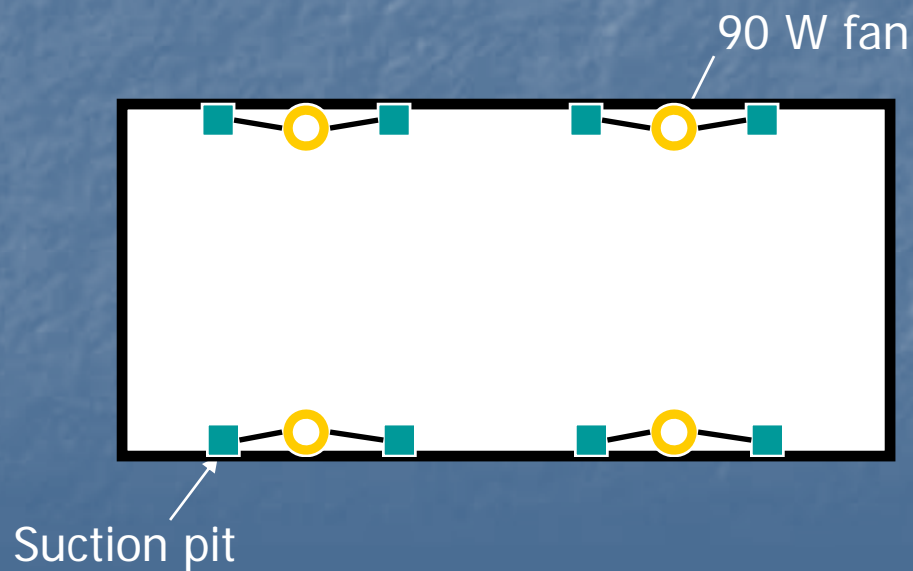
Dance Studio, CO

- Solution:
 - 4 - 90 watt roof mounted fans
 - 2 suction points per fan (8 total)



Dance Studio, CO

- Solution:
 - \$24,000 total cost
 - \$3.40/sf



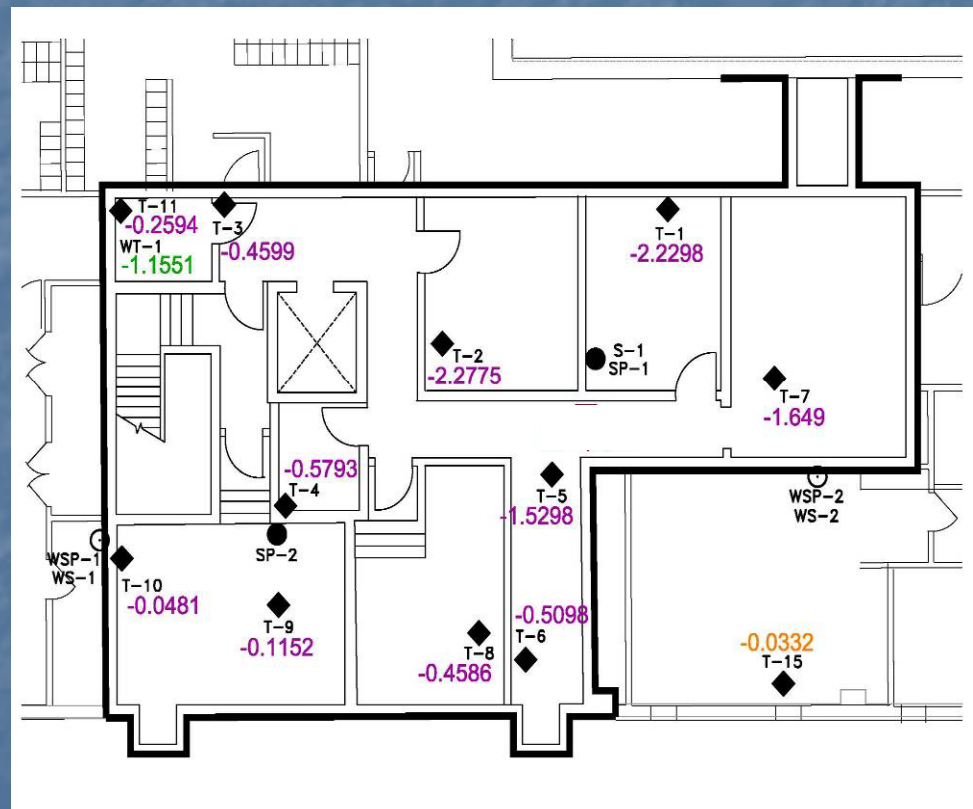
Recreation Center, NY

- Chlorinated solvents in groundwater
- Multi-story building
- 20,000 SF total
 - 2,000 SF basement
 - 18,000 SF SOG
- Day care area



Recreation Center, NY

- Basement suction points in floor
- SOG suction points in floor and basement walls
- Sumps and crawl space openings sealed



Recreation Center, NY

- Cost issues:
 - City required 4" cast iron pipes
 - Multi-story pipe runs to roof
 - Finished space



Courtesy T. Hatton, Clean Vapor Inc.

