DIFFICULT MITIGATIONS - AFTERNOON TECHNICAL SESSION

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MINNESOTA MDH DEPARTMENT OF HEALTH

Radon Mitigation 101

Ask This Old House – Season 4, Episode 14

What Makes Buildings Difficult to Mitigate?

- Construction details
- Multiple foundations
- Layout
- Pipe routes
- Finished areas
- Access to areas
- HVAC parameters
- Size
- Height of structure

- Radon levels
- Geology - Karst
- Pathways not accessible
- Lack of PFE
- Stack, HVAC, Depressurization sources: bath fans, hoods, house fans, appliances
- Weather – precip, wind, outside temps

The radon levels are not reduced

Try and Keep it Simple

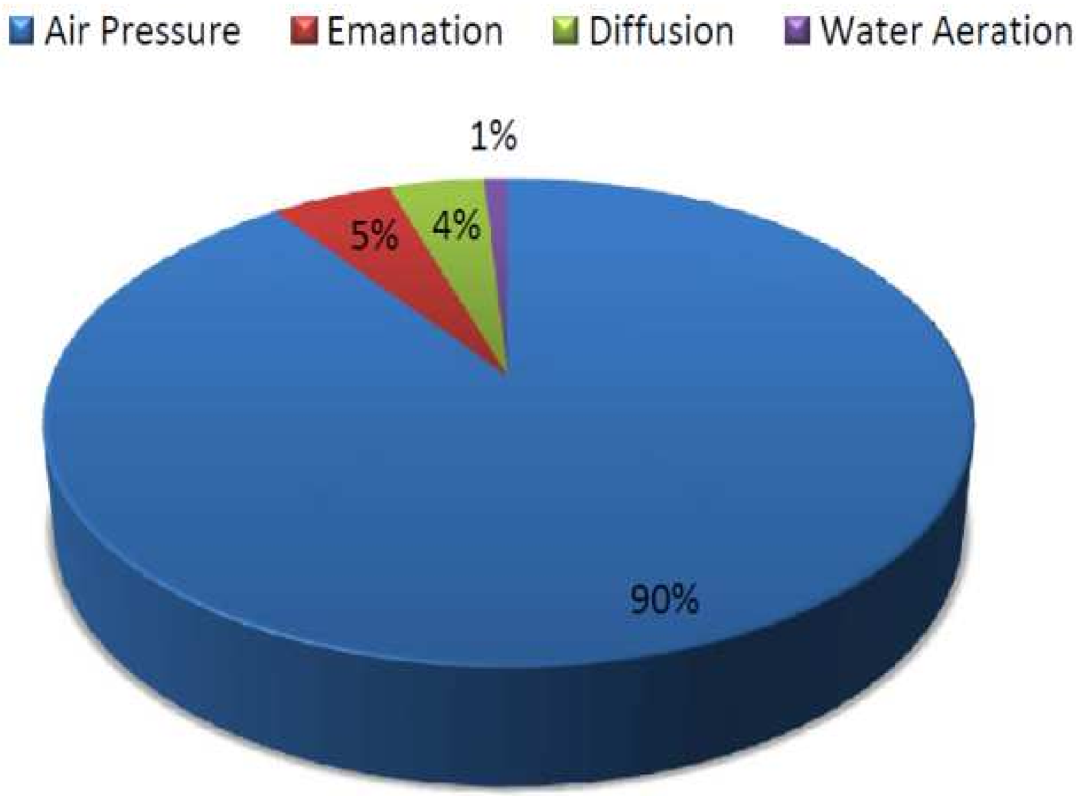
- What's needed to have a radon problem?

1. **Source**
2. **Pathway**
3. **Driving Force**

Soil Gas Pathways

- A. Cracks in concrete slabs.
- B. Spaces behind brick veneer walls that rest on uncapped hollow-block foundations.
- C. Pores and cracks in concrete blocks.
- D. Floor-wall joints (cold joints).
- E. Exposed soil, as in a sump or crawl space.
- F. Weeping (drain) tile, if drained to an open sump.
- G. Mortar joints.
- H. Loose fitting pipe penetrations.
- I. Open tops of block walls.
- J. Building materials, such as brick, concrete, rock.
- K. Well water (not commonly a major source in Minnesota homes)

Driving Forces for Indoor Radon Levels

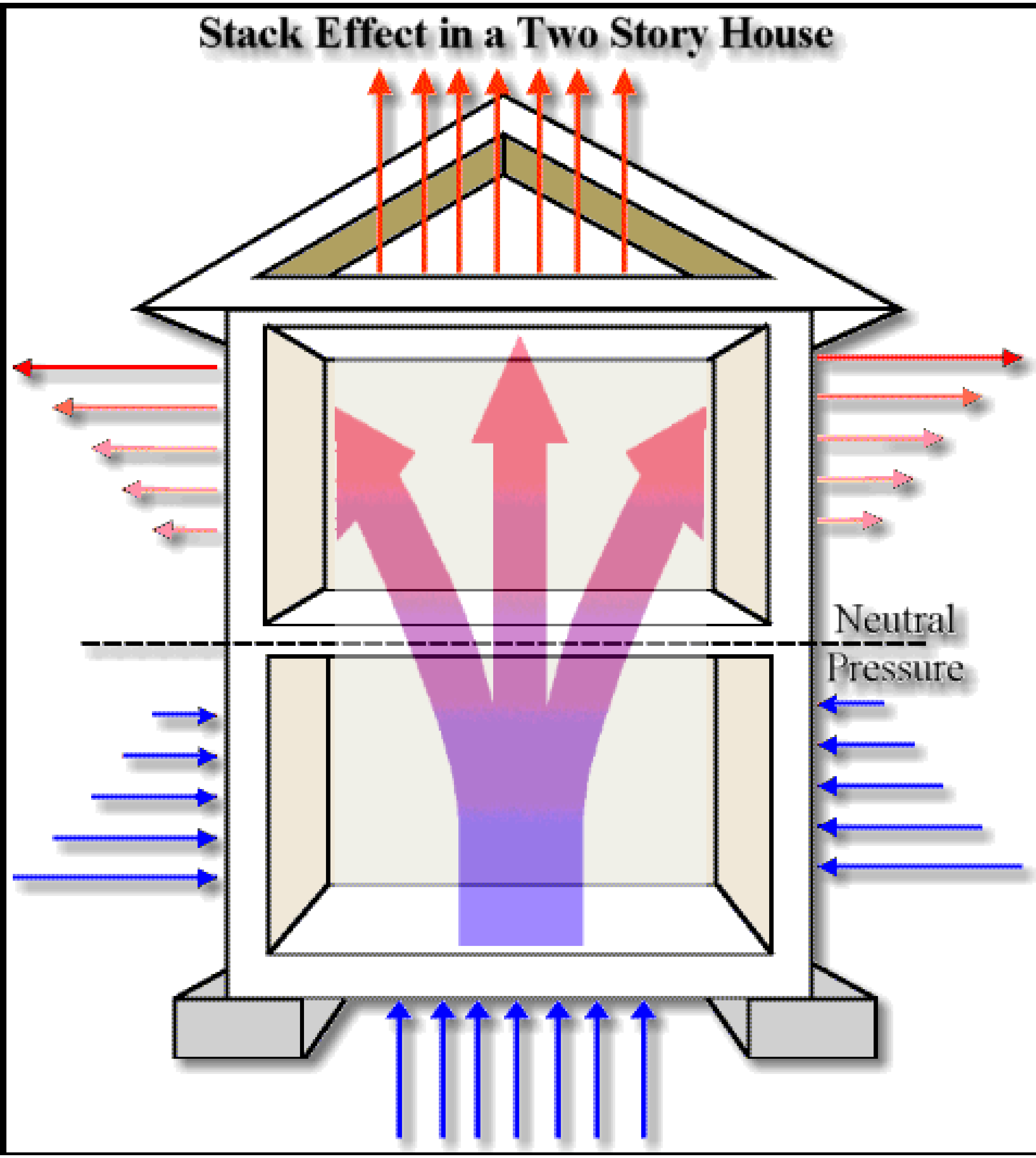


Air Pressure

Stack Effect: As warm air leaves the top of the house, air comes in the bottom of the house

Down Wind Draft Effect: Wind flowing over the top of a house creates the same effect as the stack effect

Vacuum Effect: Air mechanically exhausted from the house is replaced from other pathways


Stack Effect in a Two Story House
Neutral
Pressure


Where there's a helpful
smile in every aisle.
HyVee
DANGER
United Rentals
WHISPERWATT 7000
DANGER
DANGER

Try and Keep it Simple

- What's needed to have a radon problem?

1. Source
2. Pathway
3. Driving Force

- Keep these in mind this afternoon

- Here is our six step approach

Step 1 – Review Floor Plan

- Construction details
  - Walls
  - Foundations
  - Plumbing
  - Drainage
  - Radon entry points
  - Soil capping
  - Other strange things
- HVAC details
  - Ductwork location and condition

Step 2 – Review Radon Tests

- Who tested?
- What did they use?
  - AC, AT, CRM
- Where were they placed?
  - Lowest level, each room, etc.
- When were they conducted?
  - Occupied vs. Unoccupied
- Why did they test?
  - Real Estate, Health & Safety, Schools
- How did they test?

Step 3 – Additional Testing

- Test each room at the same time
  - Basement
  - Other floors
- Test occupied vs. unoccupied times
- HVAC on / off
- Test during different season or usage patterns
- Analyze these results to determine:
  - Where is the problem
  - When is it a problem
  - "Easy" solution

Step 4 – On-Site Building Inspection

- Review floor plan during walk through
- Take notes
- Look for:
  - Air leaks
  - Depressurization sources
  - Barriers to PFE
- Evaluate existing radon system(s)
  - Flow
  - Pressure
- Blower door to determine building tightness

Air Leaks

- Air loss through the floor
  - Plumbing knock outs
  - Cold joints and cracks
  - Sump lids
  - Penetrations
- Air loss to outside of foundation
  - Gravel
  - Karst
  - Day lighted drains you can’t find
  - Connections to city utilities (gravel trenches)

Depressurization Sources

- Exhaust fans
- Dryer
- Kitchen vent hood
- Attic fans
- Water Heater
- Furnace
- Unbalanced ventilation appliances

Step 5 – Conduct PFE

- Pressure Field Extension on existing system
  - Map results
  - Identify gaps in PFE
- Drill additional PFE holes as necessary
- Tweak system or create new suction point where PFE lacking
  - Repeat above
- Use sniffer to find stronger sources
  - Areas of low/no PFE
  - Block cores

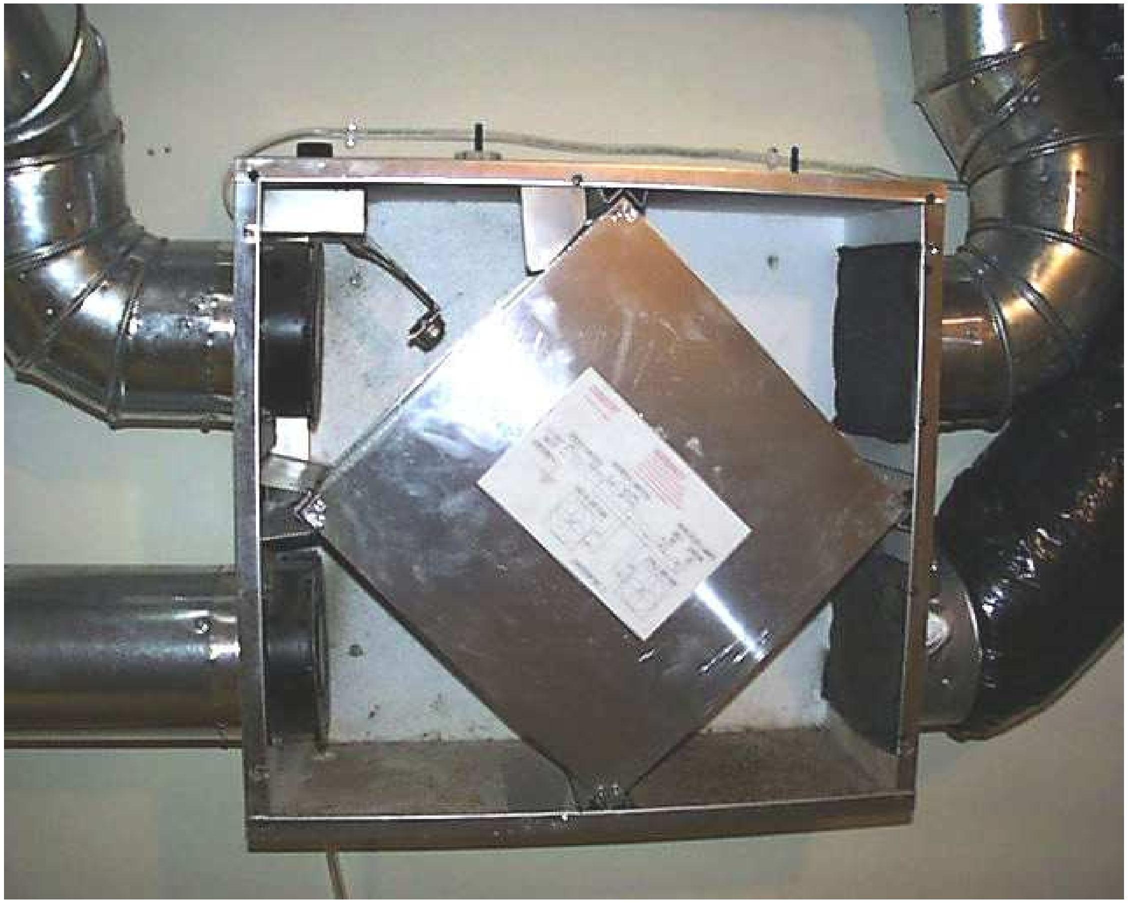
Step 6 – Ventilation Tweaks

- Only made by qualified people
- Mostly in schools and commercial buildings
- Useful in homes if furnace fan is rated for continual use
  - Rarely used
  - Not permanent
  - On-going issues as stand alone technique
    - Operating costs
    - Future ownership usage

Active Mitigation

- Uses fan to draw soil gas from sub-slab and vents above the roof
- Used for both existing and new construction
- ASTM E-2121 "Radon Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings"
  - Additional Standards published by AARST.org
- Measure Pressure Field Extension (PFE)

Why do all that, I have an HRV for that…



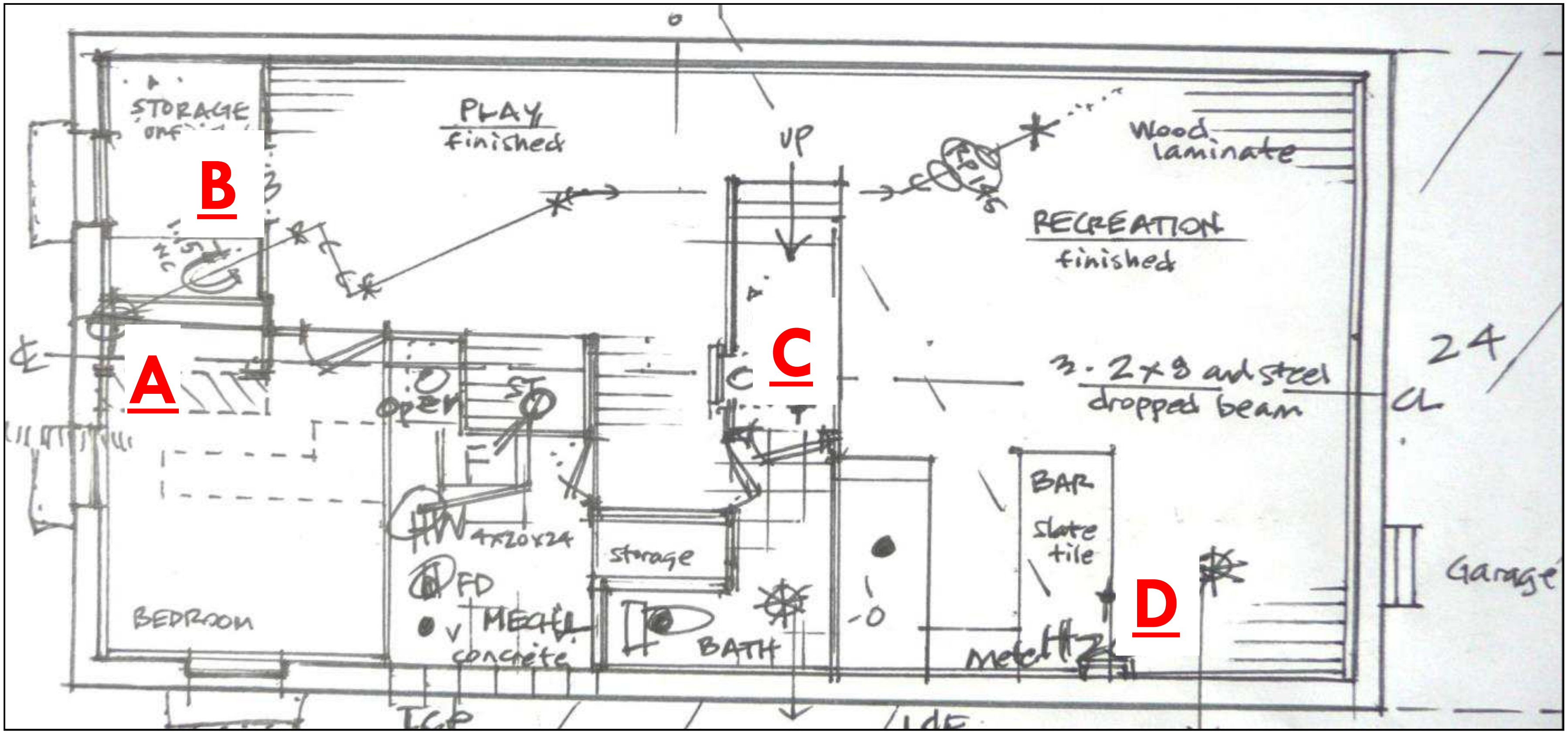
- Dilution Helps…a little bit
- Can cause more problems if not maintained

Mitigation in Existing Buildings

Example 1

- 1960s rambler
- Full basement, load bearing columns, not footing
- Contractor had PFE issues
- Radon ~ 18.0 pCi/L
  - Ave. of duplicates in heating season

