CASE STUDY:

Conventional GSHP – Isabella Stuart Gardner Museum

Presented by:
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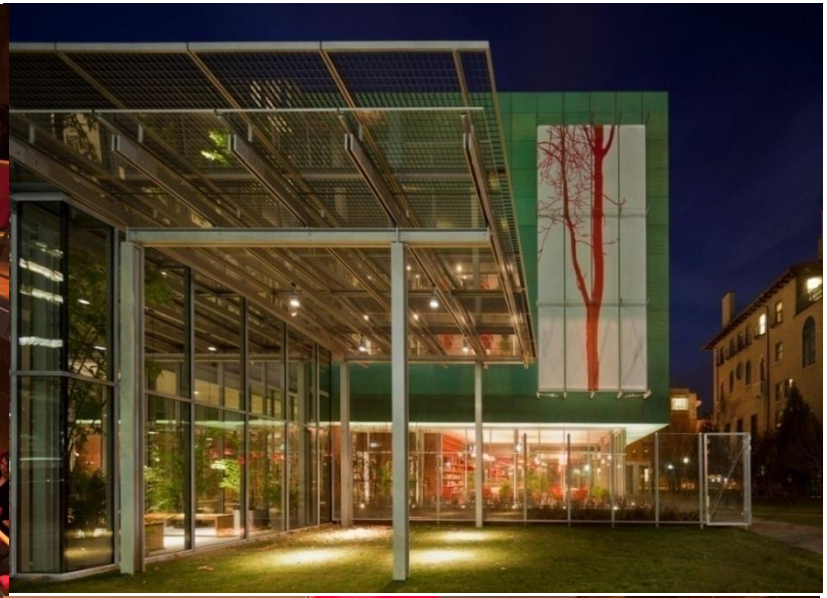
sak Environmental, LLC
advise ◆ remediate ◆ sustain

Isabella Stewart Gardner Museum Addition



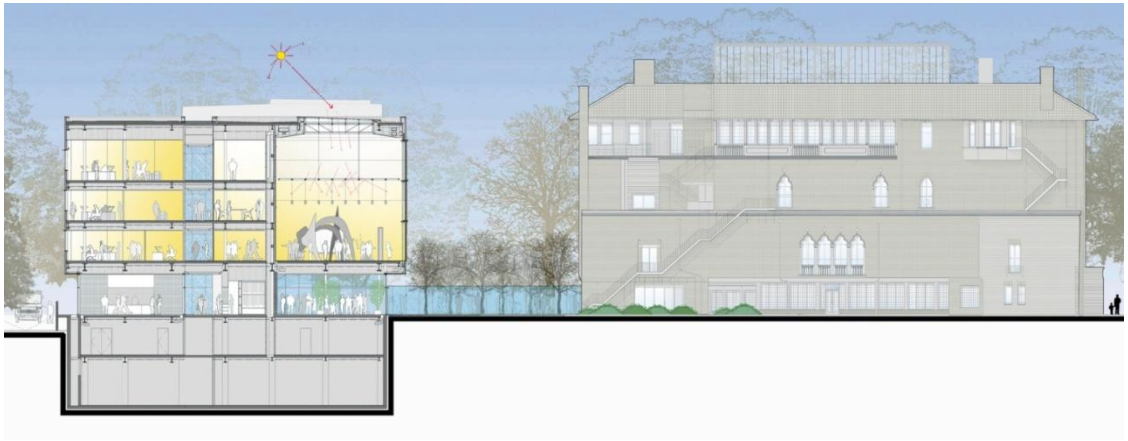
Isabella Stewart Gardner Museum Addition: Project Summary