Recreation Center, NY

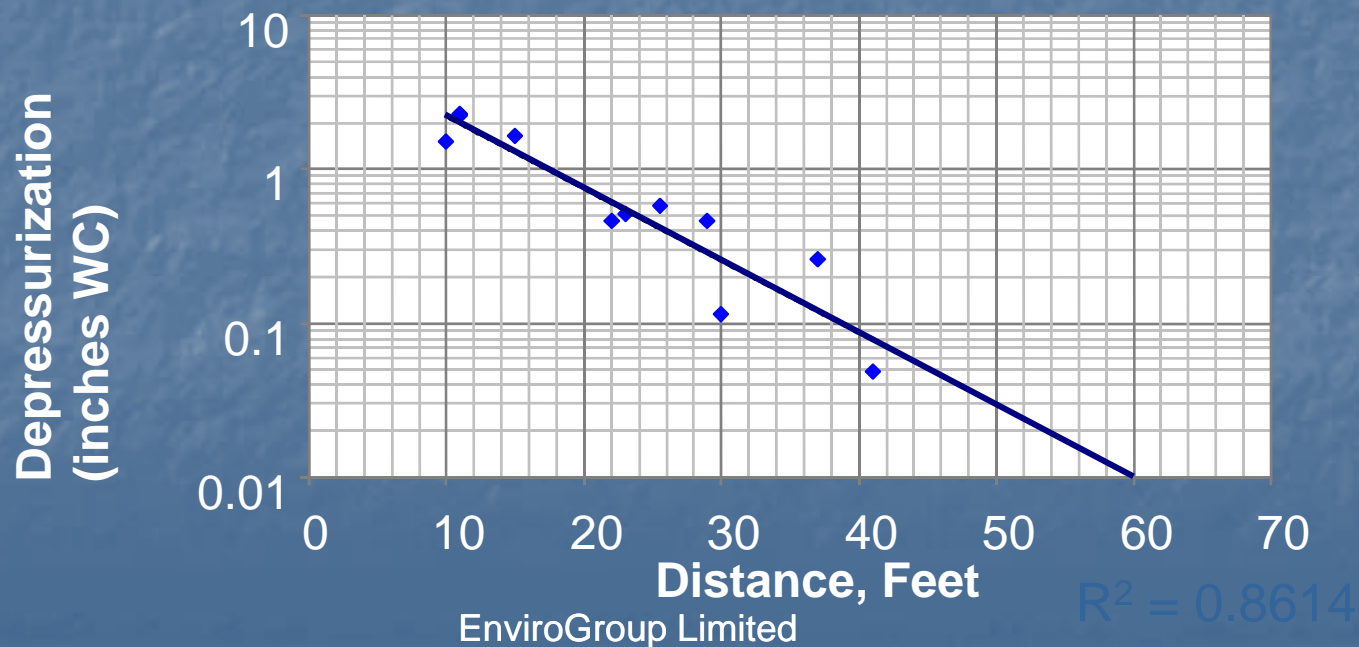
- Four blowers required:
 - 3 low vacuum high flow
 - Max 18" WC, 110 cfm
 - 1 high vacuum low flow
 - Max 50" WC, 53 cfm



Recreation Center, NY

- Cost:

- > \$10/sf to achieve 0.003" suction over entire footprint of building, including diagnostics