Designing a Mitigation System

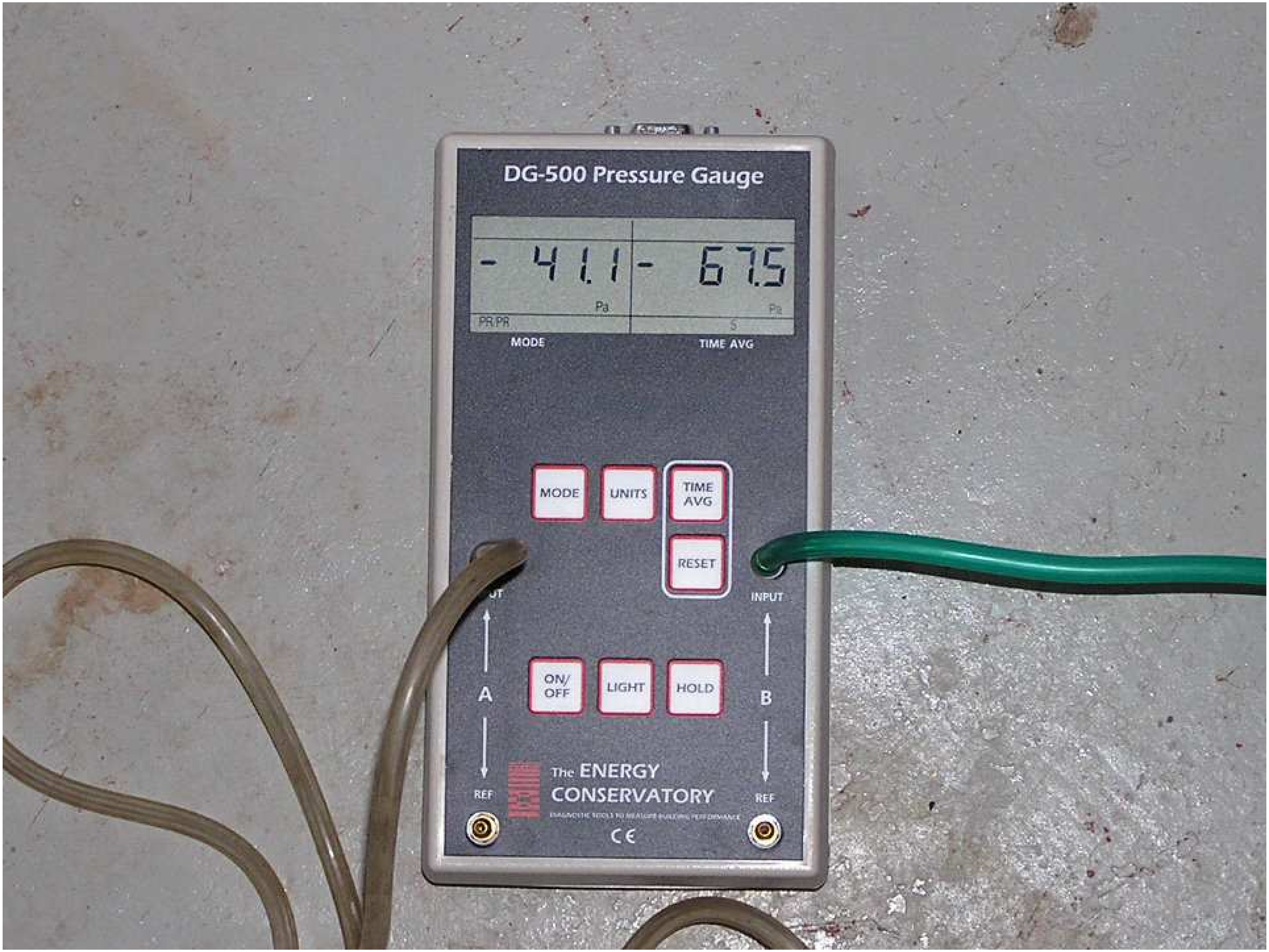


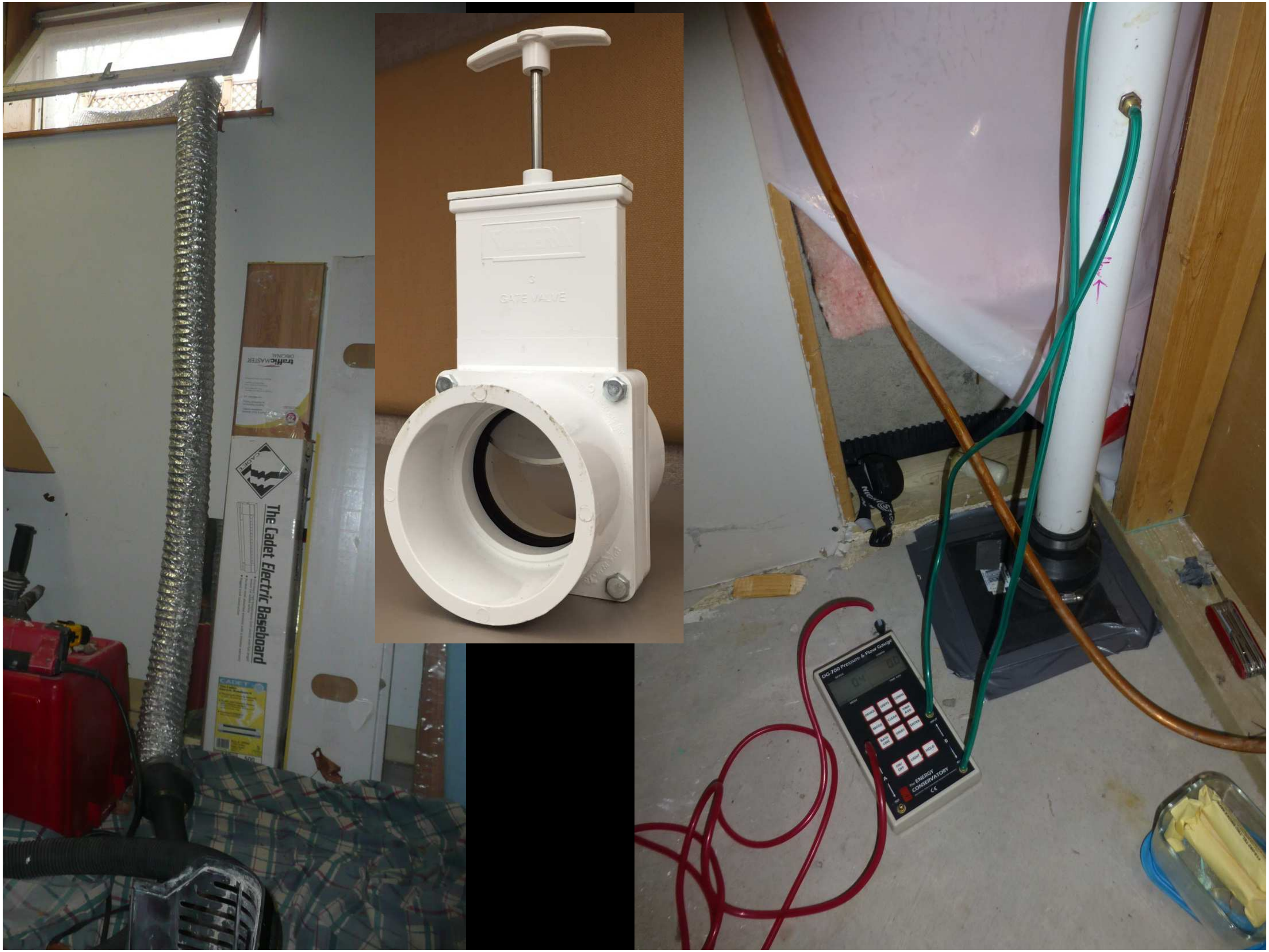
A: Desired suction point (pit)

B: Test hole 8 ft. away

C: Test hole 18 ft. away

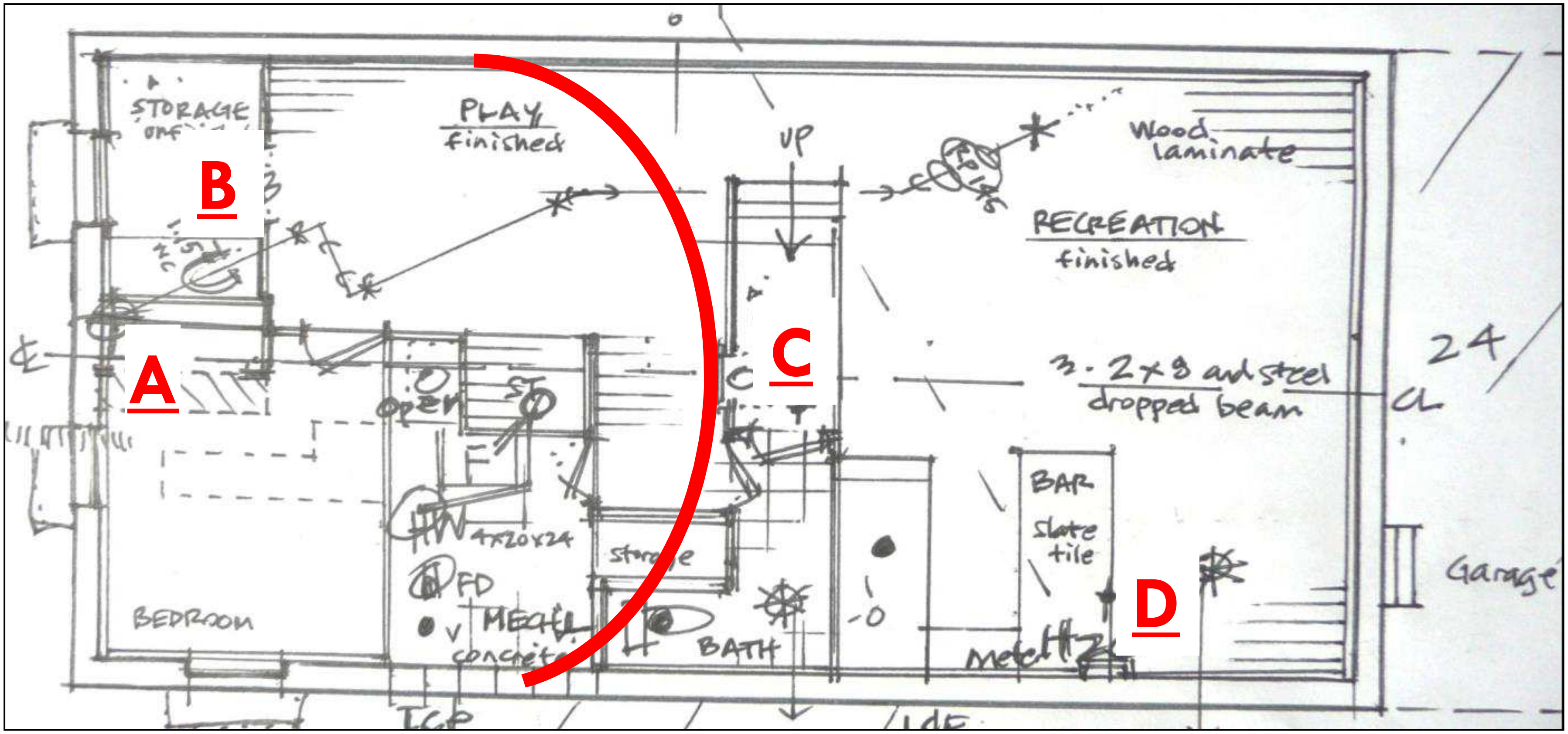
D: Test hole 35 ft. away


DG-500 Pressure Gauge
- 41.1
Pa
- 67.5
Pa
PR/PR
5
MODE
TIME AVG
MODE
UNITS
TIME AVG
RESET
INPUT
A
B
ON/ OFF
LIGHT
HOLD
REF
REF
The ENERGY CONSERVATORY
CE



The Cadet Electric Baseboard
3
GATE VALVE
DG-700 Pressure & Flow Gauge
The ENERGY CONSERVATORY