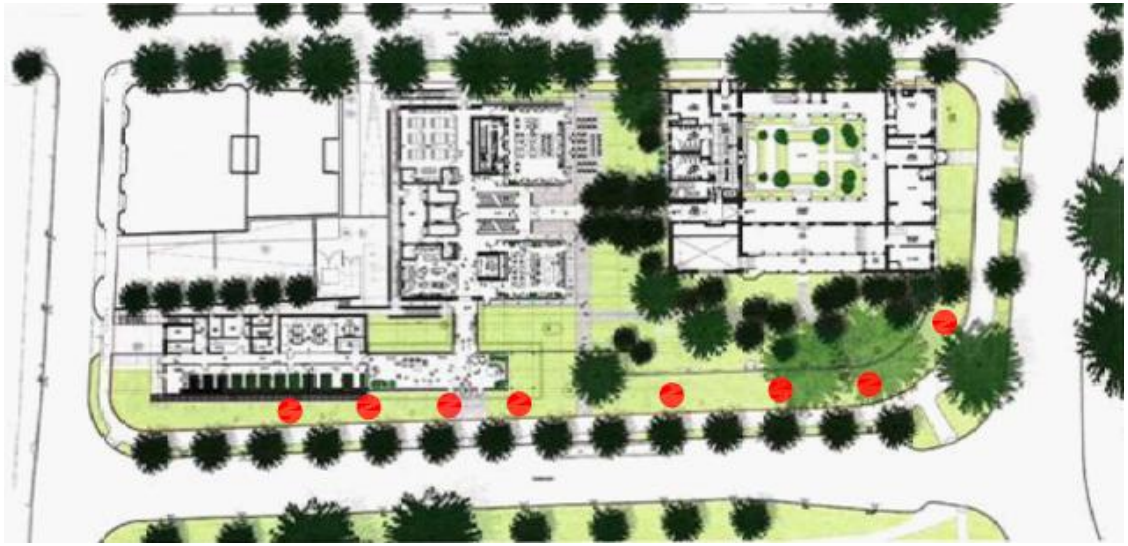
- 70,000 s.f. new wing
- Total project cost: $114M
- Calderwood Performance Hall
- Special exhibition gallery
- 1,650 s.f. greenhouse
- Conservation labs and archival storage
- Café & Museum Shop
- LEED Gold certification

Isabella Stewart Gardner Museum Addition: Project Team

- Owner – Isabella Stewart Gardner Museum
- OPM – Paratus Group, NYC
- Design Architect – Renzo Piano Building Workshop, Genoa, Italy
- Architect of Record – Burt Hill
- MEP – Buro Happold
- CM – Shawmut Design & Construction
- Total project cost - $114M
- Opened January 2012

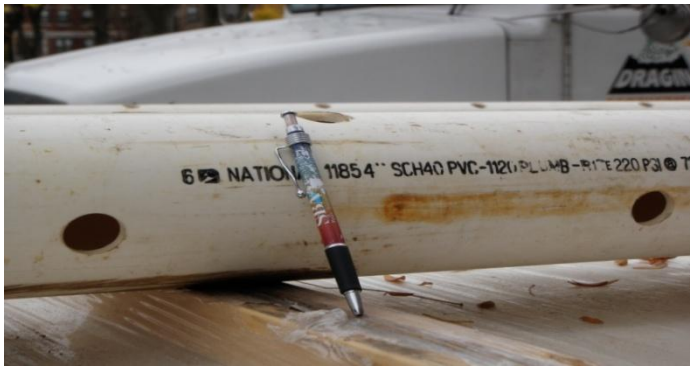
Isabella Stewart Gardner Museum Addition





Geothermal System

- Eight 1,500 ft Standing Column Wells
- 170 ton cooling capability
- 2.0M Btu/hr heating capability
- Four 2-well loops each w/ heat exchanger
- No Bleed
- Bag filtration
- Well field cost = $550,000
- Mechanical cost = $100,000



Problem Solving

- Soft rock zone - PVC sleeves installed for stabilization
- Waste water treatment - stone dust
- Space restraints …affected construction sequence…..affected initial well performance
- Filter clogging
- Pump burnout
- Well clogging

Solutions

- Review well logs, aquifer tests, development reports
- Enhanced waste water treatment
- Differentiate natural from avoidable conditions
- CORs for $275,000 avoided
- System startup in June 2011

