Geothermal Borefield Horizontal Piping Design Options

Moderator: Tracey Ogden / *Brightcore Energy*

Panel: Kim Ojanne / *Rototec, LLC USA*

Stuart Lyle / *ISCO Industries, Inc.*

Jens Ponikau / *Buffalo Geothermal*

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Geothermal borehole header systems: Sweden versus USA

A comparison of manifold vault solutions

Kim Ojanne

April 23, 2025

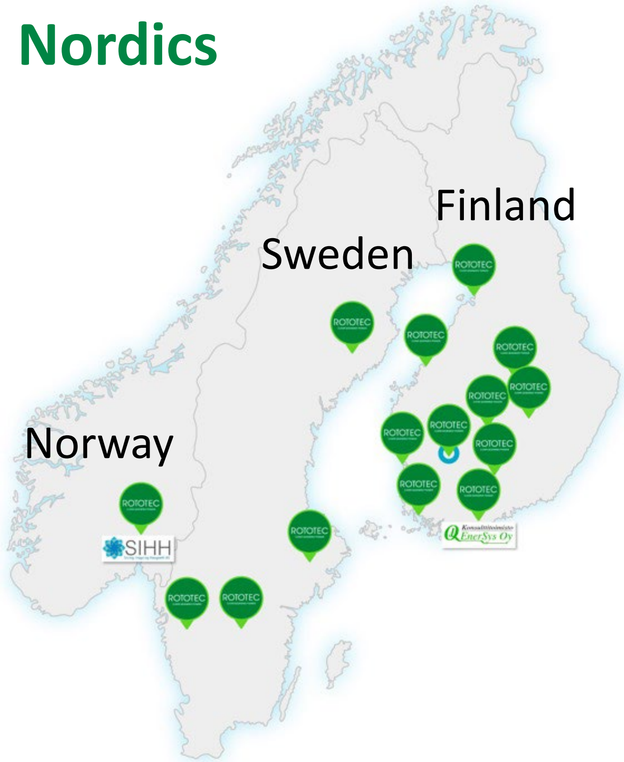
Rototec Group in a nutshell

About us

We deliver geoenergy (shallow geothermal) fields for ground source **heating and cooling** especially for large properties and industries and provide consulting services for geoenergy projects.

Locations worldwide

Nordics



USA

Germany

In numbers

6.5	140	66	310 000
Million feet of energy wells drilled per year	Employees	Modern drilling units	Tonnes/year reduction in CO_2 emissions thanks to Rototec's energy wells

Introduction

- Geothermal energy systems require efficient underground pipe connections
- The choice of header system affects cost, performance, and accessibility
- This presentation compares Swedish and American practices for manifold systems

Objectives

- Examine how the choice of header system affects cost, performance, and accessibility
- Learn the similarities and differences between Swedish and American practices for manifold systems