Initial PFE w/Vacuum – No Pit



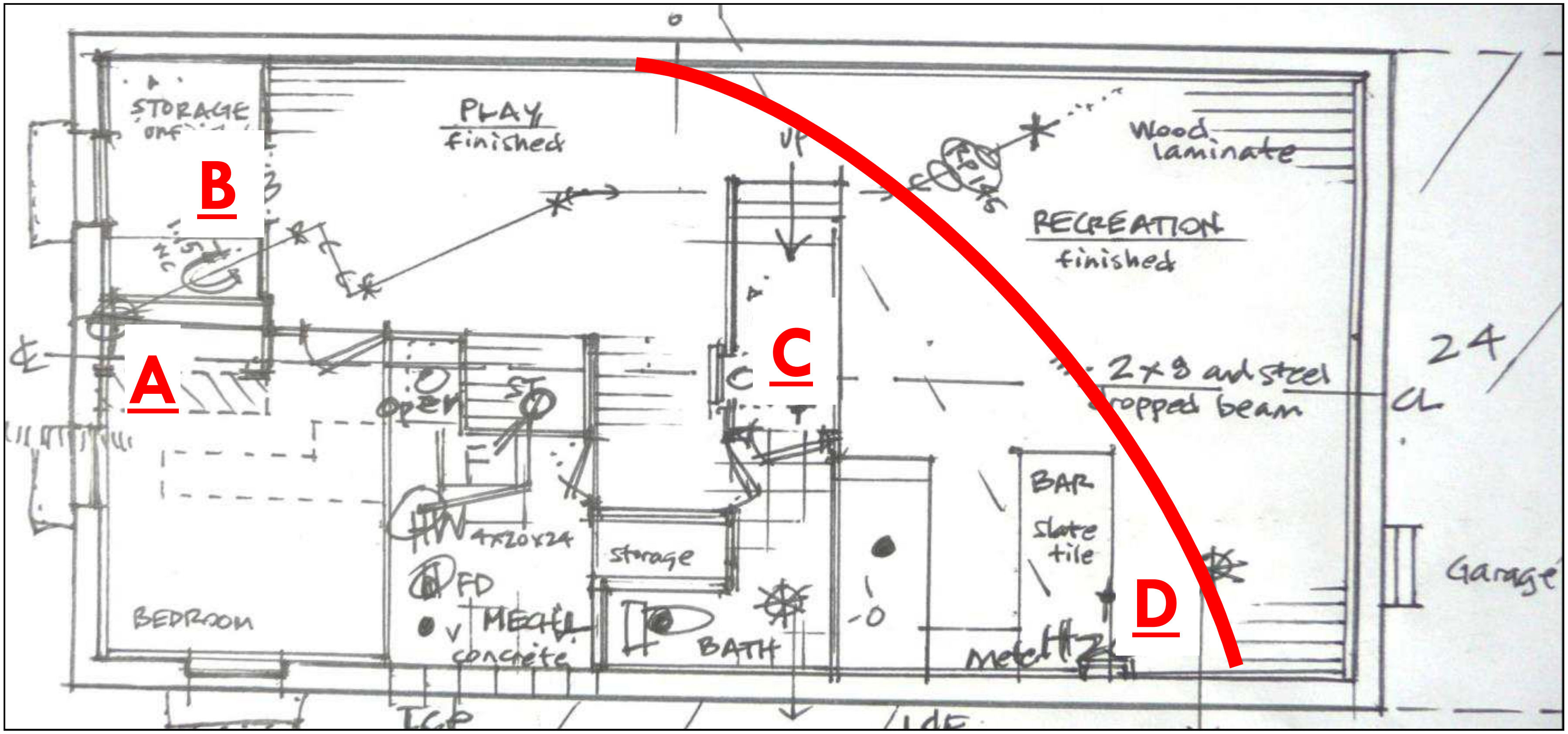
A: -1250+ Pa

B: -4.7 Pa

C: 0.0 Pa

D: 0.0 Pa

PFE w/ Vacuum – 5 Gallon Pit



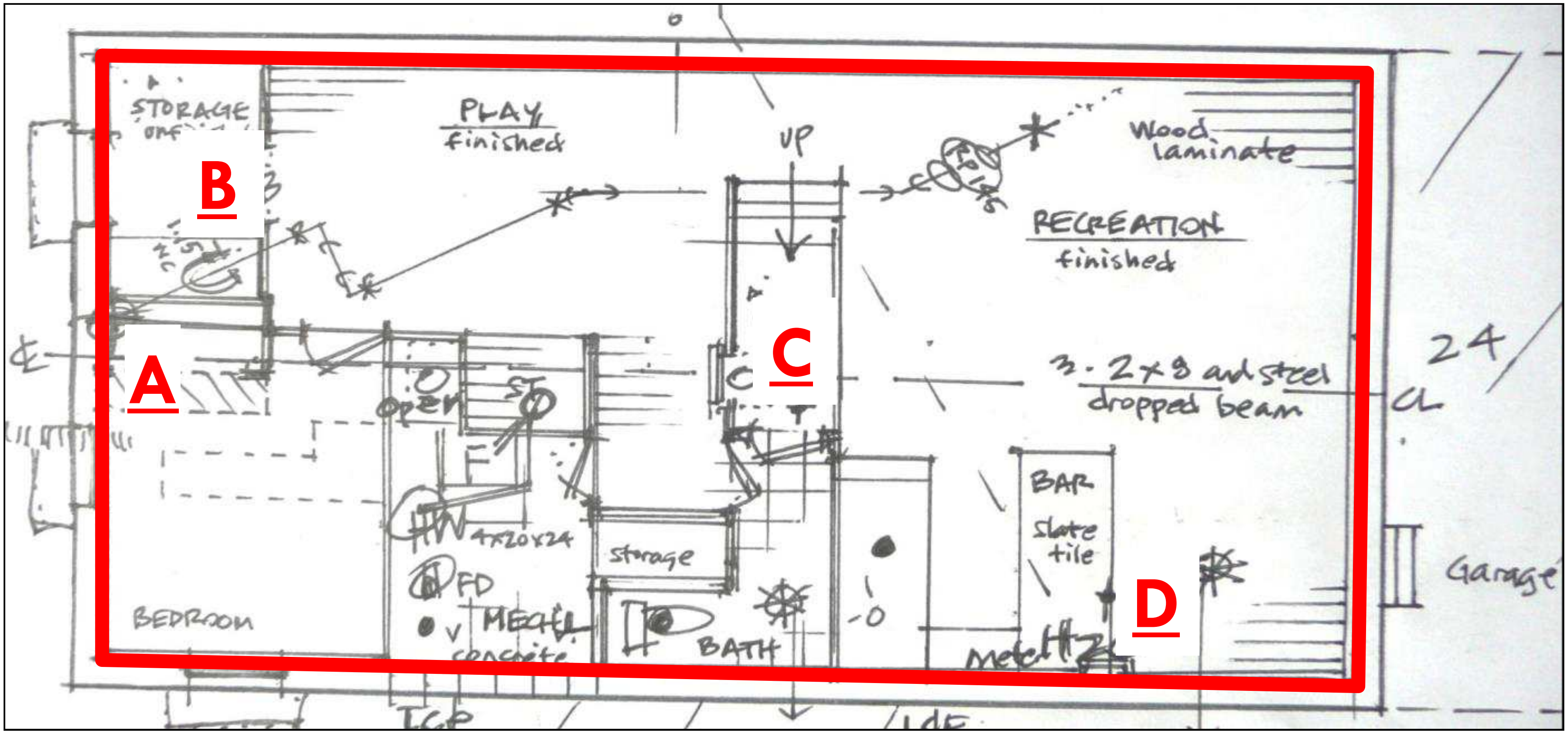
A: -975 Pa

B: -21.1 Pa

C: -8.3 Pa

D: -3.1 Pa

PFE w/ Vacuum – 10 Gallon Pit



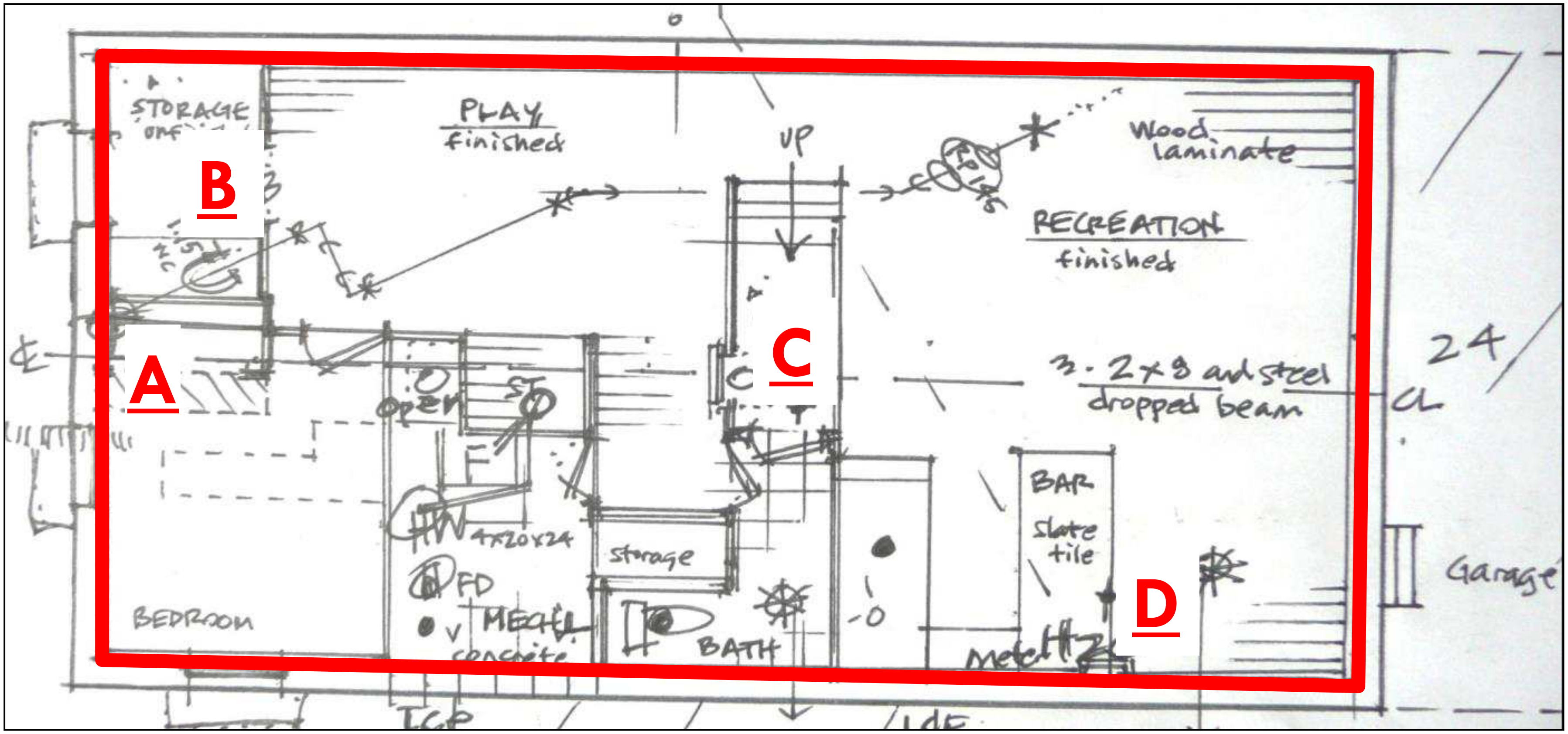
A: -892 Pa

B: -33.3 Pa

C: -13.6 Pa

D: -6.0 Pa

Optimizing Fan to System – RP145



A: -402 Pa

B: -26 Pa

Rn = < 0.3 pCi/L

C: -7.5 Pa

D: -4.0 Pa

Example Contractor Lessons Learned

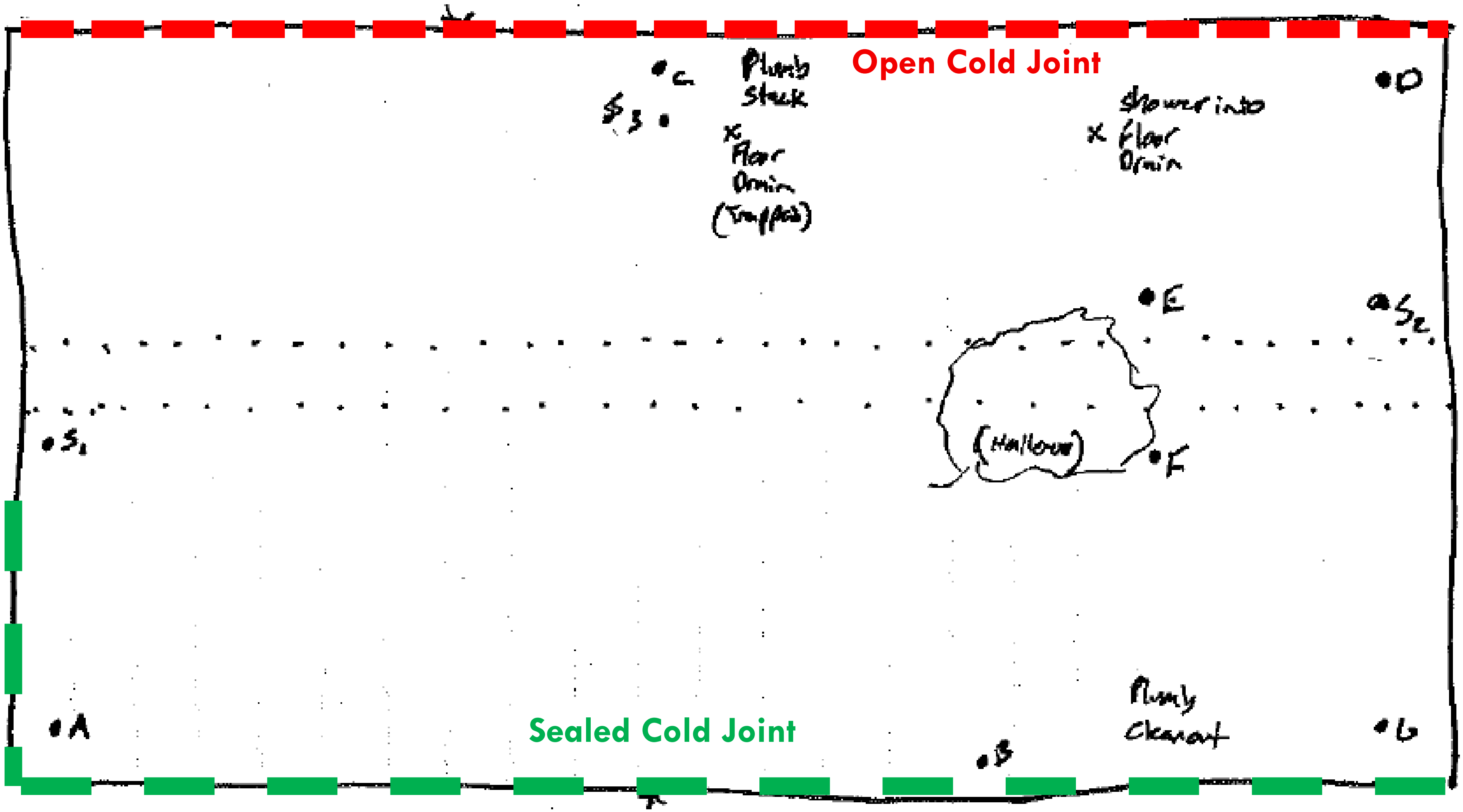
- Always conduct PFE
- Larger suction pits allow for better PFE
- No need to fear tight soils
- Don't assume high suction fans in tight soils
- Find easy and hidden PFE ports

Case Study 2

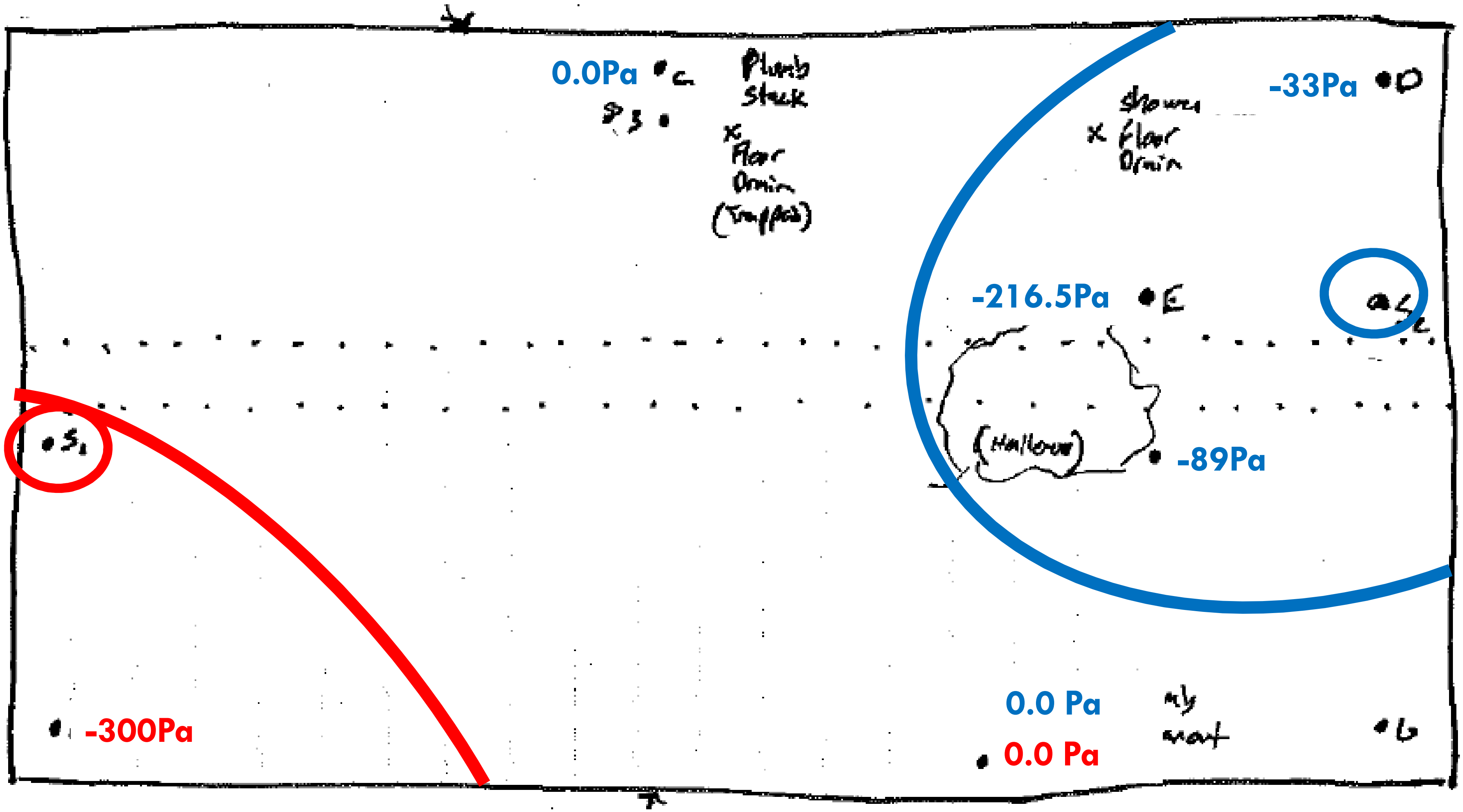
BTC Example 2

- 1960s rambler
- Radon levels between 17-18 pCi/L
- Experienced contractor cannot get communication
  - “Wet Poopy” soils
  - 2 suction pit locations
  - Only 3 PFE ports in “head scratching” locations