Warehouse, NY

- Large warehouse complex with elevated indoor air levels throughout



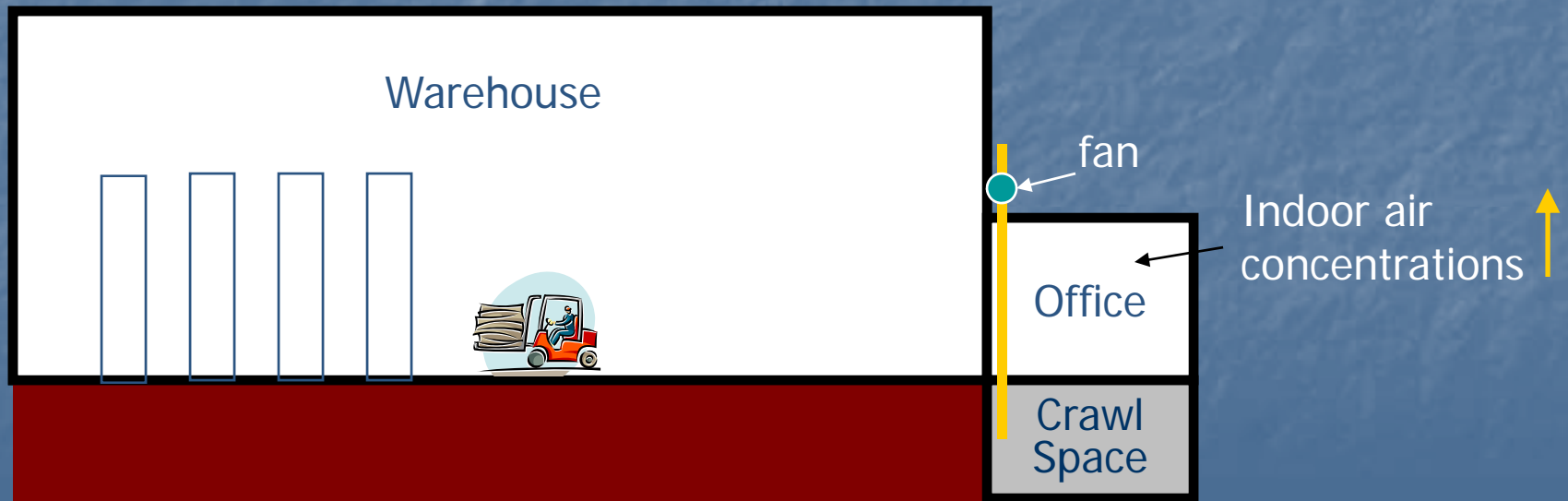
Warehouse, NY

- Solution:
 - Depressurize crawl space below office



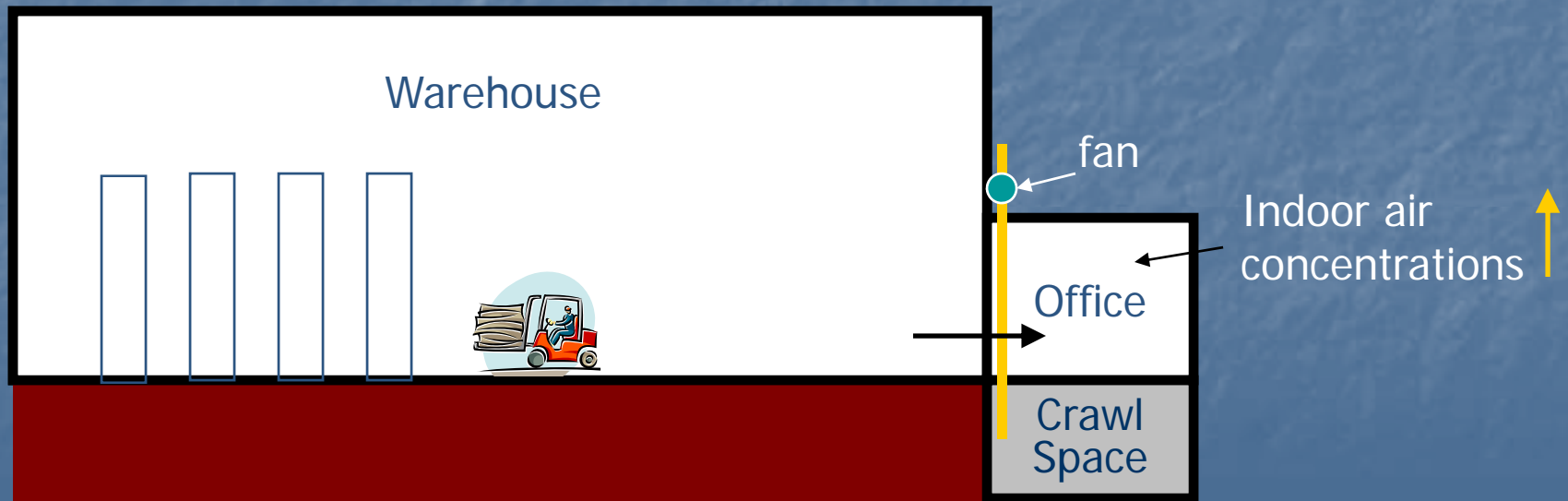
Warehouse, NY

- Problem:
 - IA concentrations in office increased



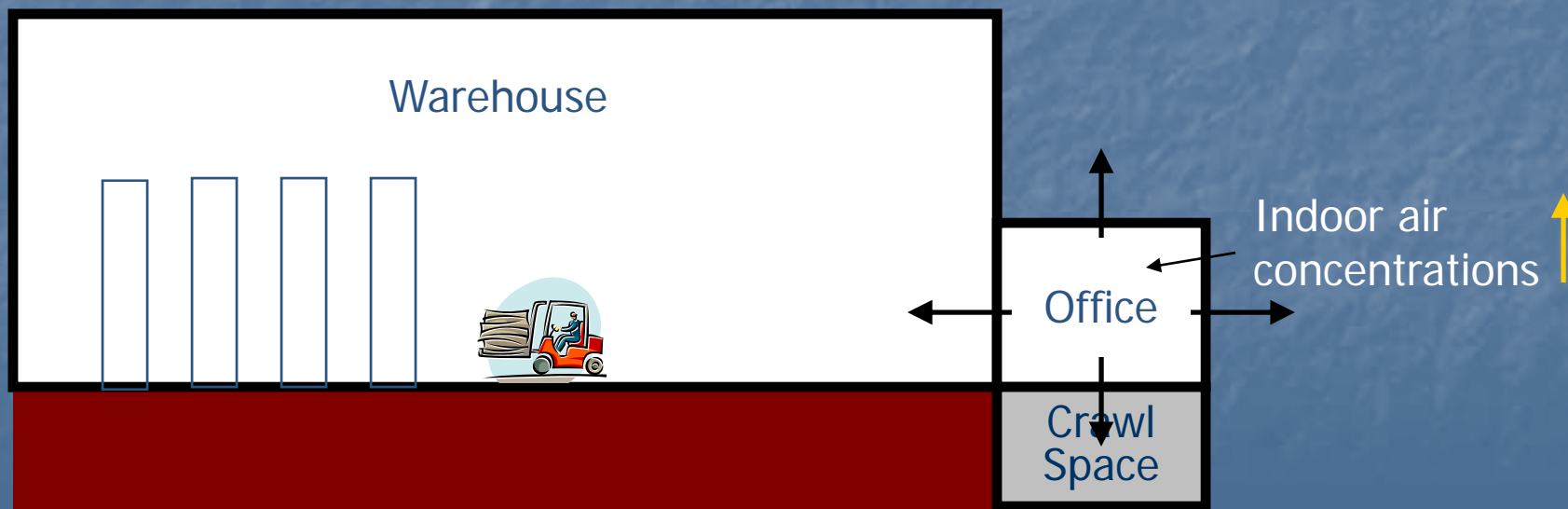
Warehouse, NY

- Cause:
 - Depressurizing crawl space also depressurized office, pulling in warehouse air