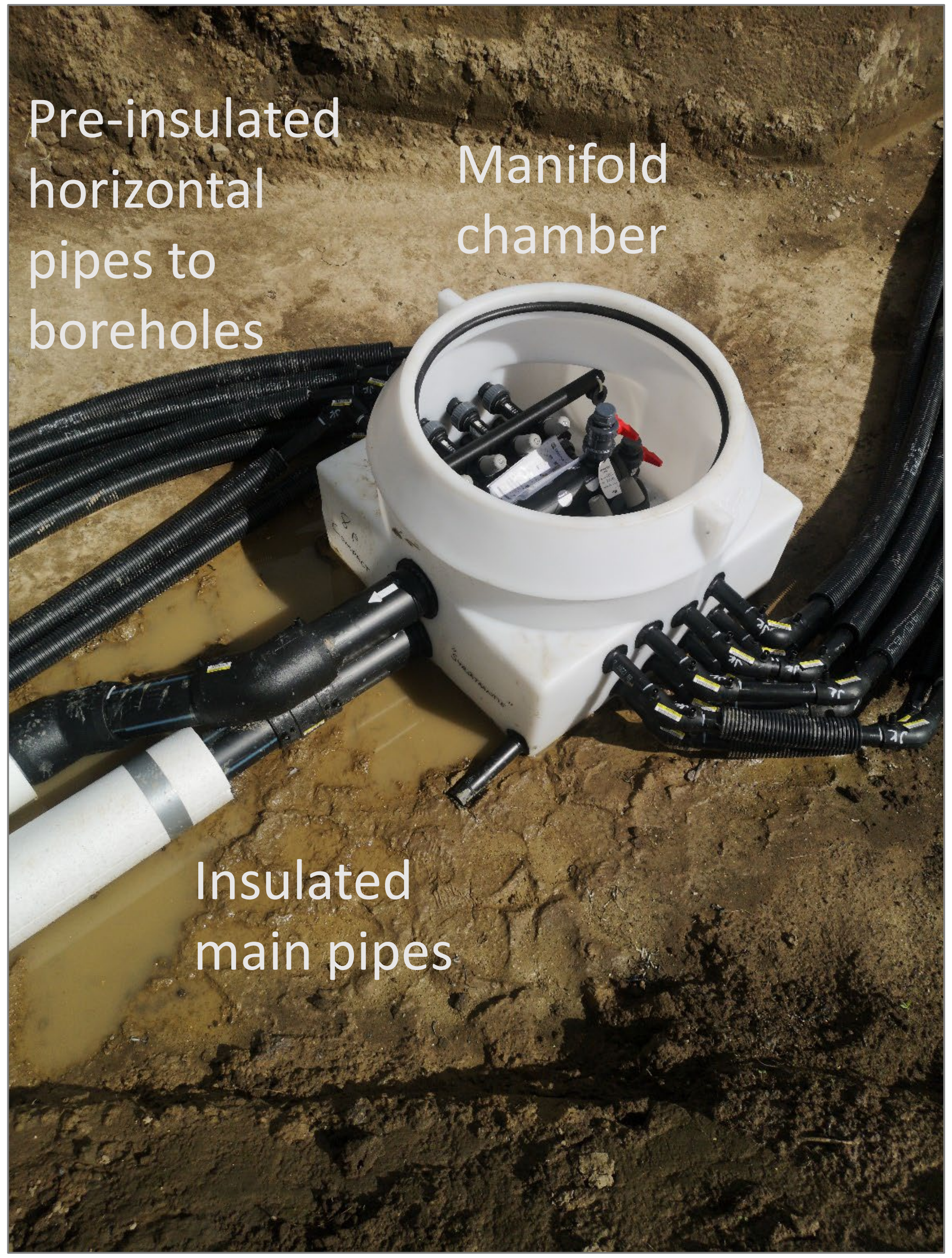
Swedish common practice: Manifold vaults

Idea

- A group of boreholes (typically up to 12 or up to 20) is connected to a manifold vault
- Each vault contains a small manifold
- Multiple manifold chambers can be connected with a single pair of main pipes
- Pipes from each borehole connect with the manifold, from where single supply/return line goes to the building

Location of vaults

- Buried underground near the borehole field
- Alternatively manifold cabinets above ground



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Design principles in Sweden – loops and pipes