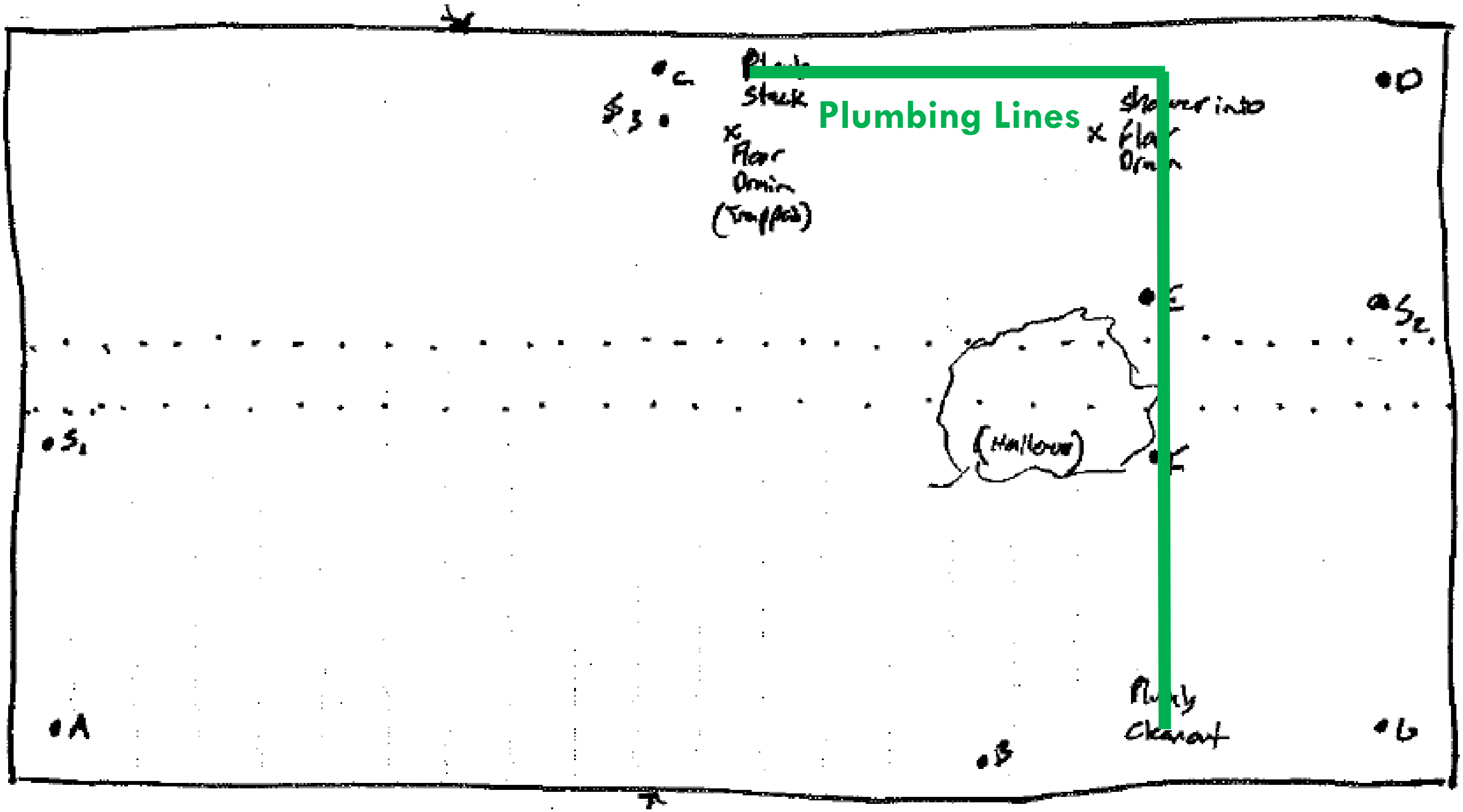
BTC Example 2



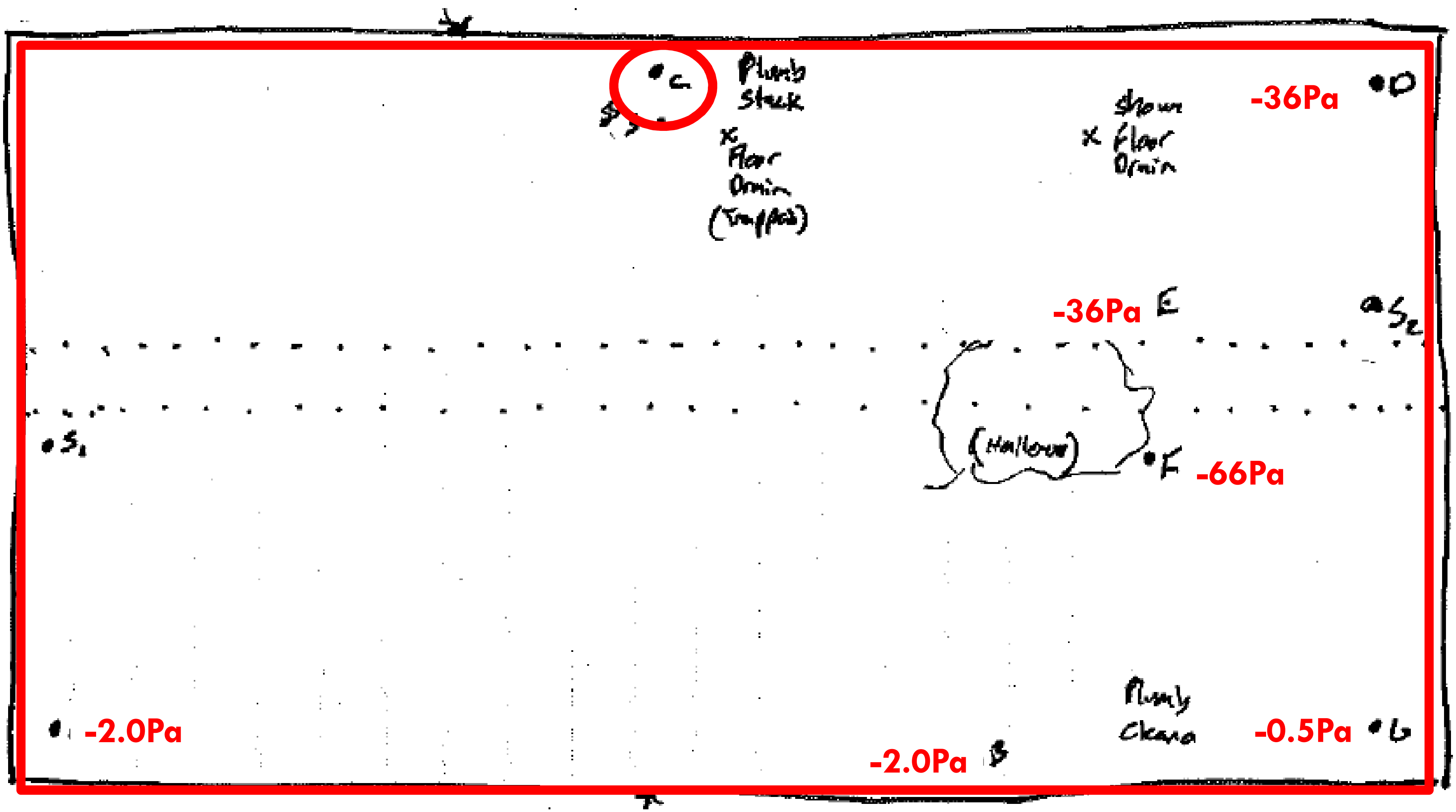
BTC Example 2



Why not use Plumbing Routes



Move Suction Point for Plumbing



Example 2 Lessons Learned

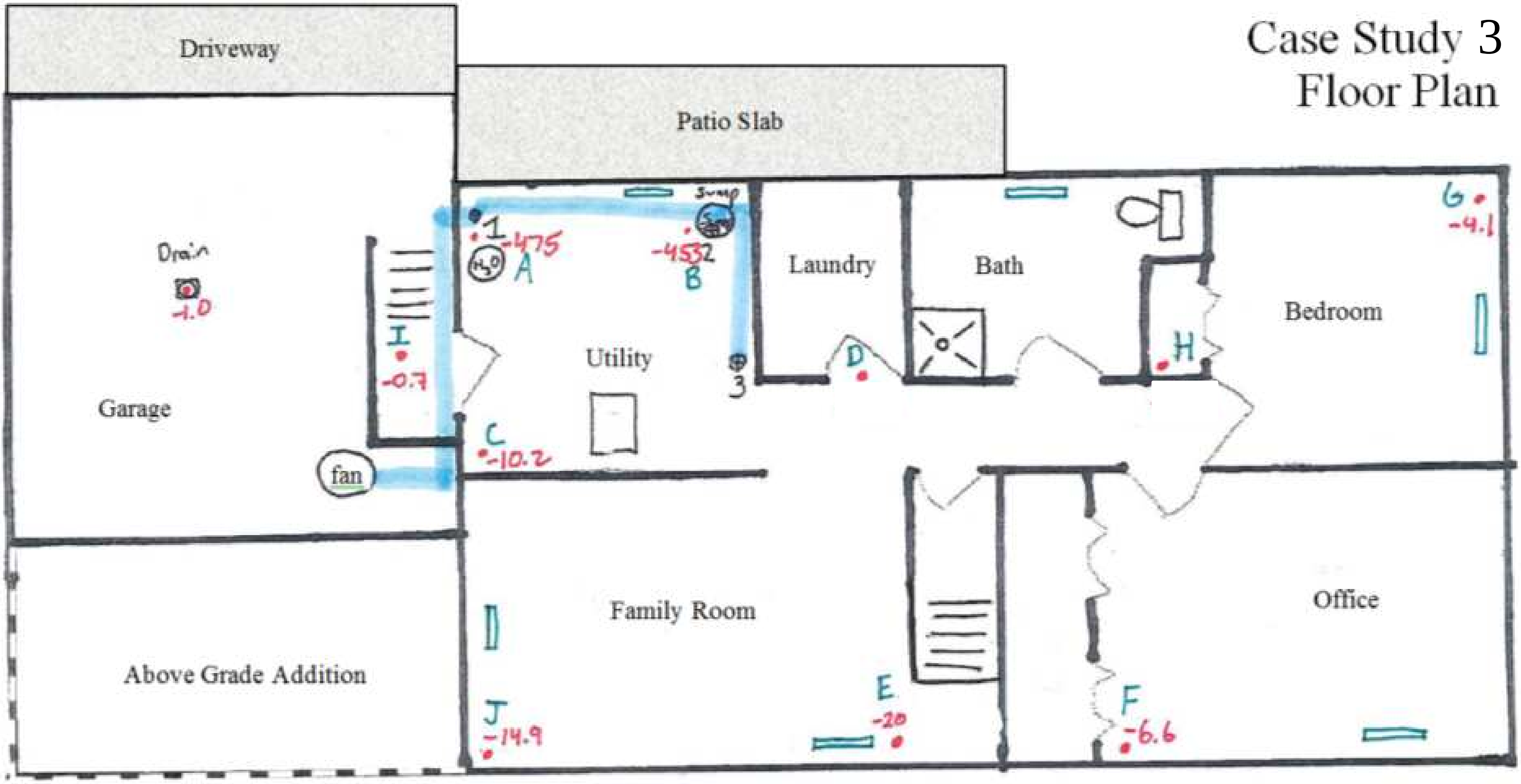
- Better located suction pits allow for better PFE
- Reversing suction pits and diag. test holes can help
- No need to fear tight soils
- Don’t assume high suction fans in tight soils
- “Thou shalt find plumbing routes during diagnostics.”

Case Study 3

Background

- Rambler built in 1987 on deep gravel bed
- 700 sq. ft. basement footprint
- Homeowner concerned Rn high in winter
- Sump with deep drain tile
- Sub-slab ductwork – well sealed
- Contractor did not do PFE
- Original system installed in 2008
- MDH Listed and NRPP certified professional
- 175’ equivalent length of 3” pipe

Case Study 3
Floor Plan



Radon System Specs:
3" pipe
3 suction points
2 in floor (1 and 3)
1 in sump (2)

Flows w/ HP220 @ 1.1" WC:
1 = <10 CFM
2 = 26 CFM
3 = <10 CFM
Red PFE numbers = Pascals WRT basement

March 15, 2013
Overcast and flurries
Little to no wind
25 degrees F
Snow cover

Background Radon Levels

- March 14, 2007 = 96.3 pCi/L
- March 28, 2007= 42.0 pCi/L

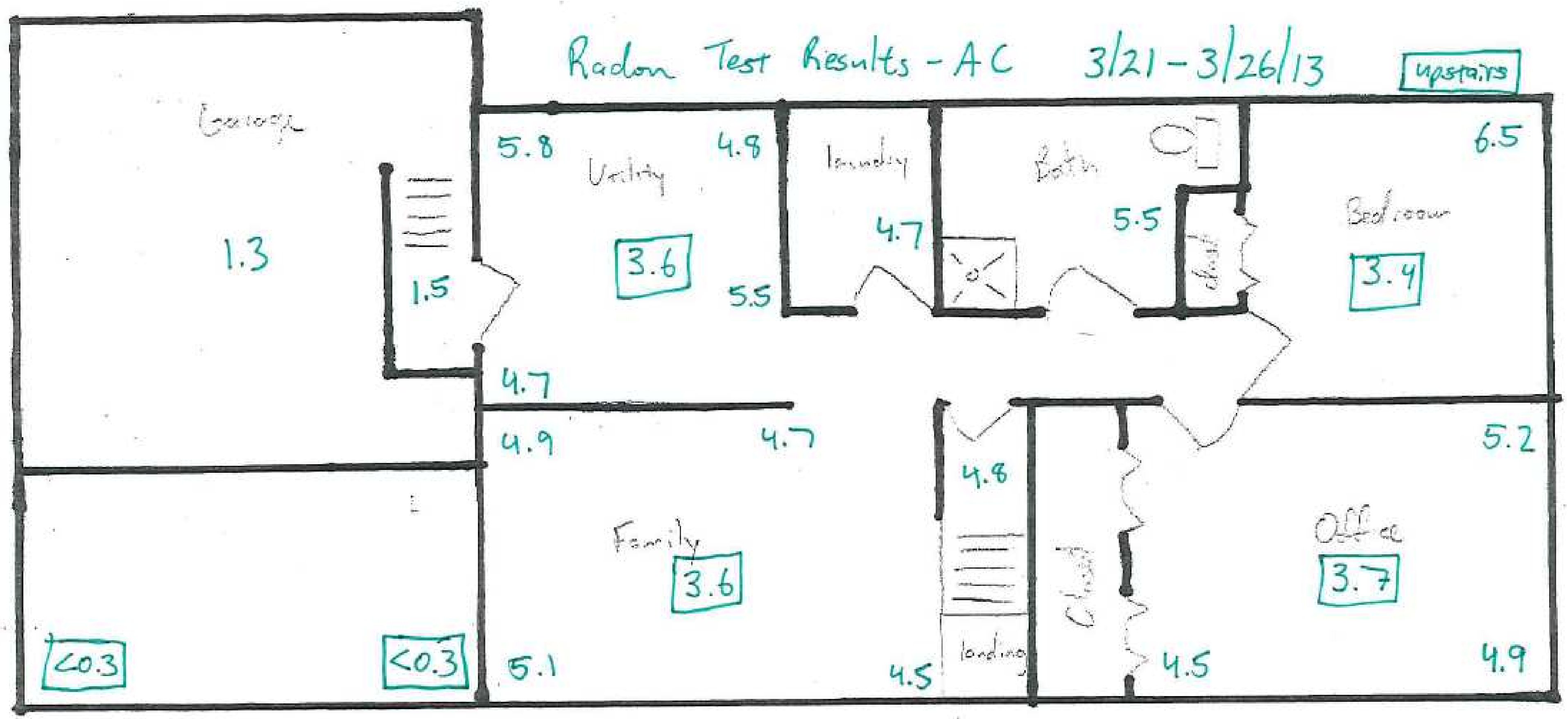
System Installed

- April 16, 2007 = 4.5 pCi/L

Additional Suction points added

- May 1, 2007 = 1.0 pCi/L
- December 12, 2008 = 17.3 pCi/L
- Additional tests show elevated radon in heating season only

Simultaneous Radon Results

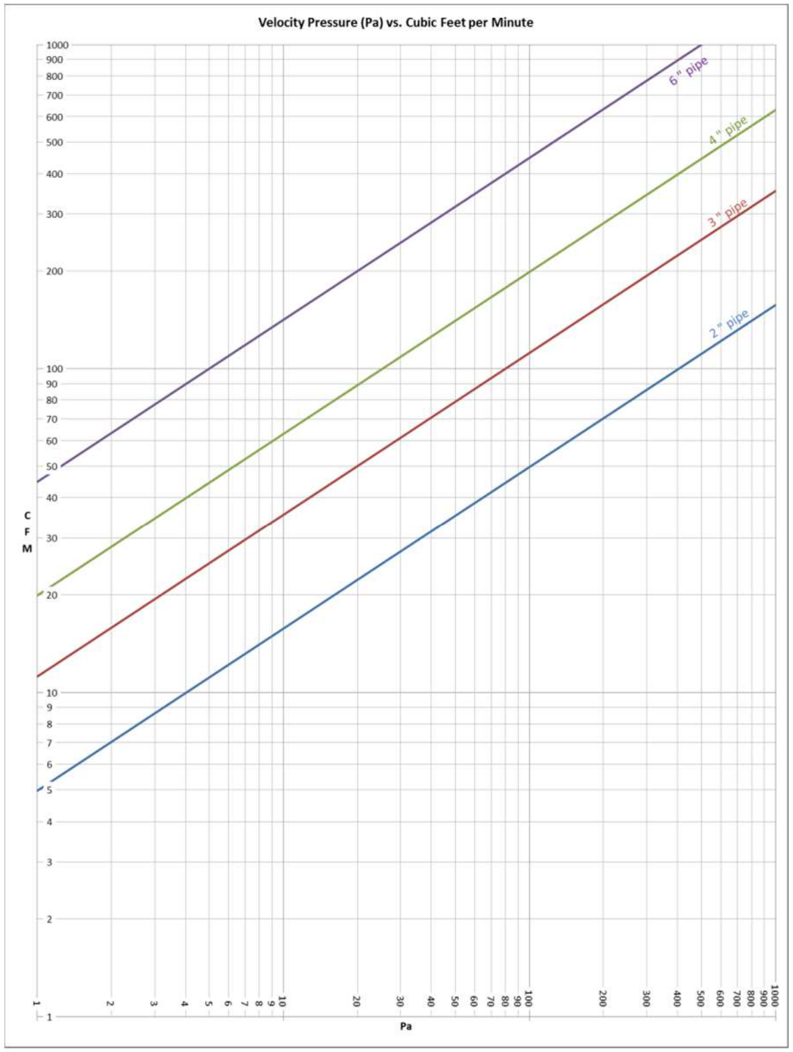


Discussion

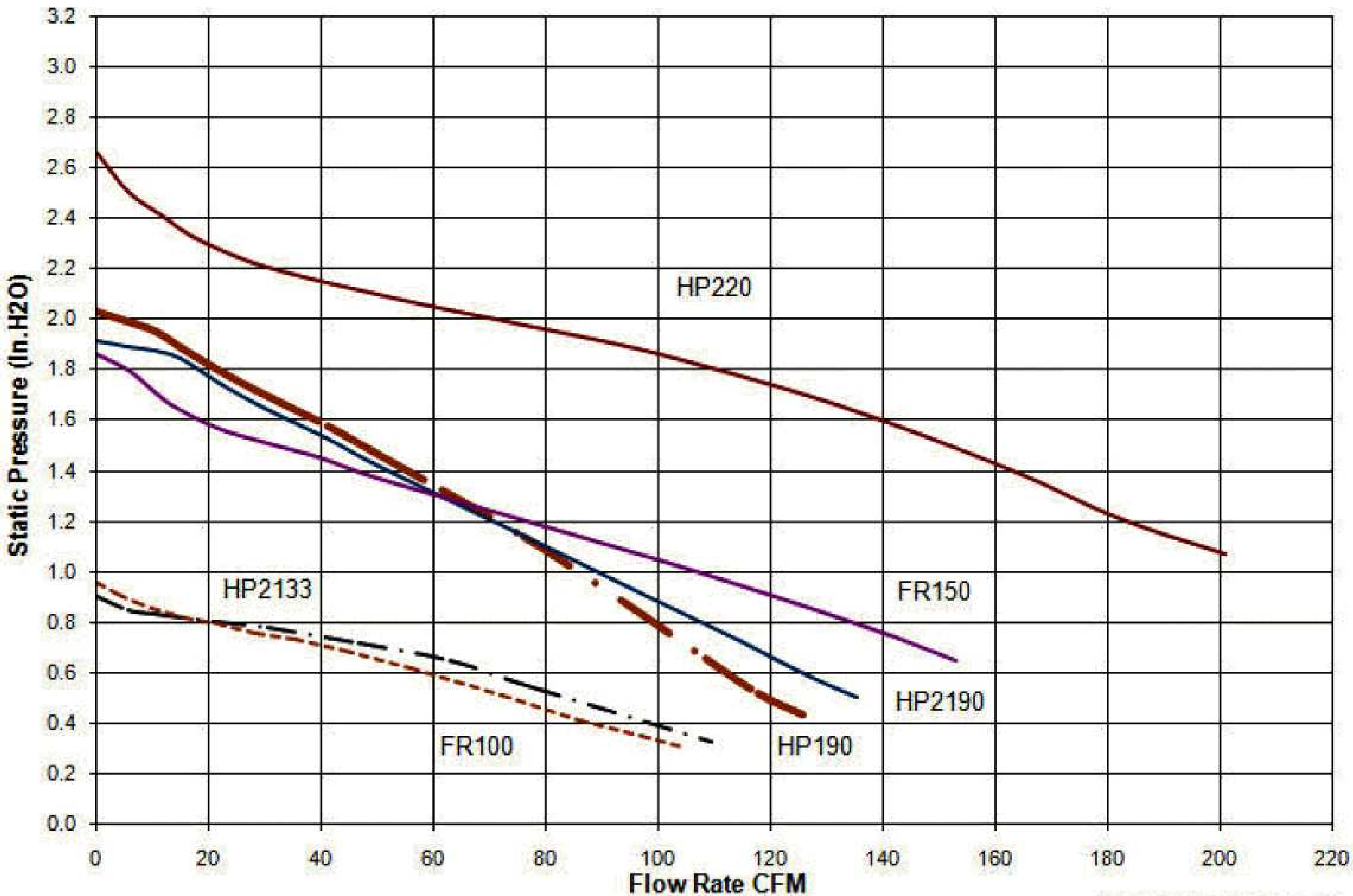
- What are some possible issues?
  - Is there PFE everywhere?
  - Why the seasonal radon issues?
  - Do the ducts play a role?
  - Why the flow differences in suction pits?

Calculating Airflow

- Pitot Tube
- Flow Tube
- Run Calculations
- Use Chart



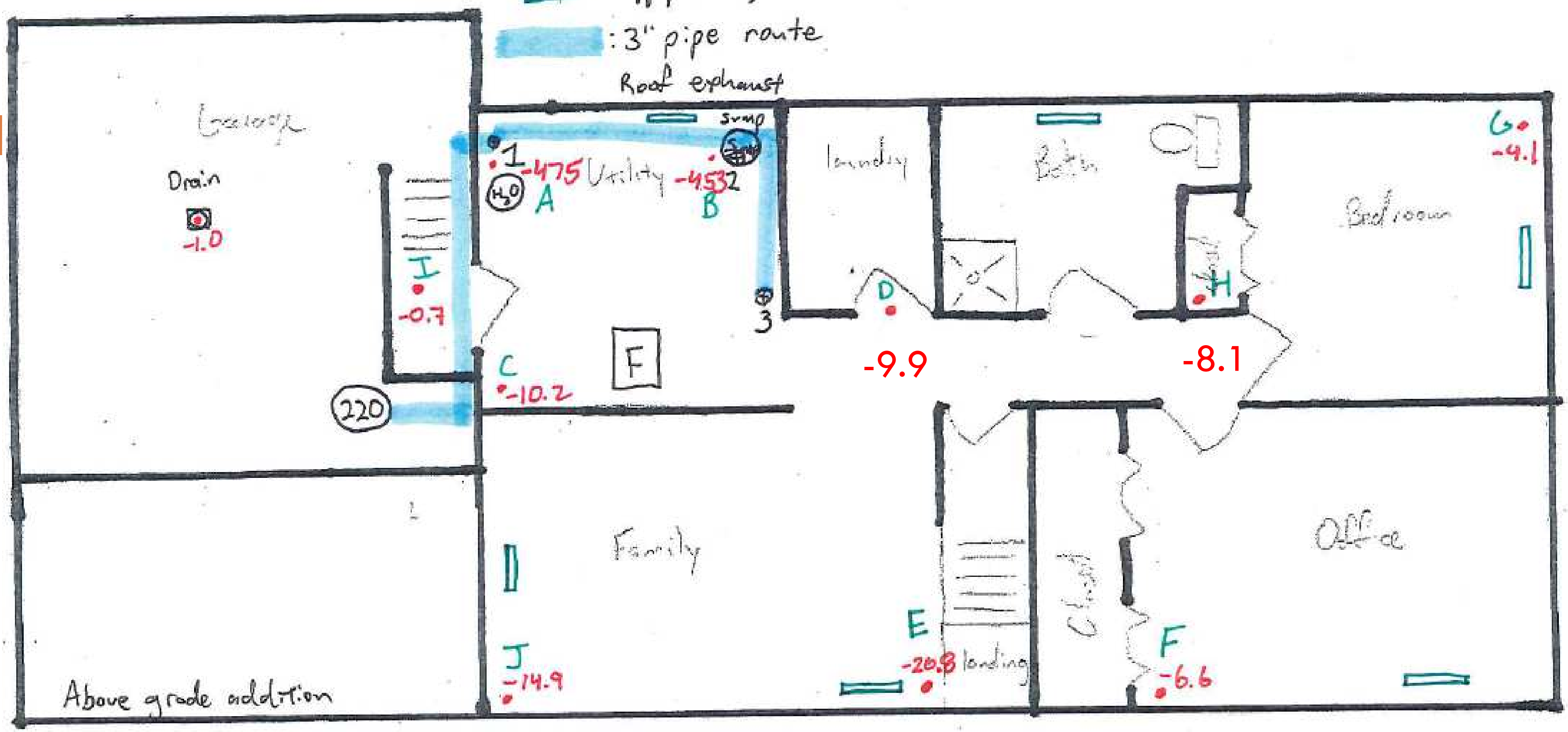
Comparison Of FanTech Fans w/10' of 4" pvc pipe



www.wpb-radon.com

Is There an Air Leak?

March 15, 2013



System Specs upon arrival

3" pipe
HP 220 @ 1.1" WC on U-tube
3 suction pts - 2 floor
1 Sump lid

Weather: Overcast
Flurries
25° F
Snow Cover

Flows:
SP1 = <10 cfm
SP2 = 26 cfm
SP3 = < 10 cfm

No Air Leak to Inside

- What's the issue? Why is radon still coming in?
  - Sniffing showed uniform source strength
  - Nothing in blocks
- Are we overcoming Max Depressurization of the house?
  - How do you know?
    - Measure it
  - How do you measure it?