Warehouse, NY

- Better Solution:
 - Pressurize office space

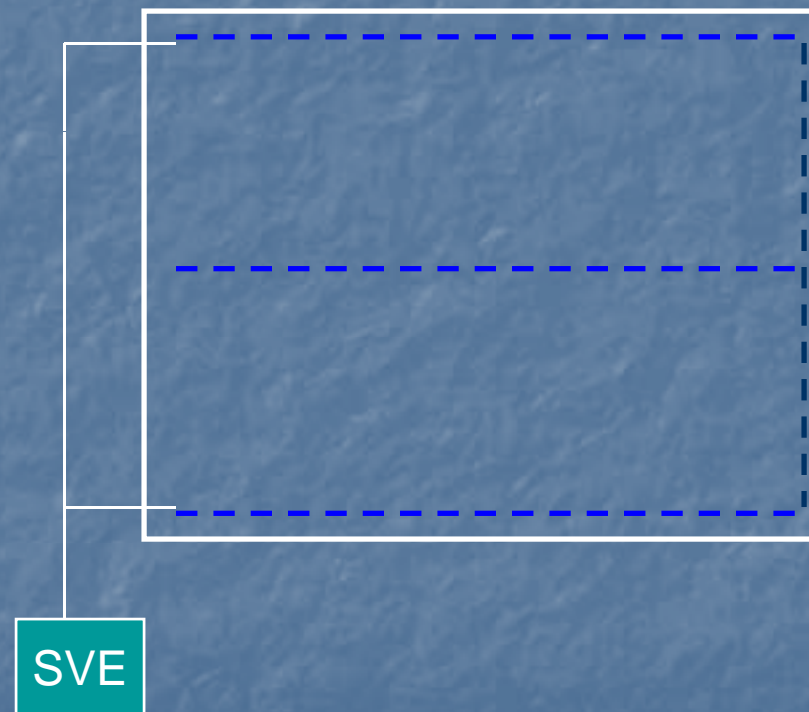


Charter School, CO

- Old gasoline plume below school
- Basement area used for pre-school and kindergarten ages
- Existing SVE system being used for UST source area

Charter School, CO

- Economic solution:
 - Foundation drains connected to SVE system
 - Limited new infrastructure
- Depressurized slab
 - Increased O_2 below slab to near 21%