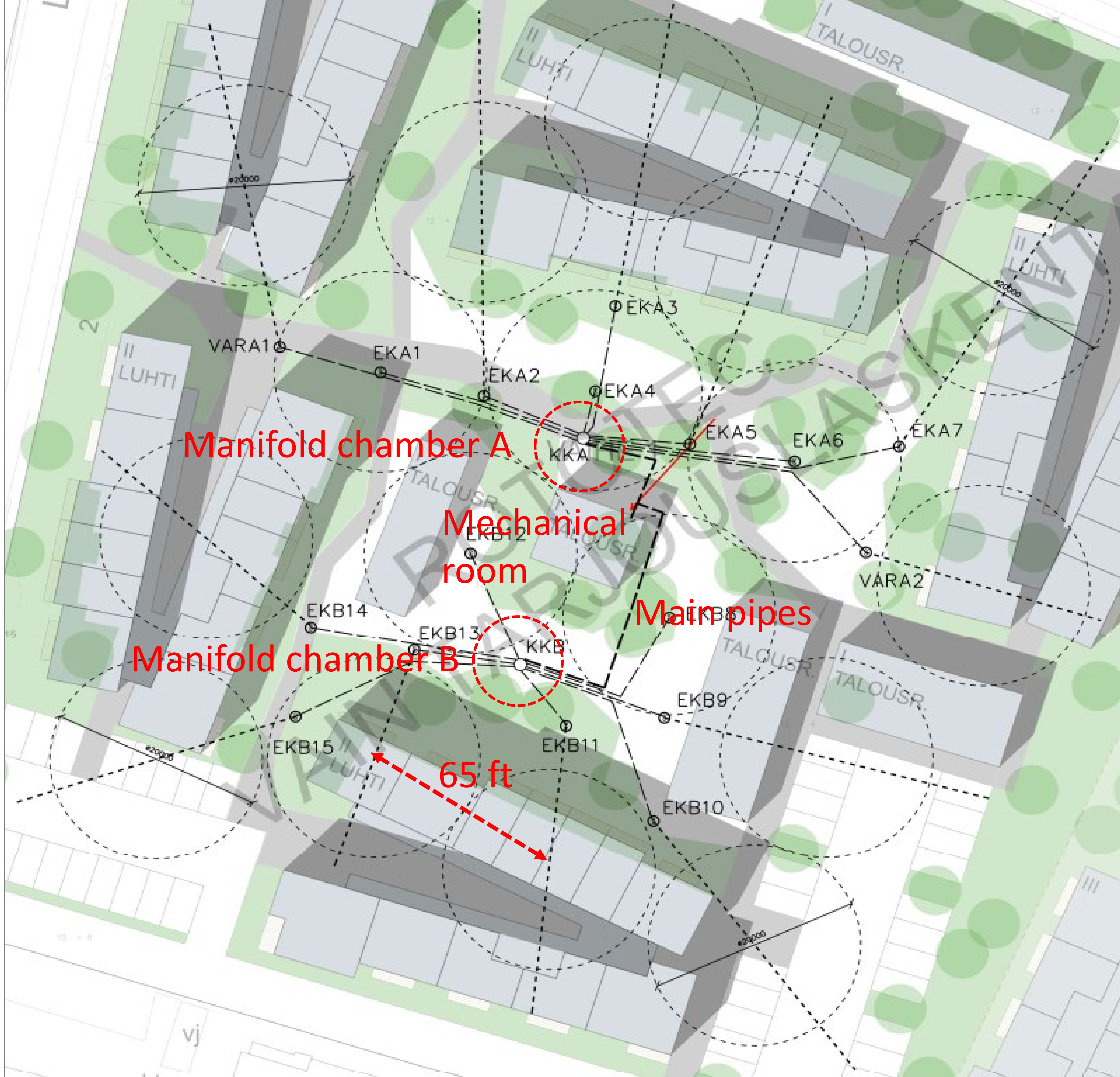
Main features of loop and pipe design

- Typically pressure category **PN 10 SDR 17** for all loops and pipes
- Vertical loops typically 1.39 in, 1.56 in or 1.74 in **inner diameter**
- Pre-insulated horizontal pipes and main pipes
- Horizontal pipes, typical **outer diameters**:
  1.57 in, with pre-insulation 2.48 in
  1.77 in, with pre-insulation 2.95 in
  1.97 in, with pre-insulation 3.54 in
- Main pipes, typical **outer diameters** without insulation: 2.95 in, 3.54 in, 4.33 in, 6.30 in
- Boreholes are connected to the main pipes with manifold chambers or manifold cabinets
- Pipes are typically fused together using electrofusion

Example design with multiple manifold chambers

Idea

- The boreholes are grouped around a number of manifold chambers
- Each borehole group connects to a separate manifold chamber
- The manifold chambers are connected to the main pipes, which feed into the mechanical room



USA common practice: Reverse return header systems

Features

- Equal pipe lengths ensure balanced flow across all boreholes
- Manifold may be large and complex due to long pipe runs

Location of vaults

- Can be centralised (big vault outside) or internal (inside technical room)

Overview of design philosophies: Manifold chambers versus reverse return header

	Manifold chambers	Reverse return header
Pipe layout	Direct to nearby vault	Reverse return loop
Manifold vault	Small underground vaults, per group of boreholes (up to 12 or 20 boreholes)	Large centralised manifold, outside or inside the building
Balancing need	Easier to balance individual wells	Requires equal pipe length design
Maintenance access	Underground access to manifolds through manhole covers	Centralised access to system, often inside the building
System simplicity	Simple installation	Complex installation