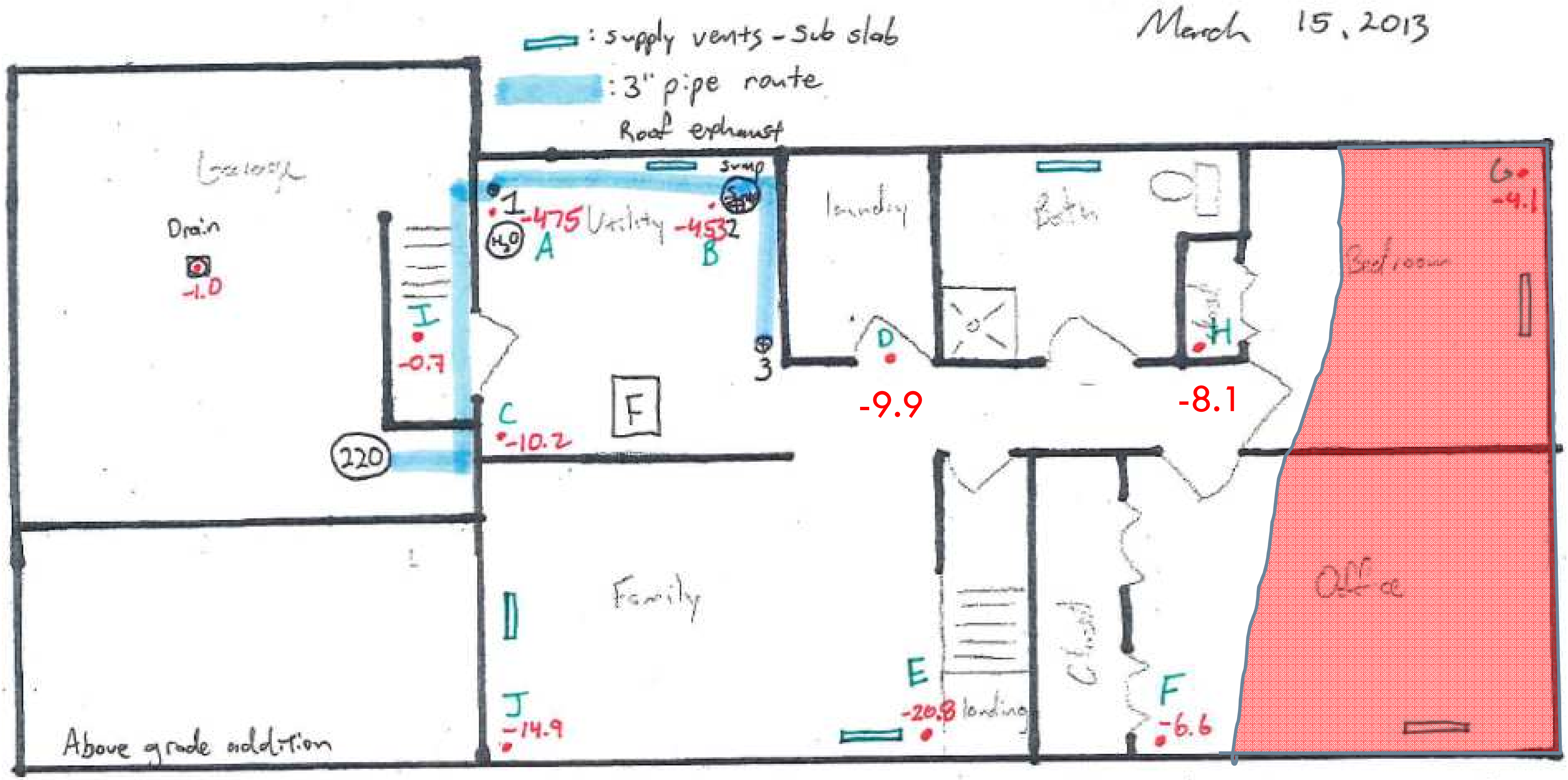
Creating Max Depressurization

1. Establish Closed House Conditions
2. Measure ΔP with Furnace on and off
   - Use higher ΔP setting
3. Turn on all exhaust fans
   - Baths
   - Kitchen hood
   - Dryer
   - Attic fans
4. Check for backdrafting
5. Measure final ΔP from basement to outside

Max ΔP

- House's Max Dep. = -6 Pa ΔP to outside

Are We Really Winning?

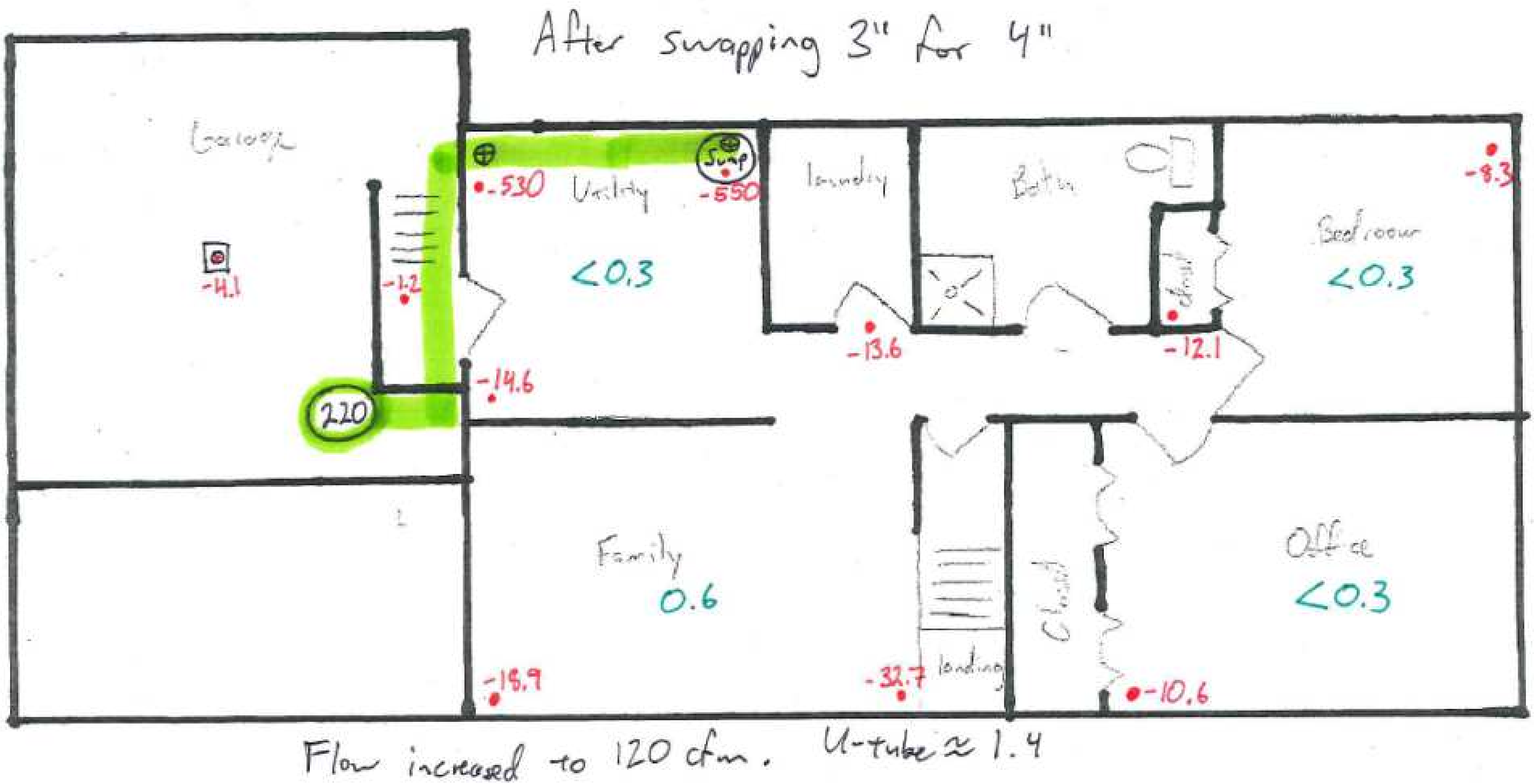


Give yourself 2 Pa wiggle room on PFE

Permanent Solution

- Move more air
- Used same fan
- Increased pipe size to 4”
- Radon levels in heating season w/ snow cover:
  - < 0.3 – 0.6 pCi/L

Final System Design



Takeaways

- More airflow through larger pipe
- May need to seal air leaks prior to PFE
- Need to know what you are up against
- Value of diagnostics
  - Material selection
  - Fan selection
  - Reduce call backs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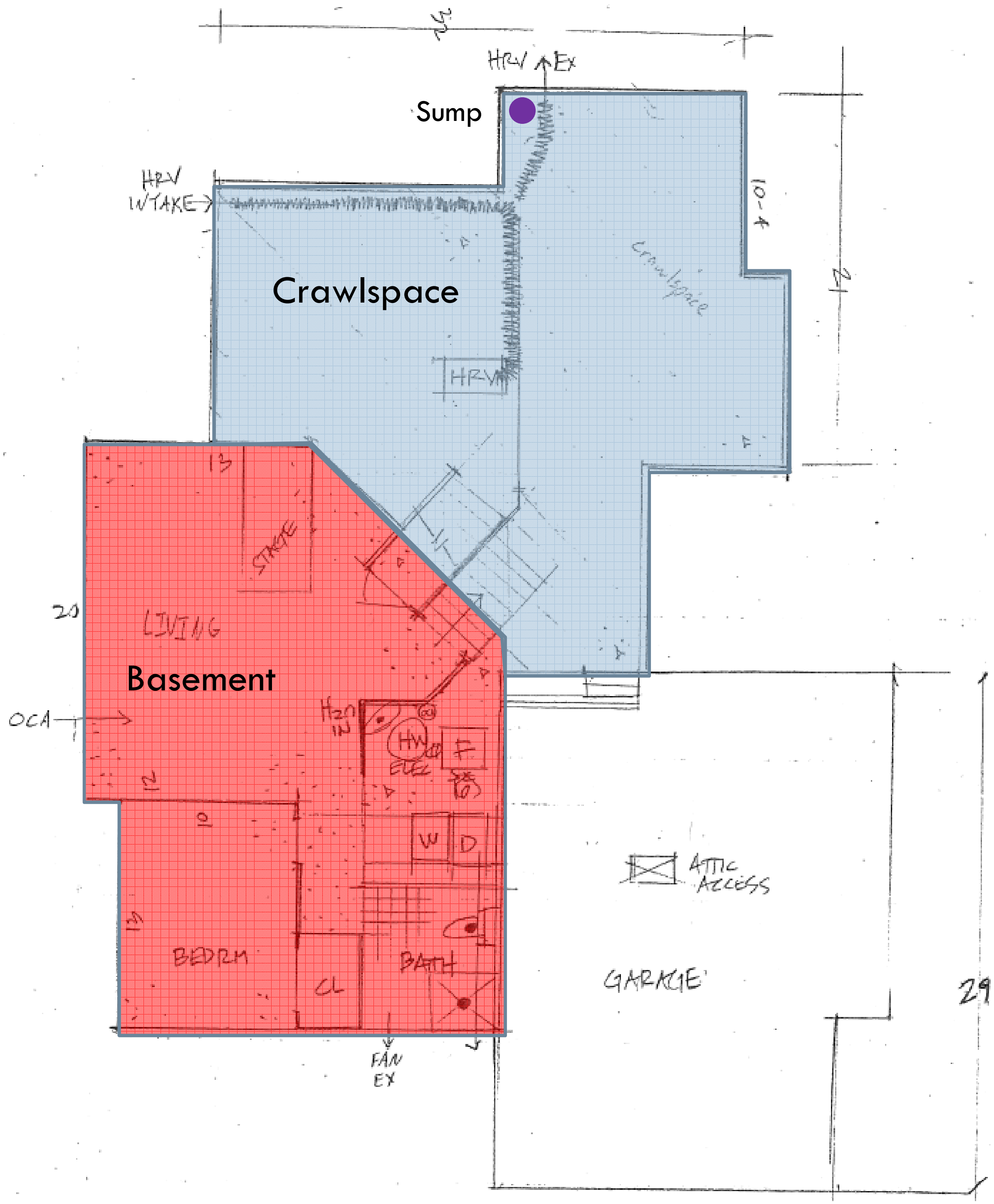
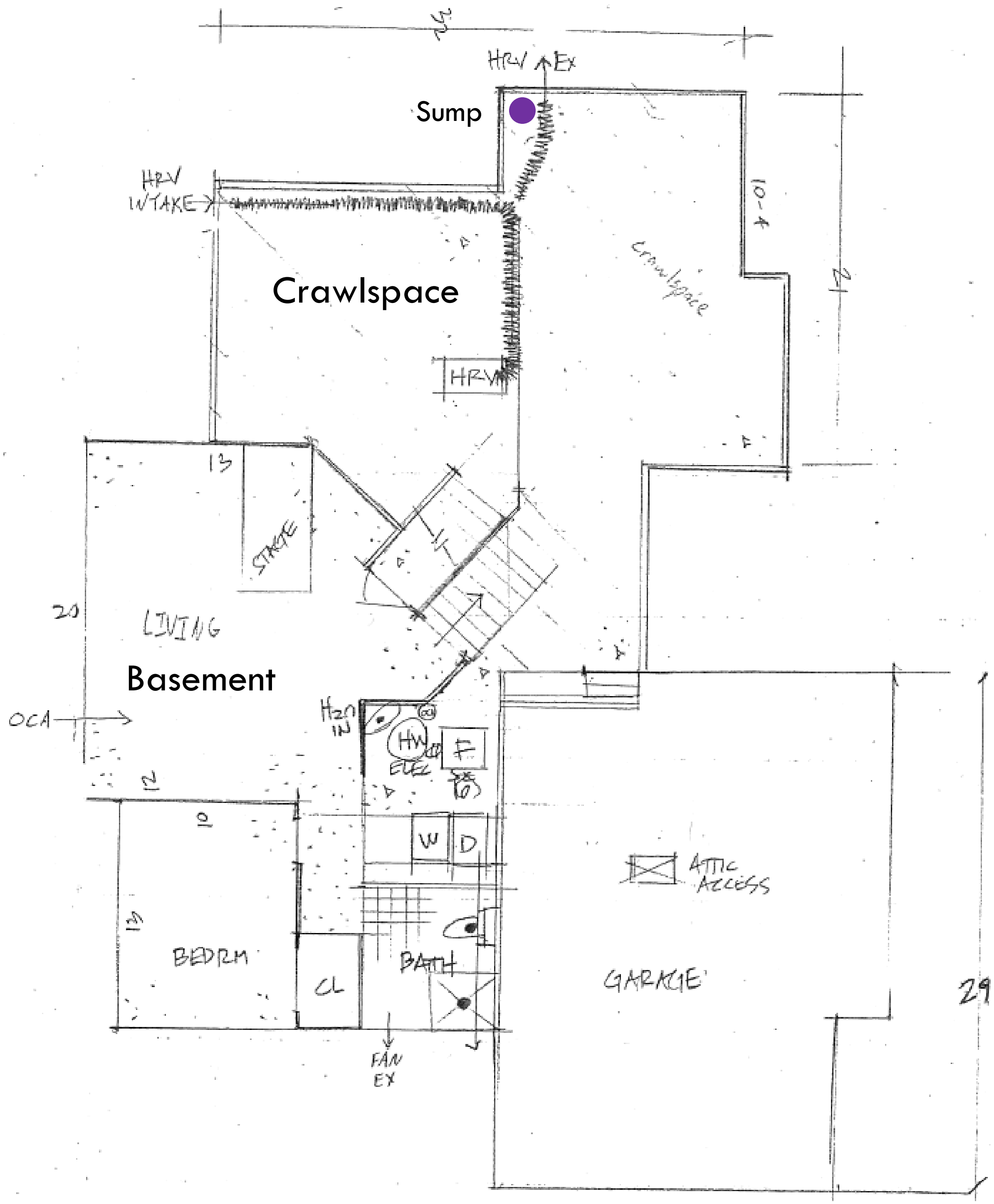
Background

- Modified Split Level
- 600 sq. ft. basement / 800 sq. ft. crawlspace
- One 1400 sq. ft. slab
- Built in early 2000s
- Rebuilt after summer 2009 tornado
- Poured concrete walls
- Sump with drain tile – bone dry / no pump
- High eff. furnace, electric H_2O, HRV installed
- Heating season condensation issues