Case Studies – Implementation of GSHP Systems at Impacted Sites

Presented by: Don Maggioli, PE, LSP, CGD (Certified Geothermal Designer)
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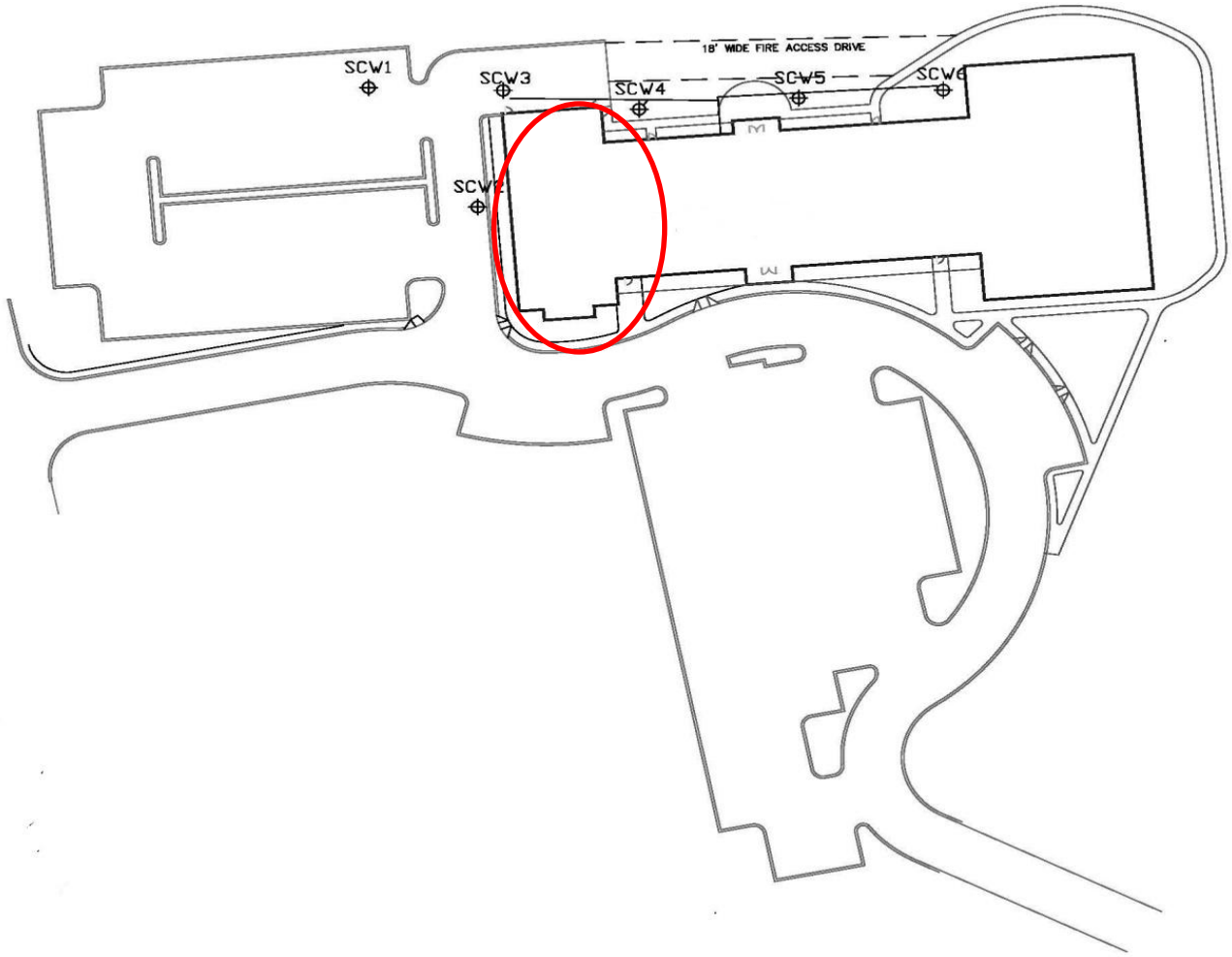
CASE STUDY No. 01- Community Center

1. City developing site as a community center. Building Load is 120 tons.
2. Existing building had a fuel oil leak from underground storage tank.
3. The site is in the MCP and has on-going groundwater monitoring with an activity and use limitation.
4. Oil is present beneath existing building slab and on water table.
5. Bedrock is present at surface at the site.
6. Design for new building includes geothermal heating and cooling using four Standing Column Wells to 1,500 feet.
7. Water from wells designed to discharge to adjacent storm drain.
8. An Environmental site evaluation for the geothermal design was not conducted.