Pros and cons of manifold vaults versus reverse return headers

	Manifold chambers	Reverse return header
Pros	+ Possibility to control the flow and maintain a stable flow through each borehole + Possibility to shut off individual boreholes in case of leaks + Easier to get rid of microbubbles + Easier installation per borehole group + Less excavating + Better suited for dense urban installations	+ Equal flow distribution + Centralised control and maintenance + Lower pressure drop + Less pumping power needed for normal operation
Cons	- Underground manifolds can be difficult to access for maintenance	- Complex design and installation - More vulnerable to single-point failures

Deep-dive: Operational advantages of using manifold chambers and manifold cabinets

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Some important advantages of operating with manifold chambers and manifold cabinets

✓ Possibility to shut off single boreholes in case of leaks adds robustness to the system. The system is not very vulnerable to a single-point failure

✓ Easy to get rid of microbubbles by shutting off all but one borehole and then forcing a large flow through this borehole. Smaller pumping capacity thus needed to flush the boreholes

✓ Using motorised valves, it is possible to customise the flow through the boreholes e.g. for temperature gradients in borehole thermal energy storage (BTES) systems. For instance, a higher temperate in the middle of the system

Additional benefits of operating with manifold cabinets

✓ Very easy access to the manifolds in comparison to manifold chambers

Questions

- What are the primary differences between Swedish and American horizontal piping designs?
- What does the choice of horizontal design depend on?
- What does Sweden prioritize in its designs, and what does the US prioritize in its designs?

Conclusions

- Both systems aim to ensure efficient geothermal heat transfer
- The choice depends on project scale, regulations, space availability, and installer preference
- Sweden prioritises modularity and simplicity; whereas the USA leans towards centralised and engineered balance