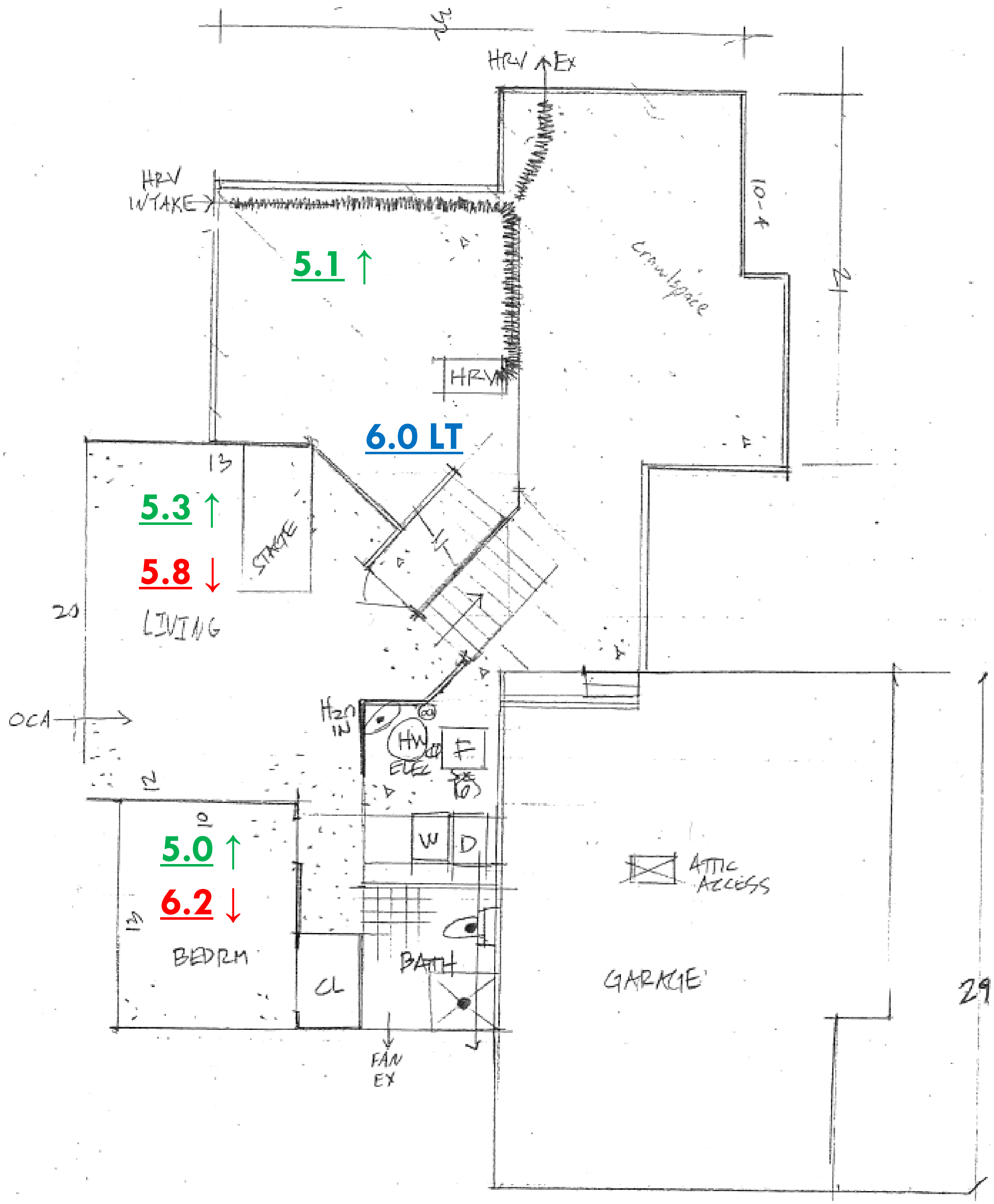
- Floor plan discussion



- Floor plan discussion

History of Radon Levels

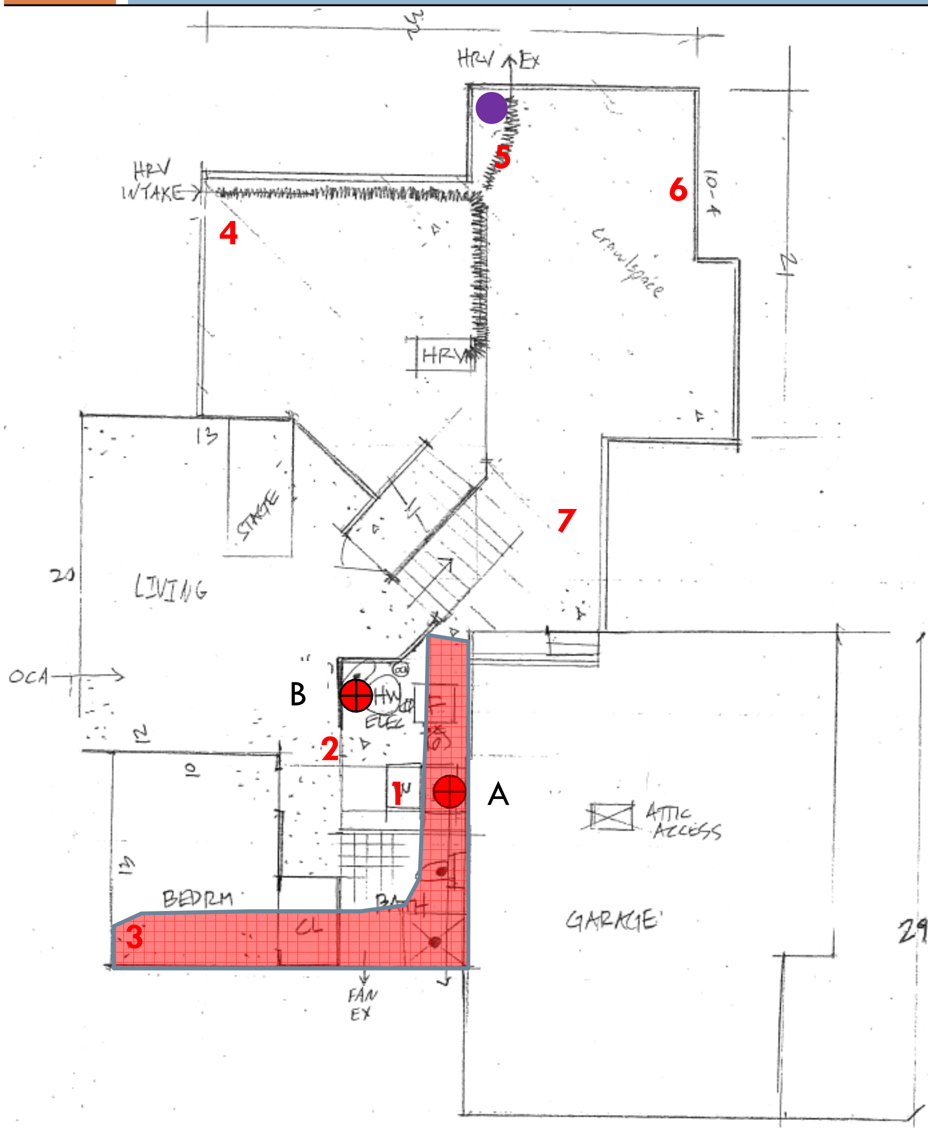
- Jan. 2013 = 5.2 - 6.2 pCi/L
  - Closed house conditions
  - HRV running normally
  - Tested multiple locations
  - Rn ~ same everywhere
- LT from Feb. - August = 6.0 pCi/L
  - Placed in living room above crawlspace



Radon Test Results

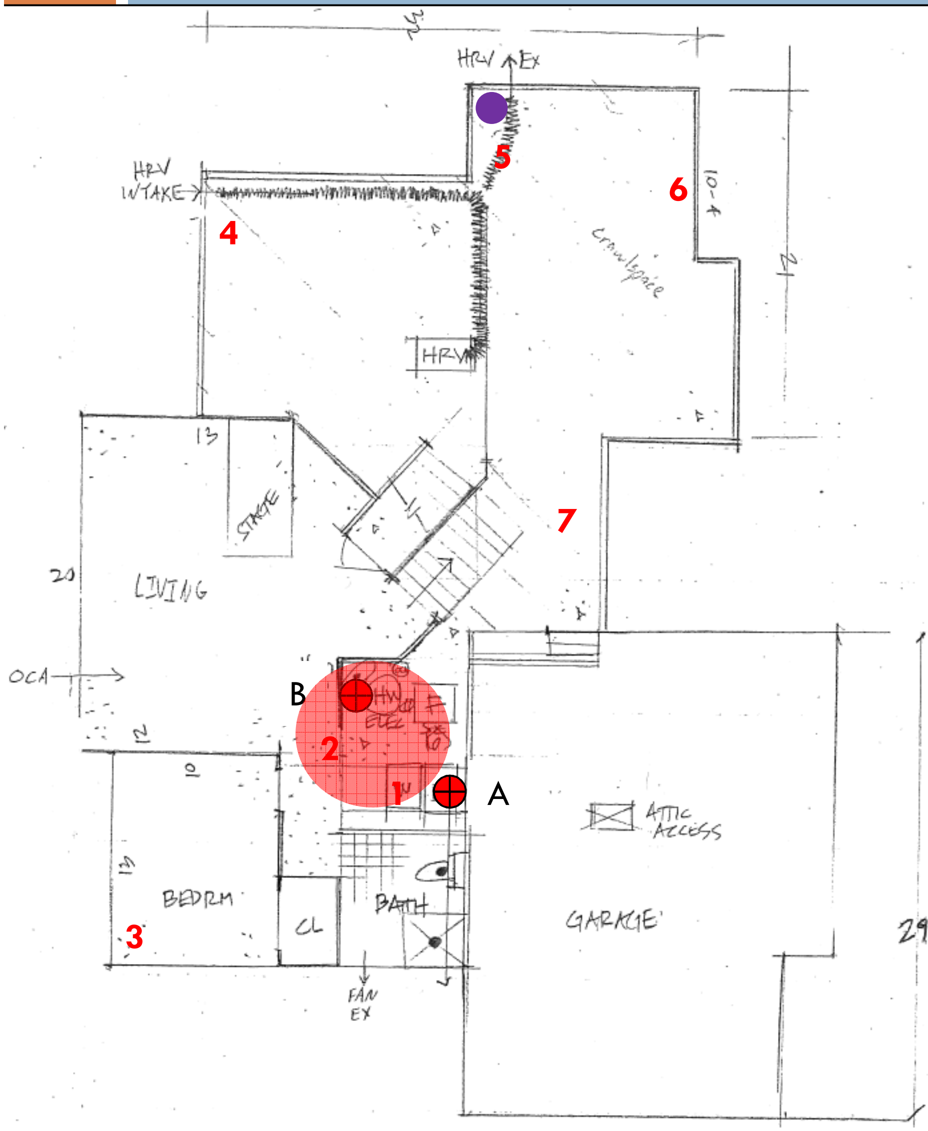
- Anything strange about these results?
- Do we need additional testing data?
- Why or why not?

Initial PFE



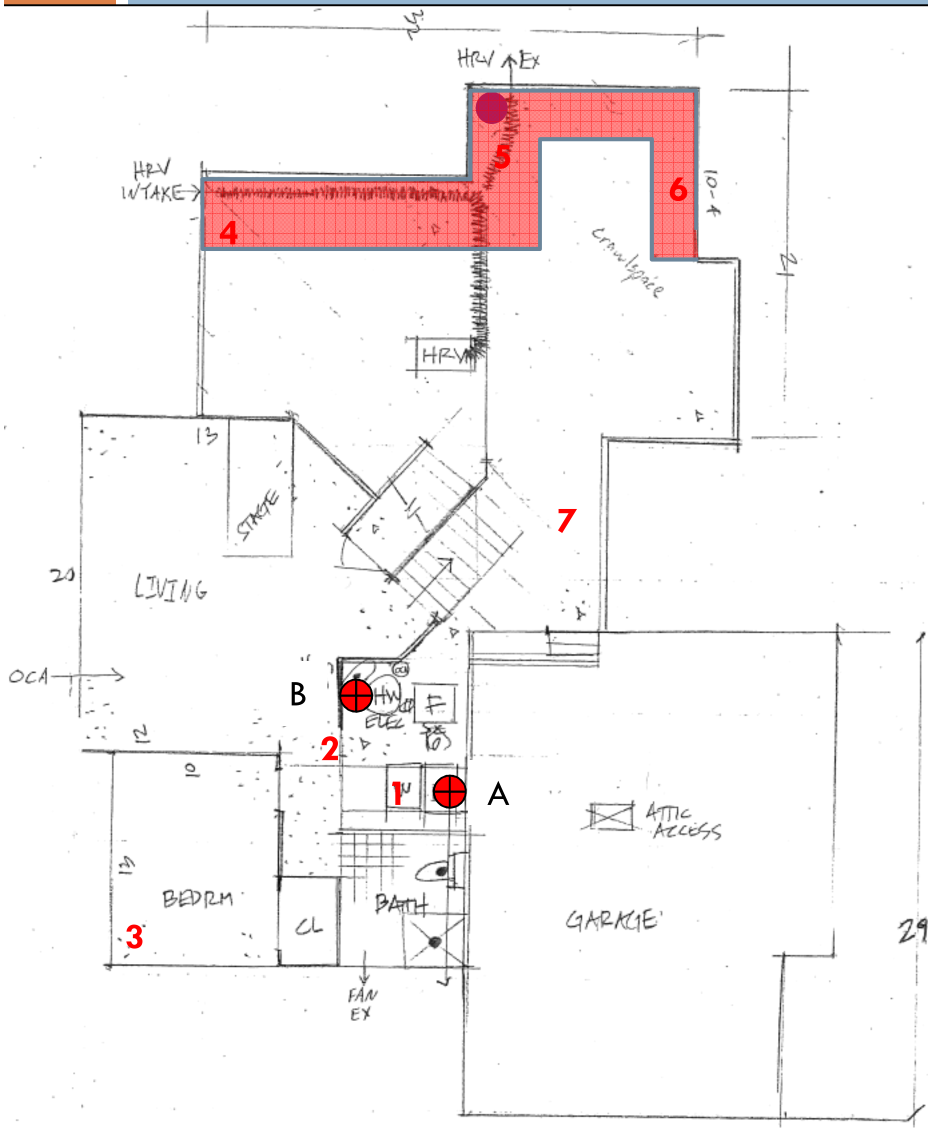
ΔP in Pascals			
	Vac @ A	Vac @ B	Vac @ Sump
1	-88	-4	--
2	--	-230	--
3	-0.3	--	--
4	--	--	-0.4
5	--	--	-120
6	--	--	-0.5
7	--	--	--
Flow	120 cfm	90 cfm	120 cfm

Initial PFE



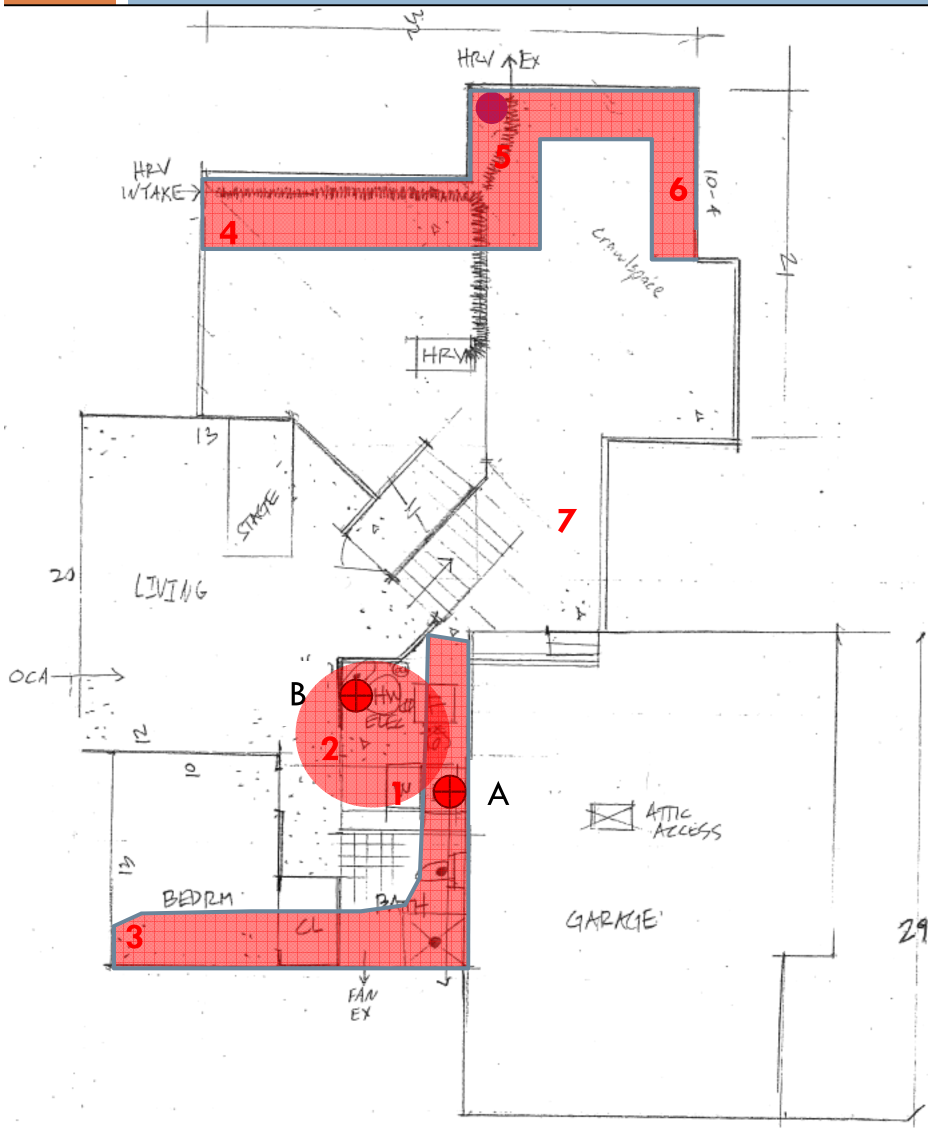
ΔP in Pascals			
Pa	Vac @ A	Vac @ B	Vac @ Sump
1	-88	-4	--
2	--	-230	--
3	-0.3	--	--
4	--	--	-0.4
5	--	--	-120
6	--	--	-0.5
7	--	--	--
Flow	120 cfm	90 cfm	120 cfm

Initial PFE



ΔP in Pascals			
Pa	Vac @ A	Vac @ B	Vac @ Sump
1	-88	-4	--
2	--	-230	--
3	-0.3	--	--
4	--	--	-0.4
5	--	--	-120
6	--	--	-0.5
7	--	--	--
Flow	120 cfm	90 cfm	120 cfm

Initial PFE

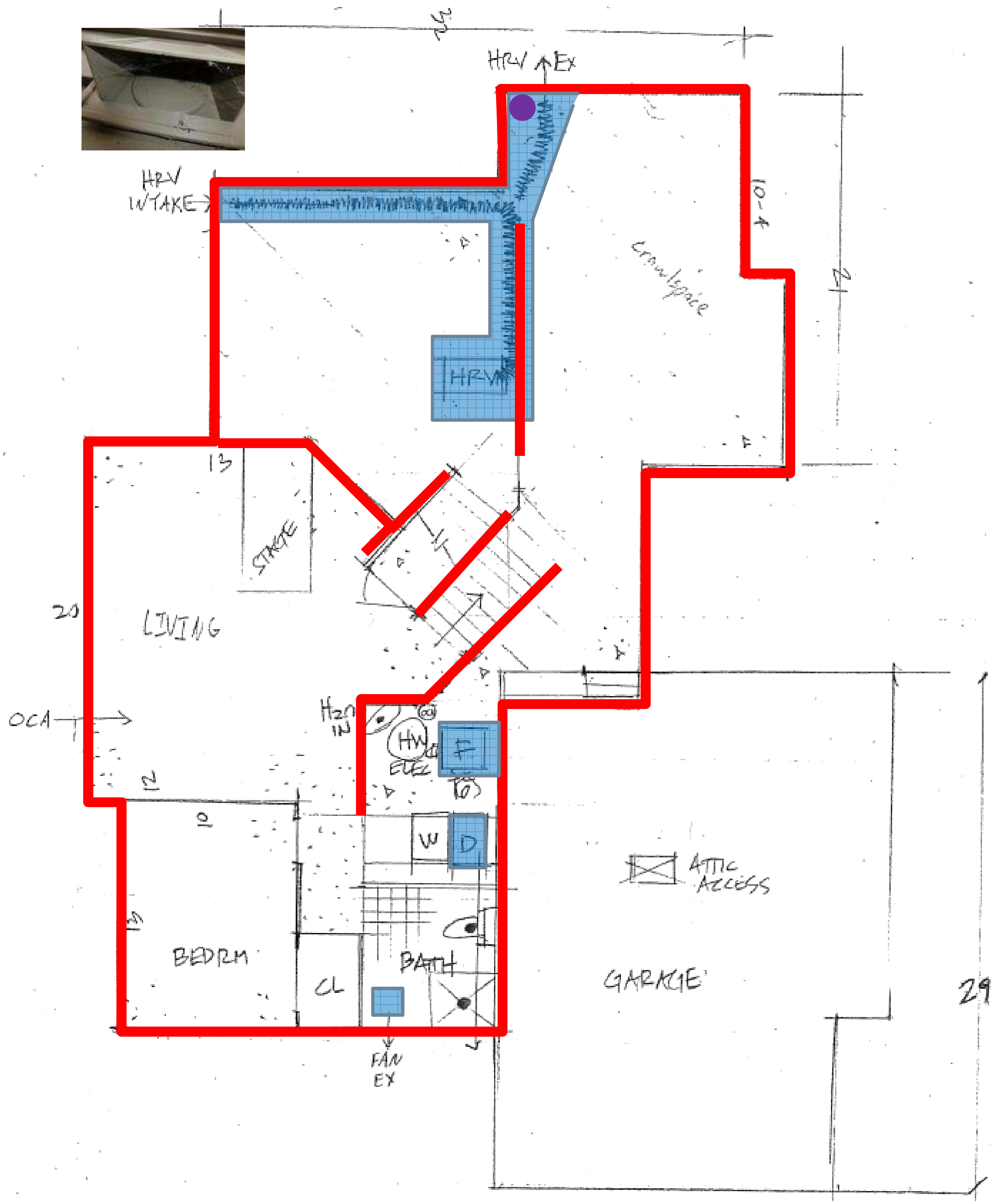


ΔP in Pascals			
Pa	Vac @ A	Vac @ B	Vac @ Sump
1	-88	-4	--
2	--	-230	--
3	-0.3	--	--
4	--	--	-0.4
5	--	--	-120
6	--	--	-0.5
7	--	--	--
Flow	120 cfm	90 cfm	120 cfm

- Will any of these work?
- Will a combo work?
- "I don't know how to fix this one."