CASE STUDY No. 01



What would you do?

1. Can you install Geothermal at this site.
2. If so, what type system would you recommend.
3. What size system would you need.
4. Do MCP issues need to be addressed.
5. Does a LSP need to get involved.
6. What permits would be required.

Case Study No. 02 – Elementary School

1. School has old boiler fueled by No. 2 Fuel Oil and wants to evaluate installing a geothermal system for heating and cooling.
2. Building load is 125 tons.
3. Existing irrigation well depth is 350 ft produces 20 gpm.
4. Till is located approximately 20 ft. below grade.
5. The School is immediately downgradient from a former drycleaner. School received a partial RAO. PCE concentrations below S-1 and GW below GW-3.
6. The school owns a field adjacent to the school. Field is 200 ft by 300 ft.

What would you do?

1. Would you allow the wells to be installed
2. What permits would be required.
3. Would water testing be required.
4. What notifications would be required.
5. How should the MCP issues be addressed.
6. Would other GSHP types be more appropriate.

Case Study No. 03

1. Developer wants to install geothermal system for his office building on Cape Cod.
2. Building load is 35 tons.
3. Existing well produces 200 gpm.
4. The building abuts a pond but is not part of the property.

Should the Developer Proceed with the System

1. What are the flow rate requirements.
2. Is the well sufficient for the building load
3. What would be the Permit requirements.
4. What other systems would be appropriate.

Case Study No. 04

1. A school is thinking of switching from all electric to geothermal.
2. Building load is 150 tons.
3. There are athletic fields adjacent to the school.
4. There is an abandoned water well on-site (500 ft. 50 gpm)

Is it feasible to install Geothermal at the School

1. Should they investigate trying to use the existing well.
2. Is the well sufficient for the building load
3. What would be the Permit requirements.
4. What other systems would be appropriate.

Imagining Case Studies

Lawrence Lessard, LSP
Achieve Renewable Energy, LLC.

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P&T or Bio Enhancement

- Can changing the soil/groundwater temperature enhance remediation?
- Can we potentially change limiting factors such as microbial activity, NAPL viscosity and vapor pressure?