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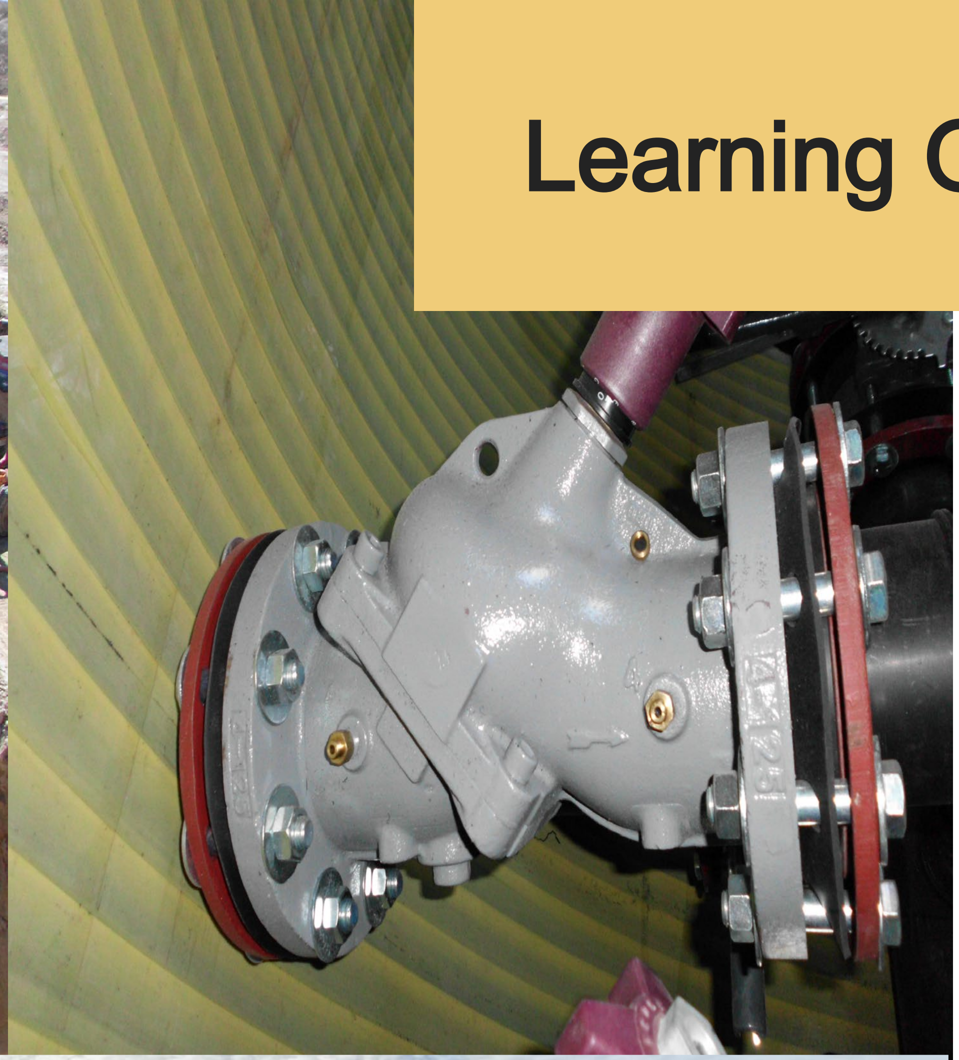
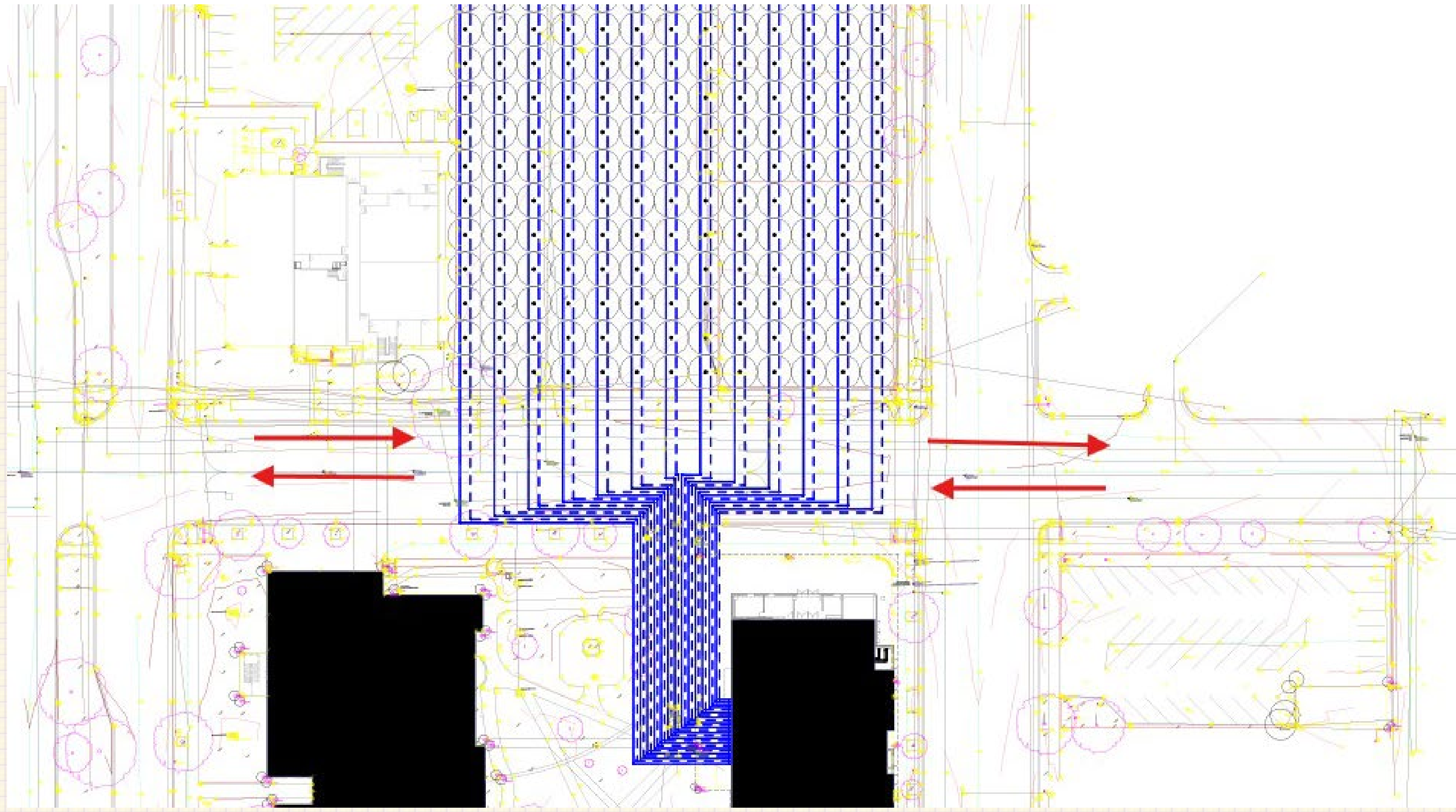
GHX Piping Designs