Office Building, WY

- Former petroleum refinery site
- Redeveloped as golf course and office park



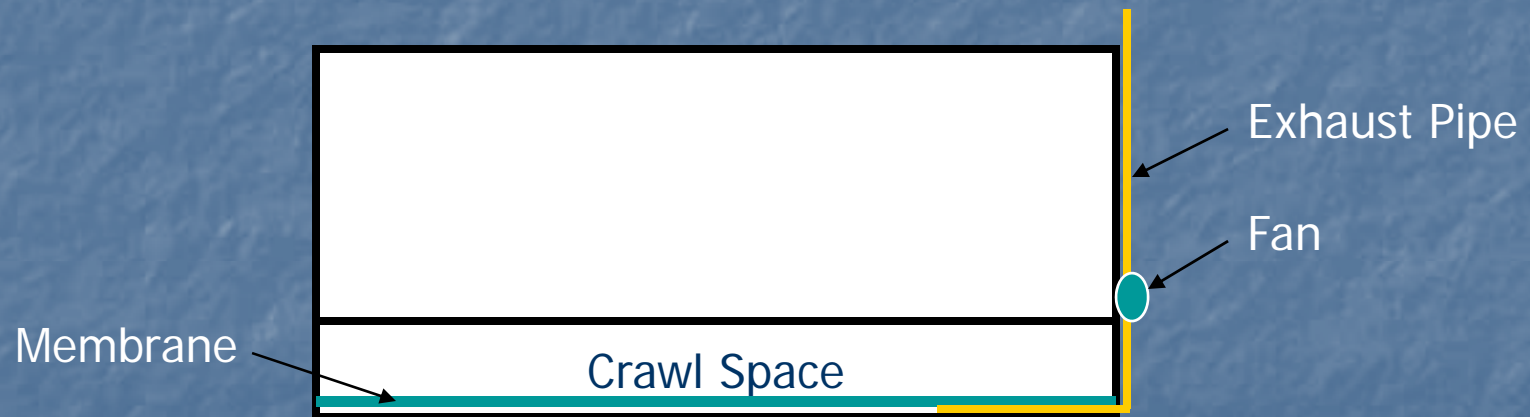
Office Building, WY

- Need for active VI control based on elevated soil gas levels (100X IA target levels)



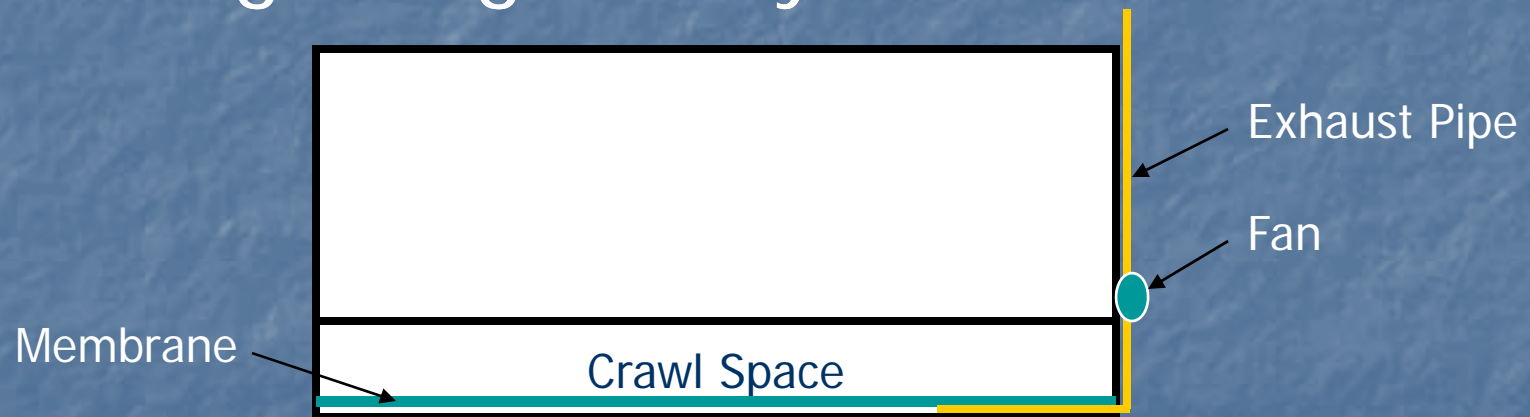
Office Building, WY

- Designers chose crawl space with membrane design
- Soils below membrane depressurized



Office Building, WY

- Membrane must not be damaged
- Seals to foundations must be maintained
- Slab on grade generally more robust



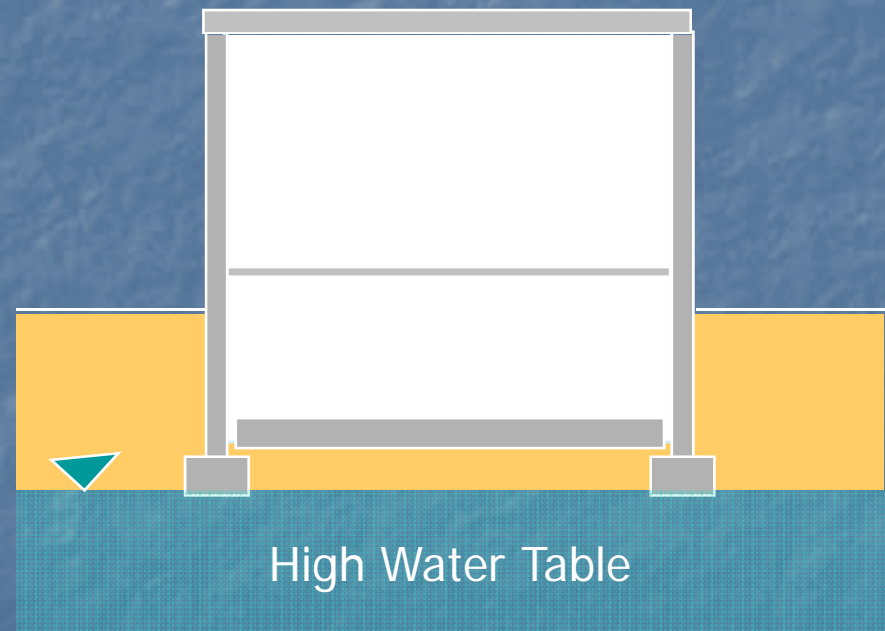
Law Office, KS

- Gasoline plume caused building to explode
- Resulting fire suppression water forced plume under neighboring law office