On-Site Building Inspection: Air Leaks

On-Site Building Inspection: Depressurization Sources



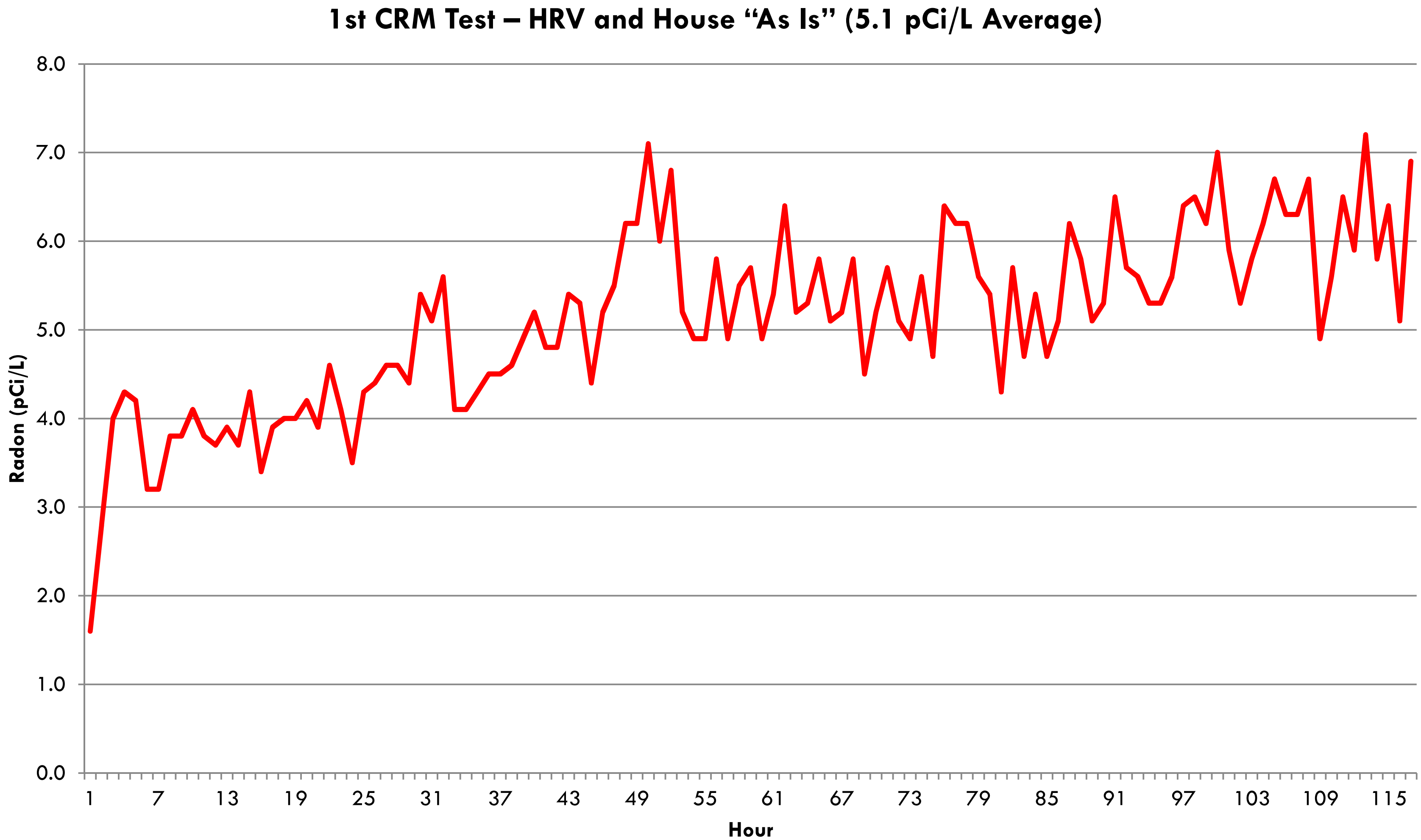
On-Site Building Inspection:

- Air Leaks
- Depressurization sources
  - HRV and ducts – unsealed, but insulated
  - Furnace ducts - unsealed
  - Exhaust fans

Is There an Easy Solution?

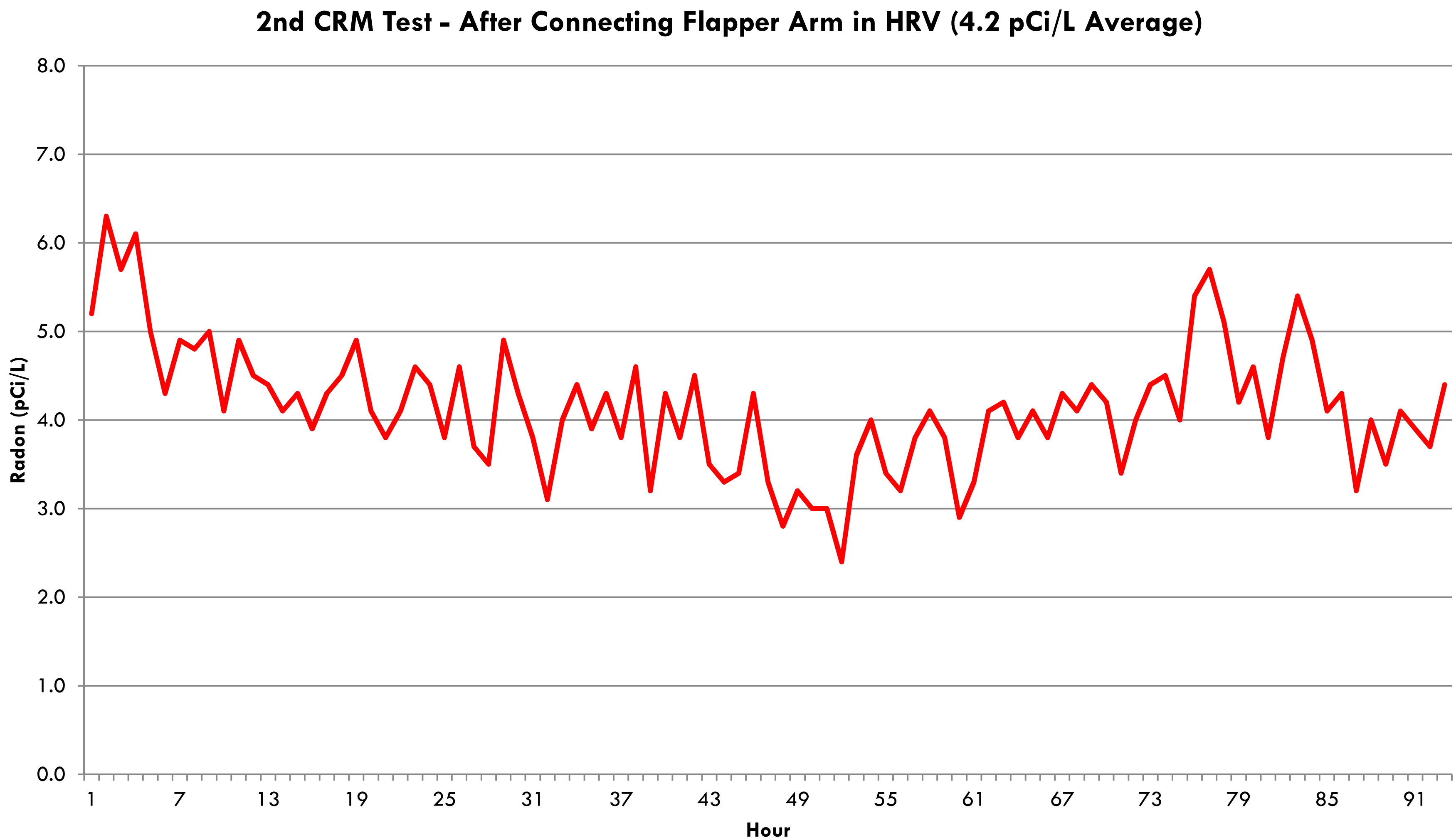
- CRM test on house “as found” (broken HRV)
- Fix HRV and retest with control arm attached

1st Test



1st CRM Test – HRV and House "As Is" (5.1 pCi/L Average)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Radon (pCi/L)
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
Hour

2^{nd} Test


2nd CRM Test - After Connecting Flapper Arm in HRV (4.2 pCi/L Average)
Radon (pCi/L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
Hour

Is There an Easy Solution?

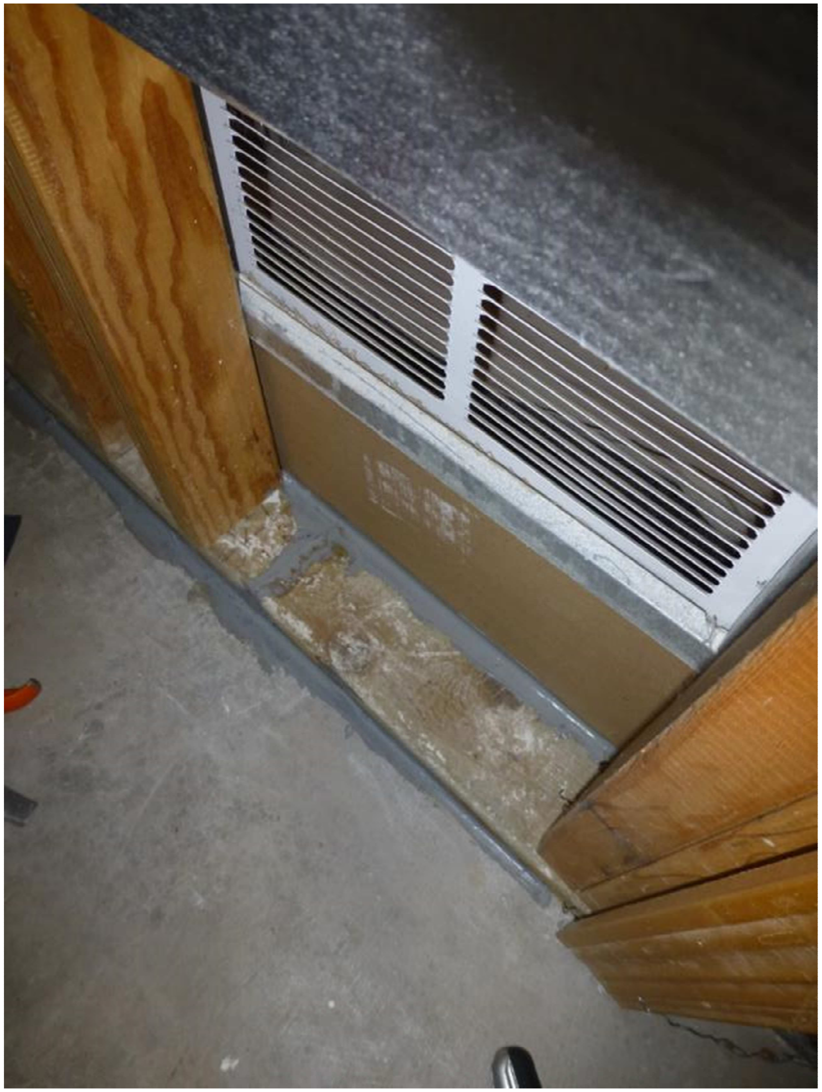
- CRM test on house “as found” (broken HRV)
- Fix HRV and retest with control arm attached
- NO!
- Now what?
  - Time to start sealing