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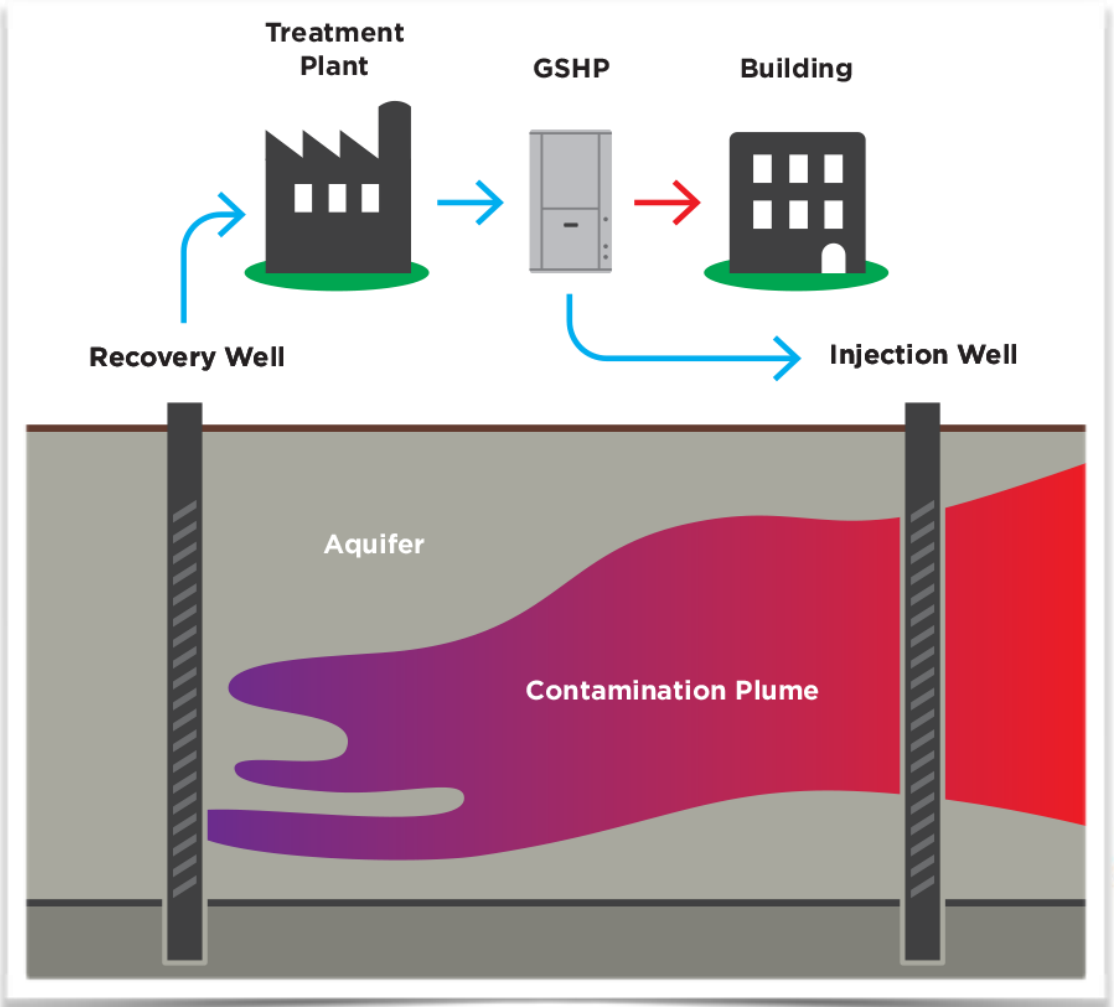
GSHPs with Pump and Treat



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GSHPs with Pump and Treat

- A 10 C increase in temperature doubles microbial activity, decreases NAPL viscosity and increases VOC vapor pressure.
- For 10 GPM flow a 10 C increase requires ~93,000 BTU
- 5,160 pounds/hr * 18 F = 92,880 BTU
- Warming the soil around the infiltration area requires additional capacity due to advection and dispersion of heat. How much more heat depends on variables such as soil type, moisture, infiltration, groundwater effects and the size of the desired area of impact.
- Pilot testing could be quite helpful.

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GSHPs with Pump and Treat

- 93,000 BTU is 7.75 tons.
- Given subsurface variance, might start design assuming a 15-20 ton GSHP if an adequate source is available.
- Remember that there are constant flow and water quality issues to consider.
- Also, you need a source from which the GSHP can draw heat.
  - Separate ground-source that could be used after remediation
  - If available a heat source on-Site could be utilized
- Telemetry could be helpful.