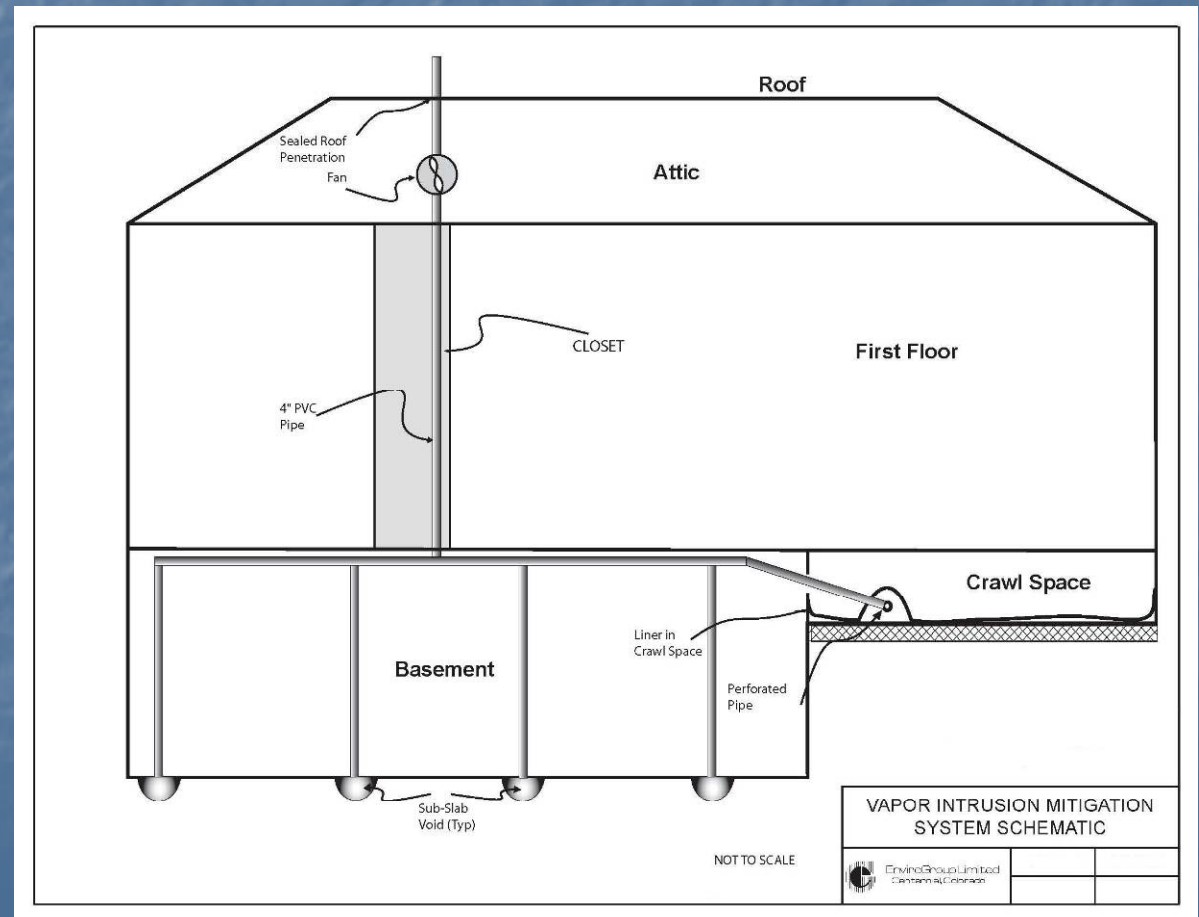
Law Office, KS

- Mitigation of Law Office
 - Protect against vapors
 - Prevent explosions
 - Deal with high water table