Leaks Everywhere

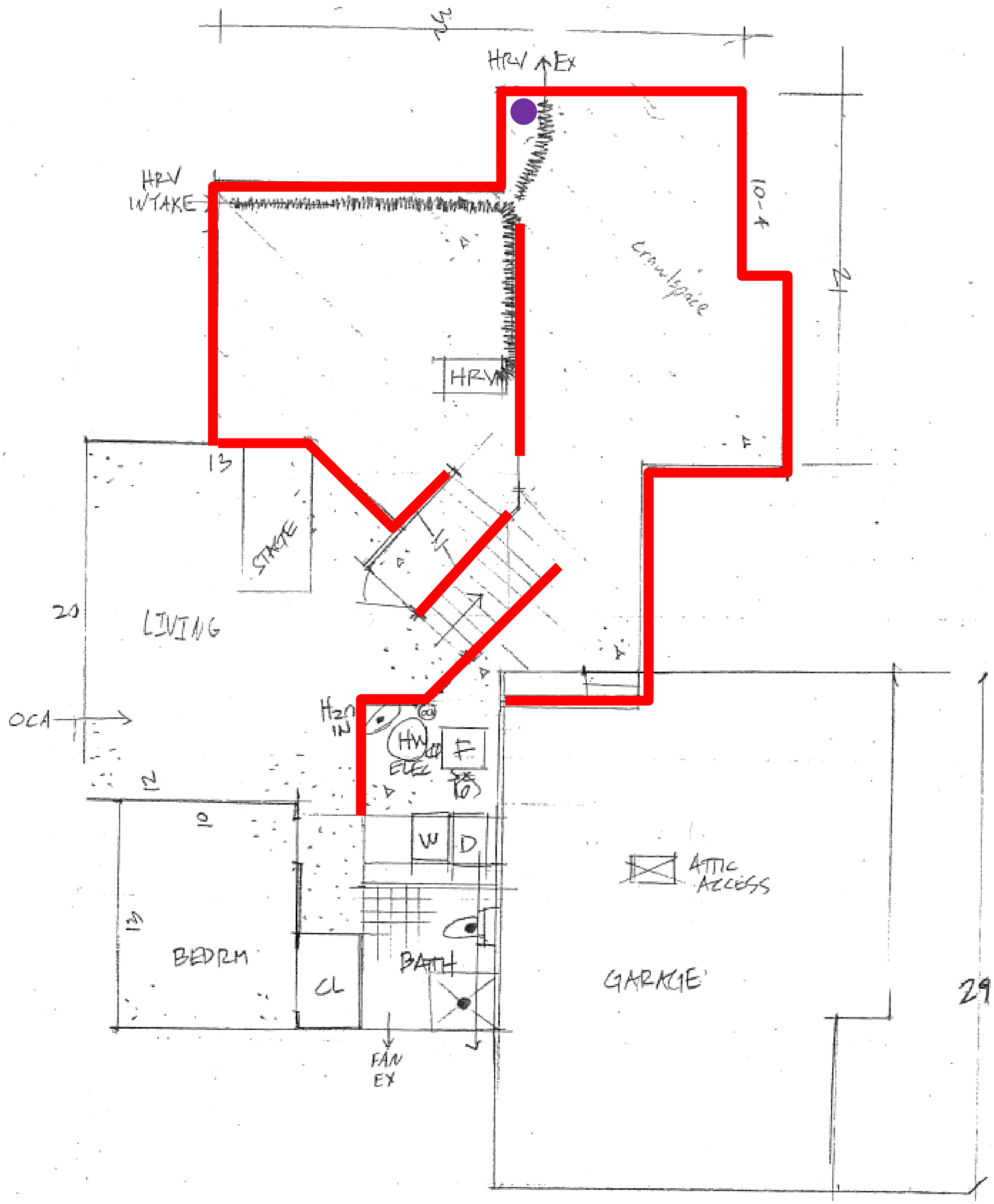
Sealing Leaks

Sealing Leaks

Sealing Leaks



Sealing Leaks



Sealed all air leaks

- Crawlspace
- Utility room
- Sump

HRV Issues Continue


Original Intake


Original Exhaust

HRV Issues Fixed

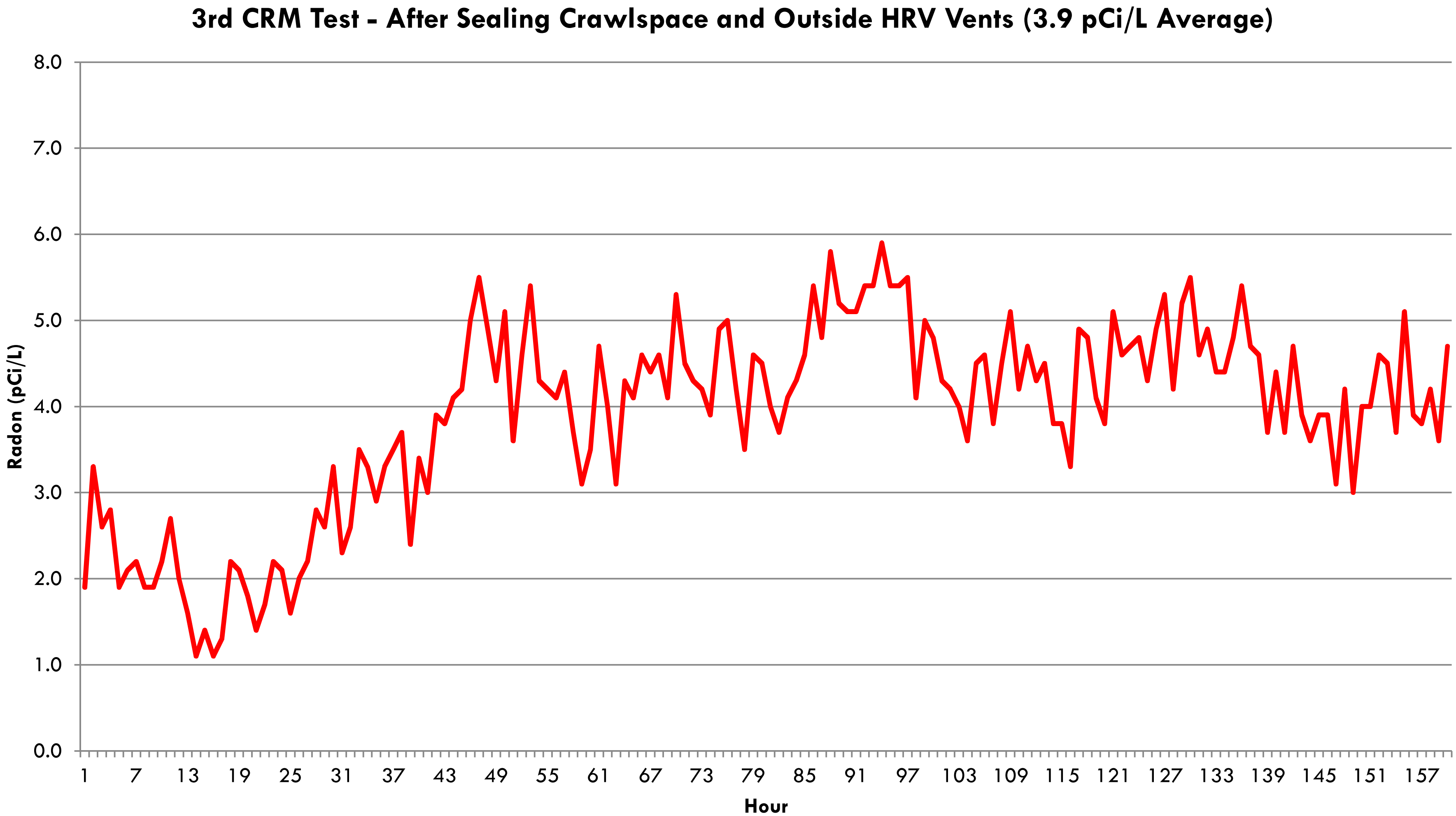

New Exhaust

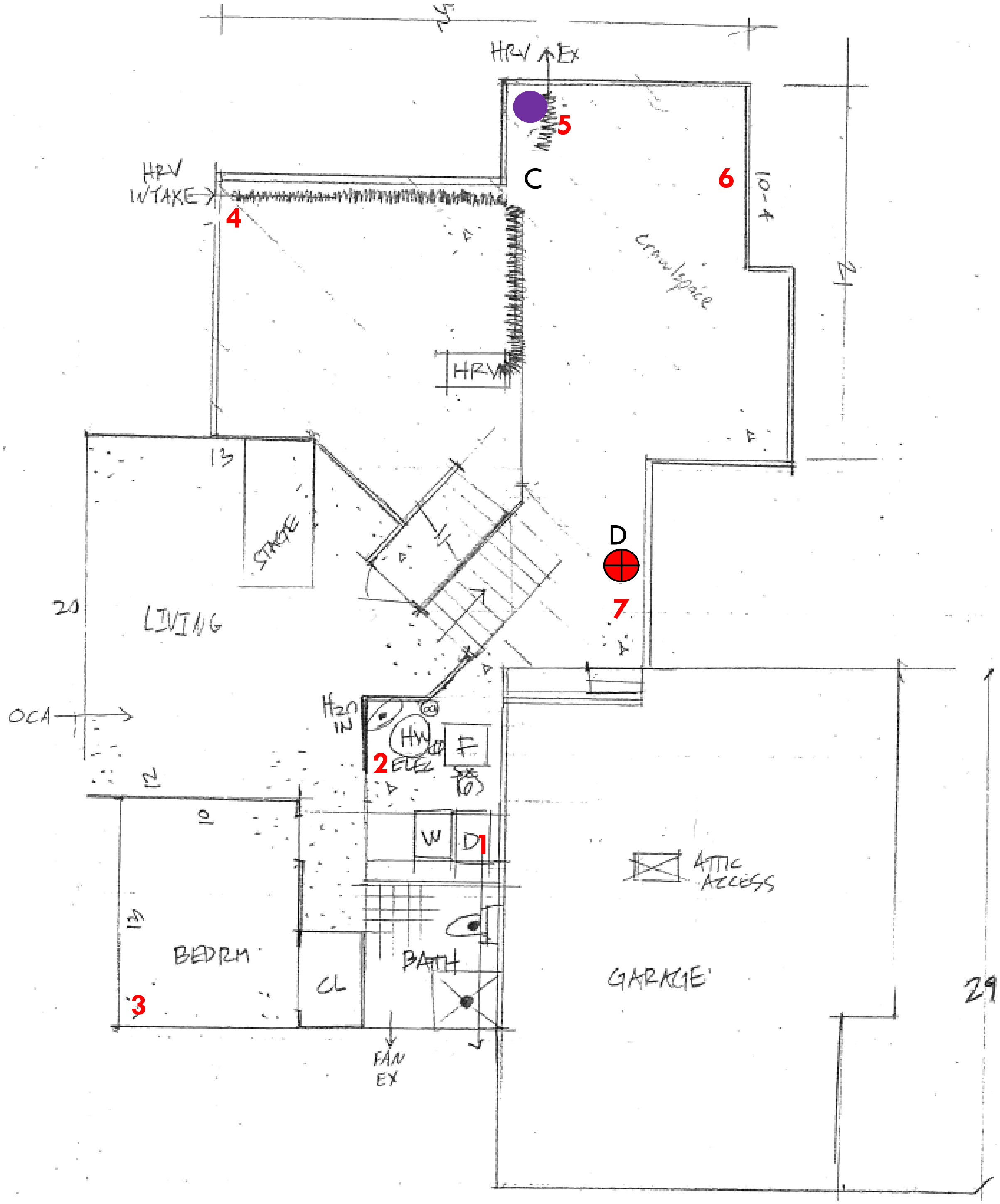

New Intake

CRM Round 3

- After Sealing crawl and fixing HRV
- Was it Enough?
- Graph 3

3rd CRM Test

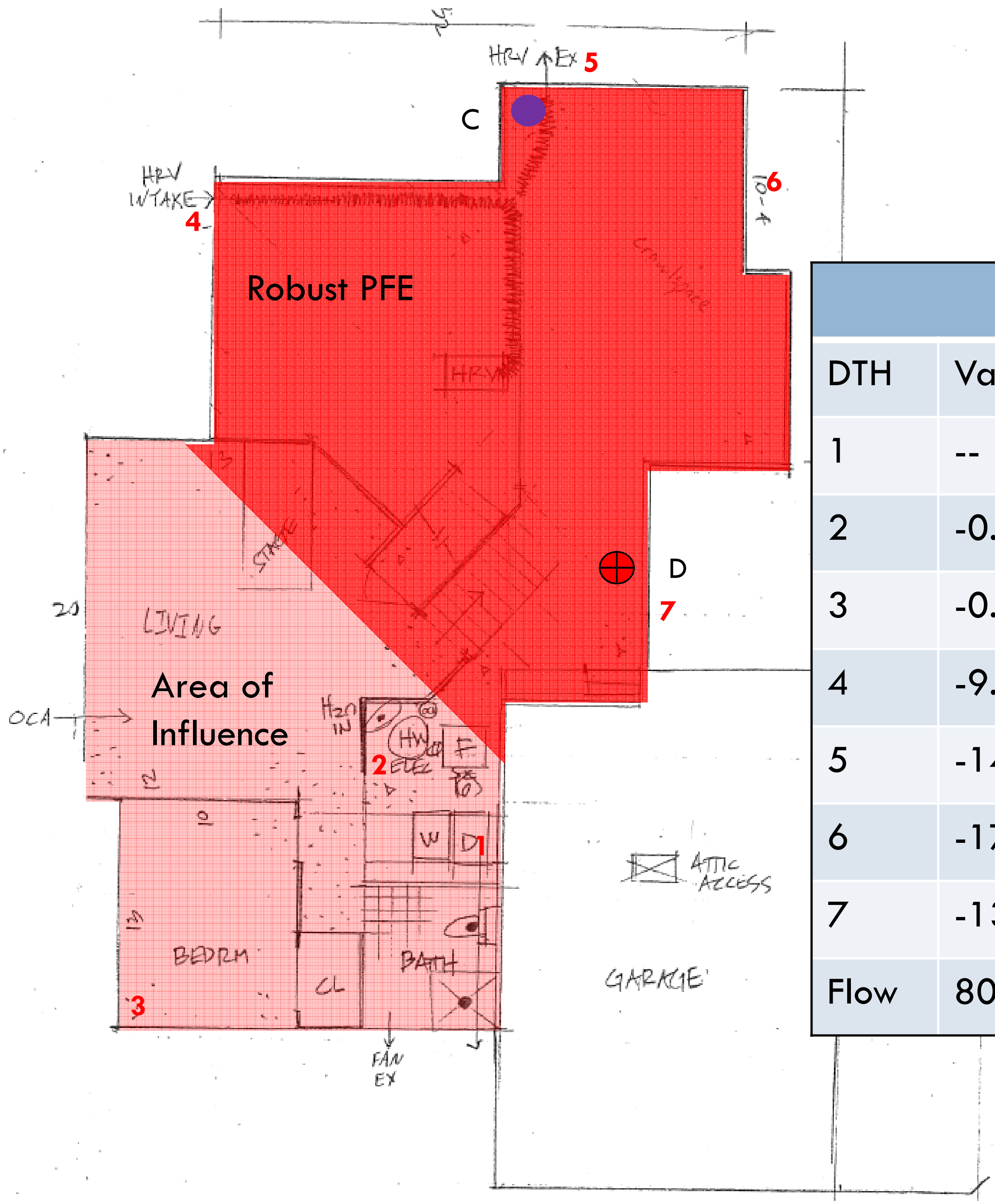

3rd CRM Test - After Sealing Crawlspace and Outside HRV Vents (3.9 pCi/L Average)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Radon (pCi/L)
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157
Hour



∆P in Pascals		
Pa	Vac @ C	Vac @ D
1	--	--
2	-0.1	-0.3
3	-0.1	-0.4
4	-9.0	-14
5	-14.2	-23
6	-17	-28
7	-134	-76
Flow	80 cfm	60 cfm

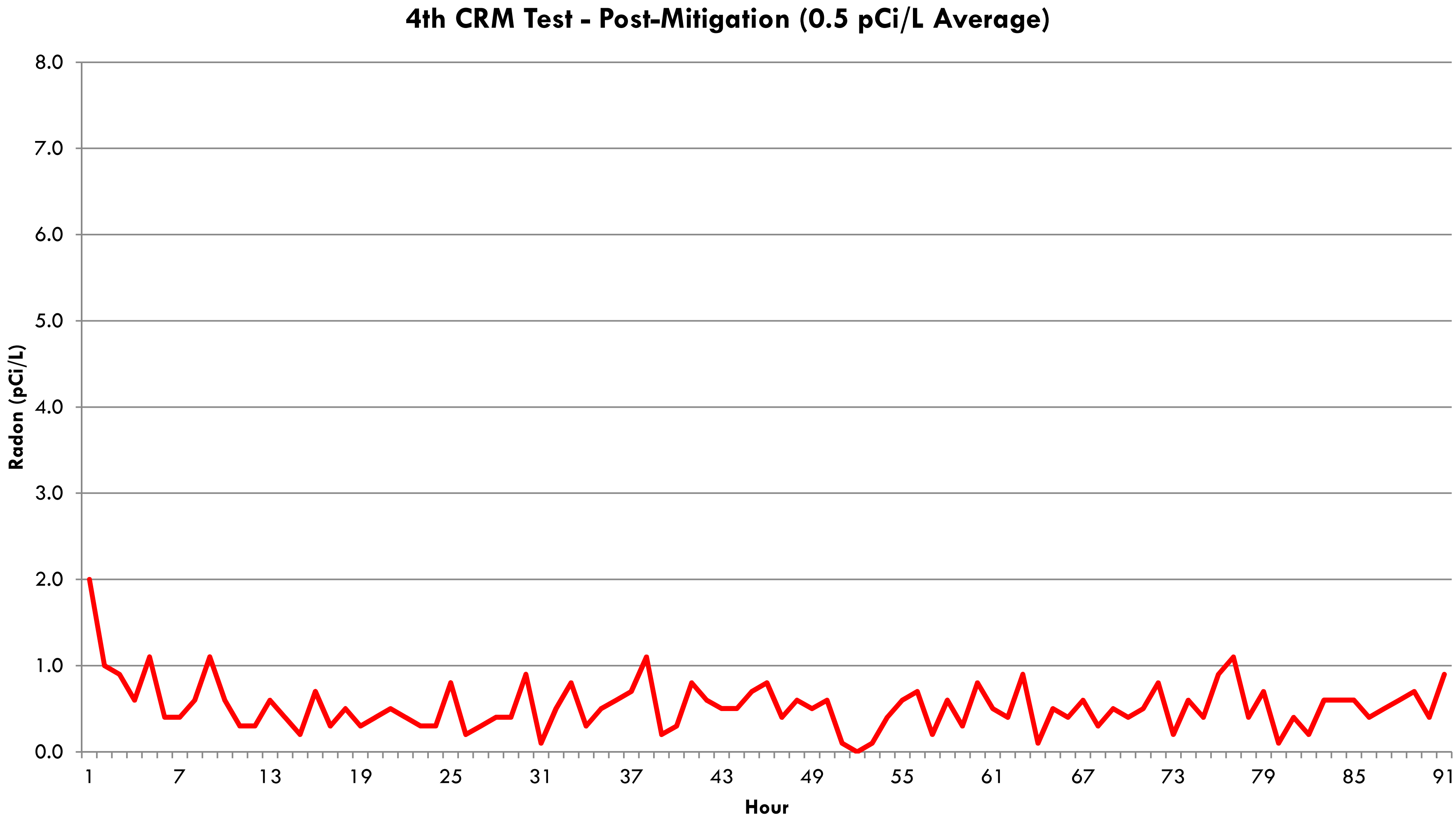
Pit Dig

Final System Install

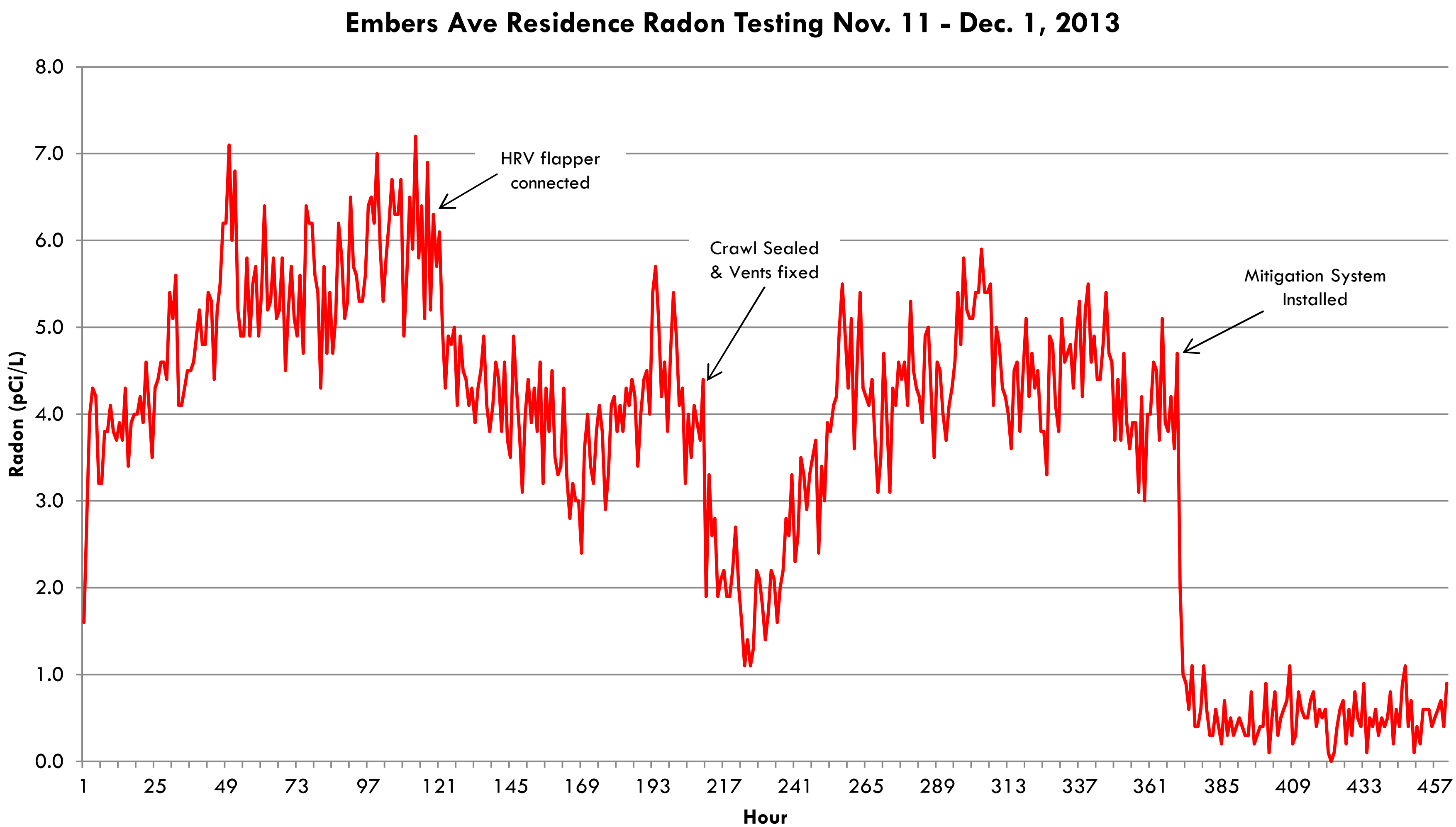


ΔP in Pascals			
DTH	Vac @ C	Vac @ D	RP140 @ D
1	--	--	--
2	-0.1	-0.3	-0.3
3	-0.1	-0.4	-0.2
4	-9.0	-14	-15
5	-14.2	-23	-24.2
6	-17.0	-28	-29.1
7	-134	-76	-77.7
Flow	80 cfm	60 cfm	55 cfm

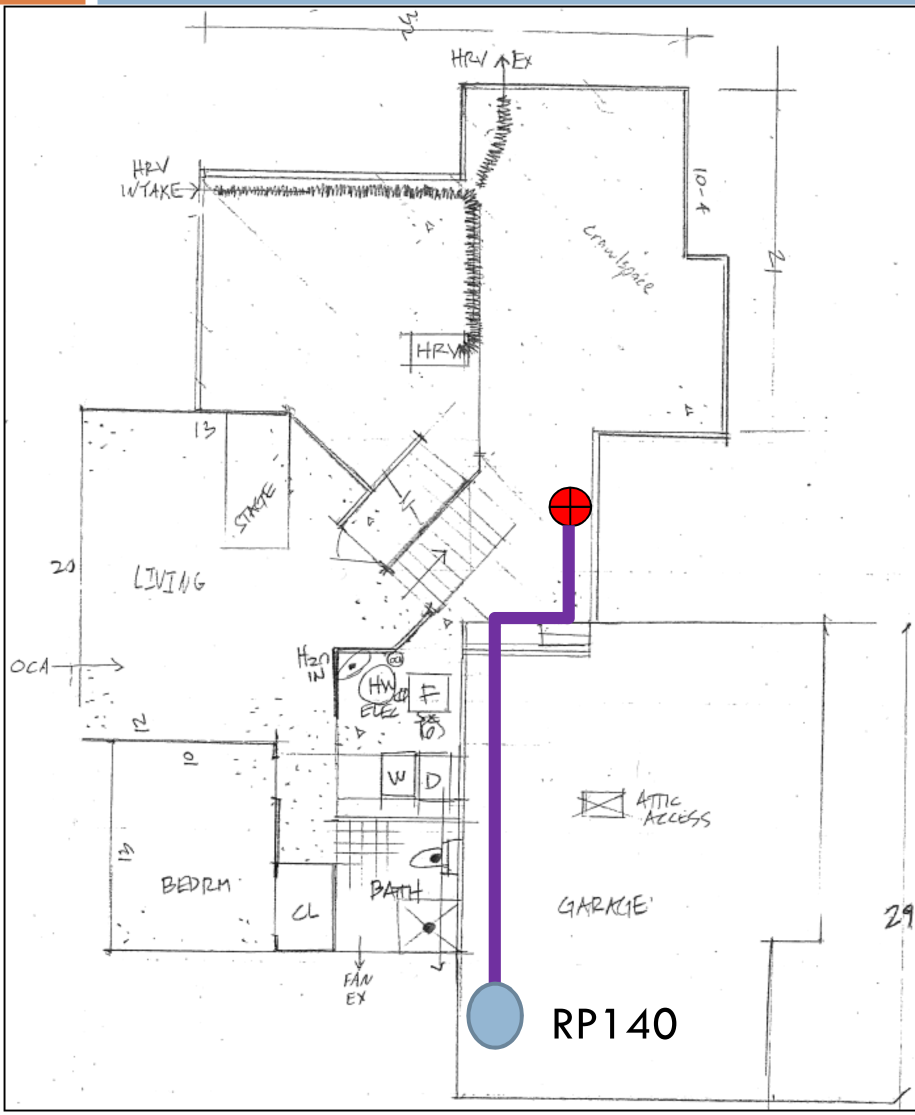
Post-Mitigation CRM



Project CRM Results



Final System Design



- Smallest fan
  - 20 watts
  - 55 cfm
- HRV operating normally
- No more condensation issues
- Radon low - 0.5 pCi/L
- House is drier in winter

Takeaways

- Use MDH Steps 1-6 to diagnose issues
- Pay particular attention to:
  - PFE or lack thereof
  - Air flows at each location
  - Where are the air leaks**
- Sealing will greatly influence system:
  - Efficiency
  - Effectiveness


RETURN
REGRESE


3/4

Smoke Comparison

Contact Info

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