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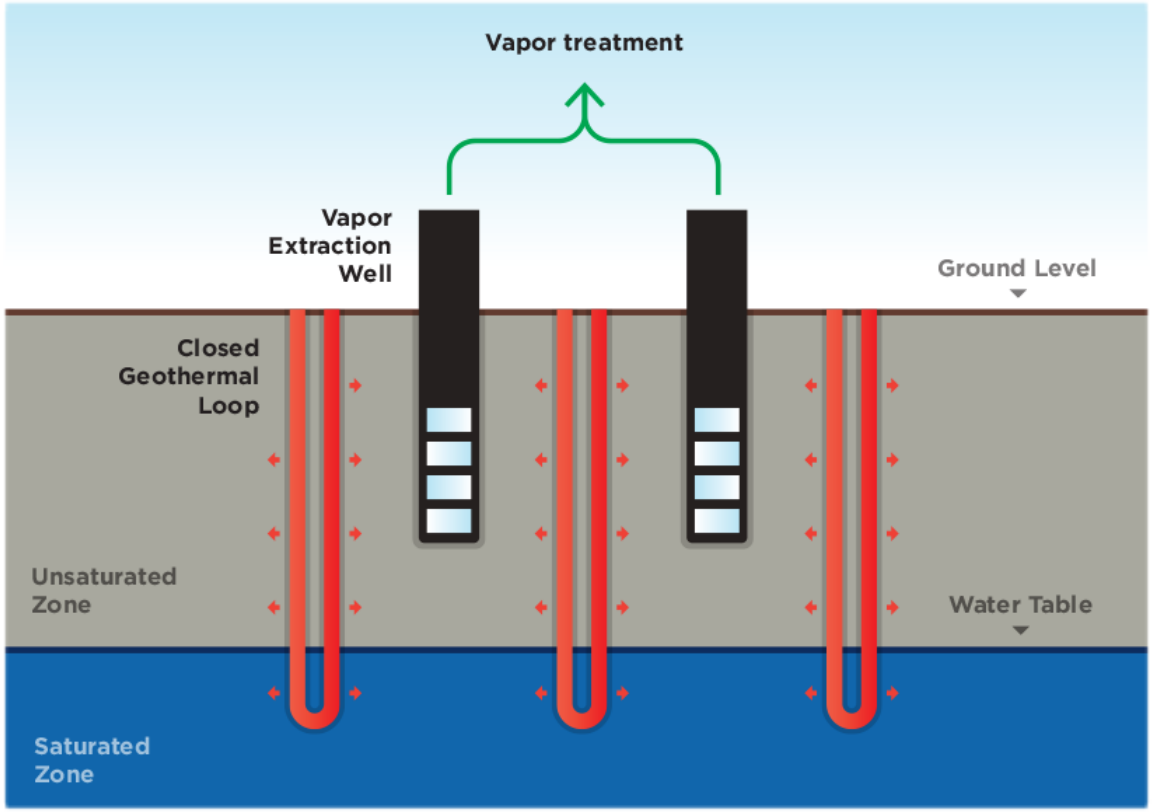
SVE with GSHP Heating