Law Office, KS

- Solution:
 - Multiple suction points
 - Intrinsically safe fan
 - ~\$4/sf



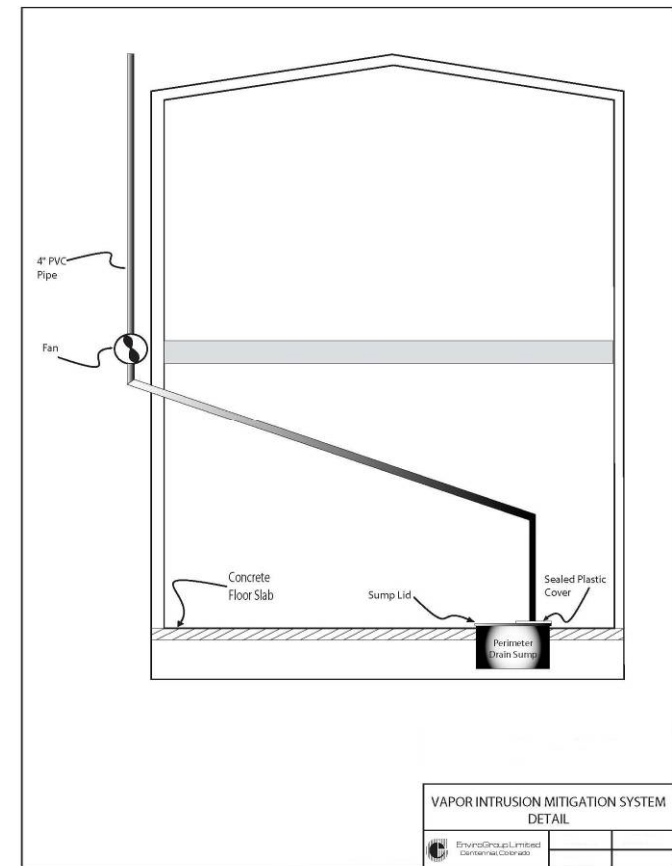
Vocational School, KS

- Chlorinated solvents in groundwater below school
- Groundwater collects in open sump in basement
- Air stripper installed in basement to treat groundwater
- Elevated indoor air concentrations of TCE



Vocational School, KS

- Solution
 - Sump sealed and depressurized
 - Also depressurized french drain pipes
 - Exterior wall mounted fan
 - Total cost ~\$4,000



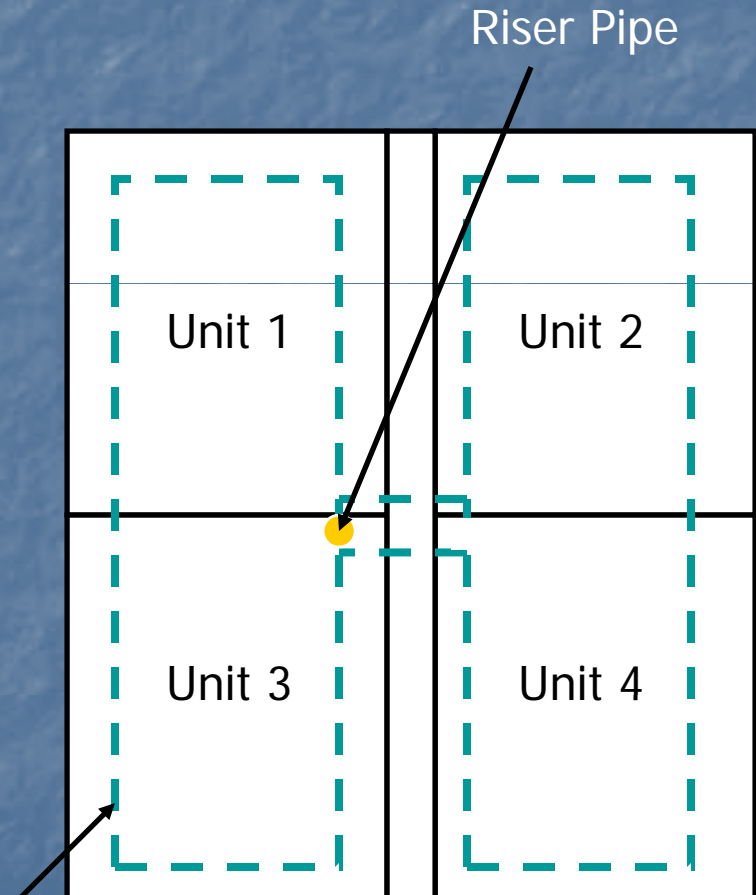
Condominium Complex, CO

- Brownfields site
 - disseminated sources of chlorinated solvents
 - Condominiums being constructed
- Challenge:
 - Minimize number of active systems
 - No indoor air testing desired

Condominium Complex, CO

■ Solution:

- Perforated pipe placed below each unit
- Pipes manifolded to one riser every 4 units
- Initially passive
- Fan added if sub-slab vapor exceeds 10 times indoor air target level



Perforated Pipe
Below Slab

Toronto Ferry Terminal

- New terminal for ferry between Toronto and Rochester
- Methane present in soil
- Poor load bearing conditions
- High water table