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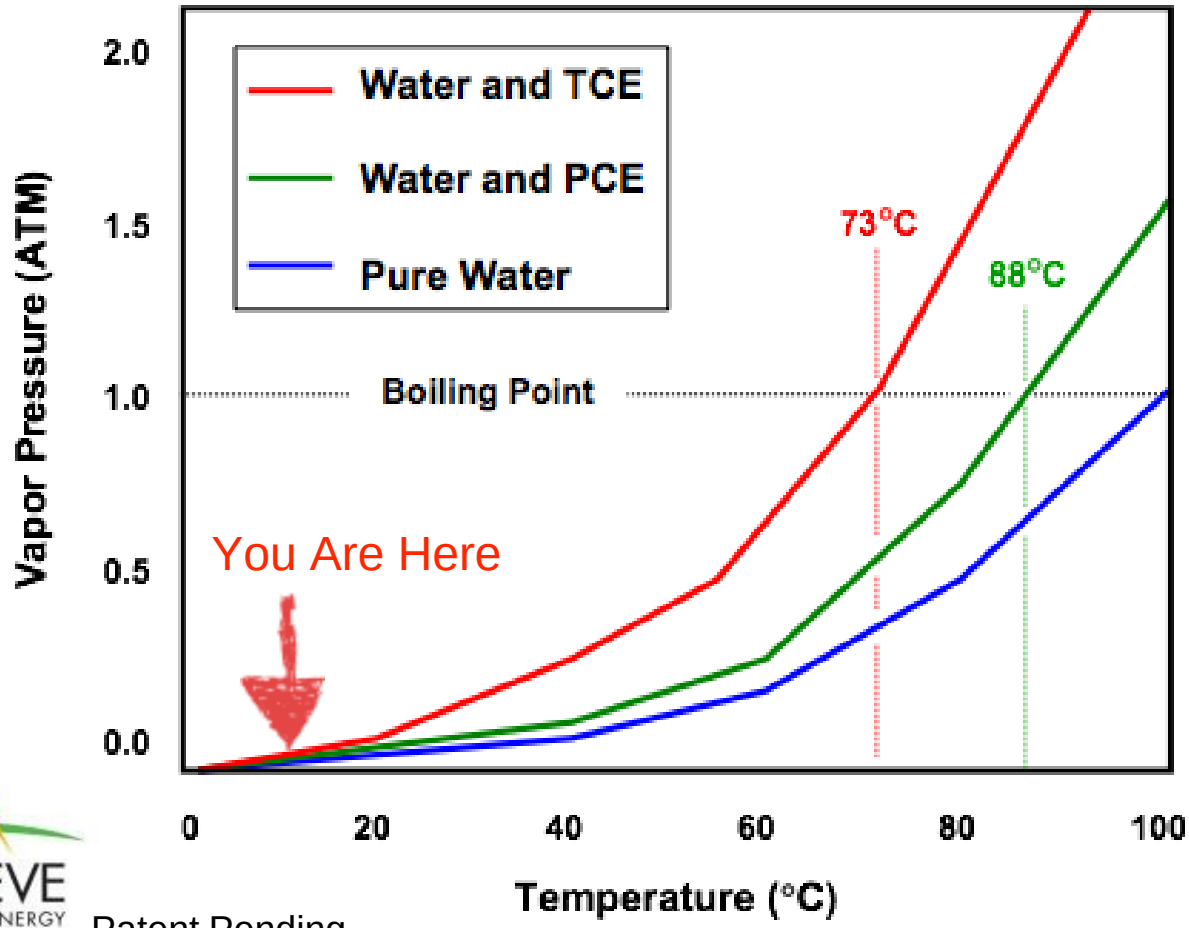
Changing Volatilization Rate



Pure TCE
B.P. = 87°C

Pure PCE
B.P. = 121°C

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SVE Enhancement

- At 10 C/50 F, TCE+water vapor pressure on chart is less than 0.1.
- At about 40 C/100 F. TCE+water vapor pressure increases to about 0.3 — about triple the lower temperature.

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SVE Enhancement

- COP of electric or fossil fuel heating is 1 or less.
- COP of GHSP is 3-4 or more.
- For an equal amount of heating, GSHP requires one-third to one-quarter the energy of electric resistance.
- Benefit-cost analysis of delta-T of ‘traditional’ heating v. GSHP heating given the fuel and GHG savings is warranted.
- Loop in remedial area could be intentionally designed ‘too small’ to enhance effects.

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Financial Impact of Using GSHPs

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Incentives

- Brownfields Tax Credit
- Federal Investment Tax Credit for GSHP
- 5-Year Accelerated Depreciation (MACRS) for GSHP
- Thermal RECs (T-Rex?) - In Massachusetts, AECs can be earned for Remedial Heating.
- Super-efficient heating or cooling available during or after remediation

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Impact on SVE System Net Cost

Task	Base Cost	Incentive	Incentive Value	Cost w/GSHP+ Incentives
Trenching	$80,000	•10% ITC •MACRS	$8,000 $26,400	$45,600
Equipment Installation	$150,000	BTC?	TBD	$150,000
GSHP Installation	n/a	•10% ITC •MACRS	$15,000 $49,500 ($150,000 pre-incentive)	$85,500
O&M	$160,000 ($40,000/yr. x 4 yrs)	•T-Recs •O&M Reduced to 3 yrs.	•$15,000/yr AECs •$40,000/yr O&M (10 tons continuous and $15/AEC)	$75,000 (AECs could continue for total of 10 years)
Total:	$390,000			$356,100 (9% reduction)

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Questions?

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