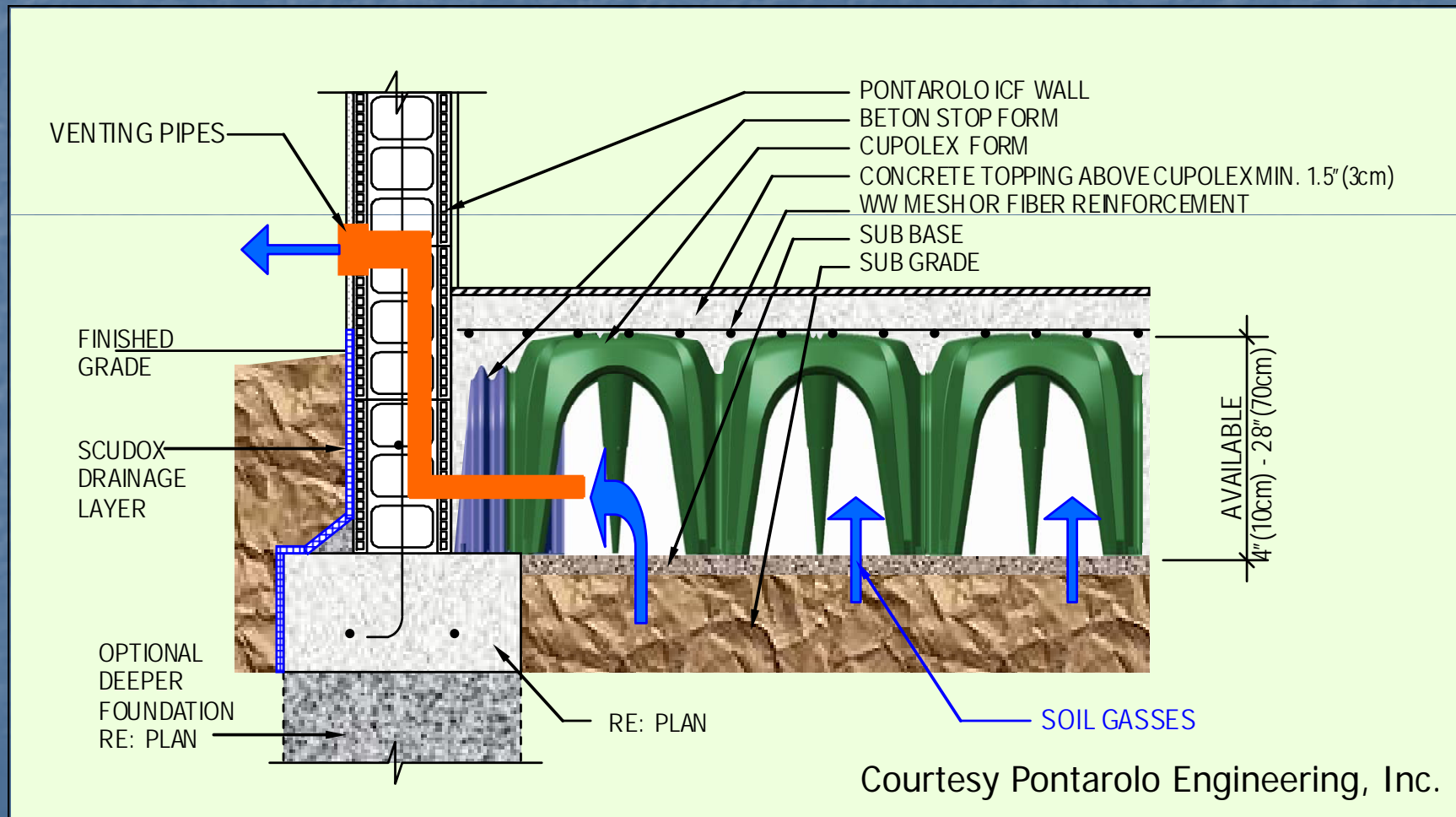
Toronto Ferry Terminal

- Solution:
 - Aerated floor system
 - Slab poured on patented forms
 - Passively ventilated voids formed in slab
 - No sub-excavation required
 - No venting media required
 - 80% concrete & rebar of normal slab



Courtesy Pontarolo Engineering, Inc.

Toronto Ferry Terminal



Summary of Key Points

- SSD is an effective mitigation technique for commercial & industrial buildings
- Focus systems
 - May not be necessary to depressurize entire footprint
- Consider most cost effective fan arrangement
 - Manifold several suction points to one blower, or
 - Multiple smaller fans
- Costs can exceed \$10/sf due to
 - Multi-story pipe runs
 - Permit requirements (e.g., cast iron pipes)

Summary of Key Points

- Understand the effects of depressurizing
 - Air can be pulled from adjoining rooms or buildings
- Use existing building and remediation infrastructure
 - Depressurize french drains and sumps
 - Use SVE blowers if available

Summary of Key Points

- Depressurization can occur at
 - slab interface, below membranes, in drains, in crawl spaces
- Use explosion-proof equipment when appropriate
- Passive systems should be convertible to active, based on performance tests

Summary of Key Points

- Consider aerated floor systems for new buildings
 - Avoid sub-surface venting layers
 - More efficient sub-slab void network
 - Cost effective compared to traditional systems