ISCO INDUSTRIES



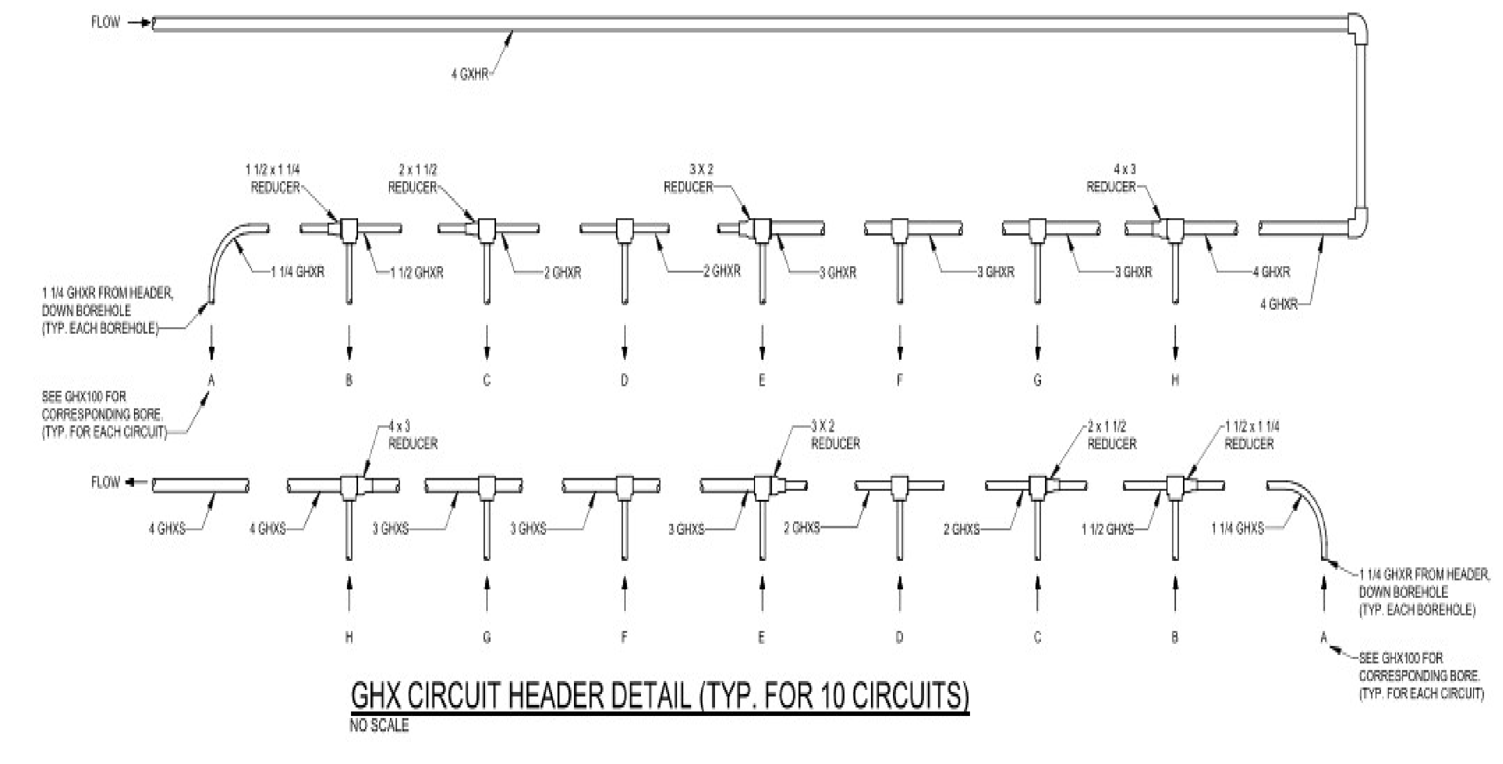
Learning Objectives

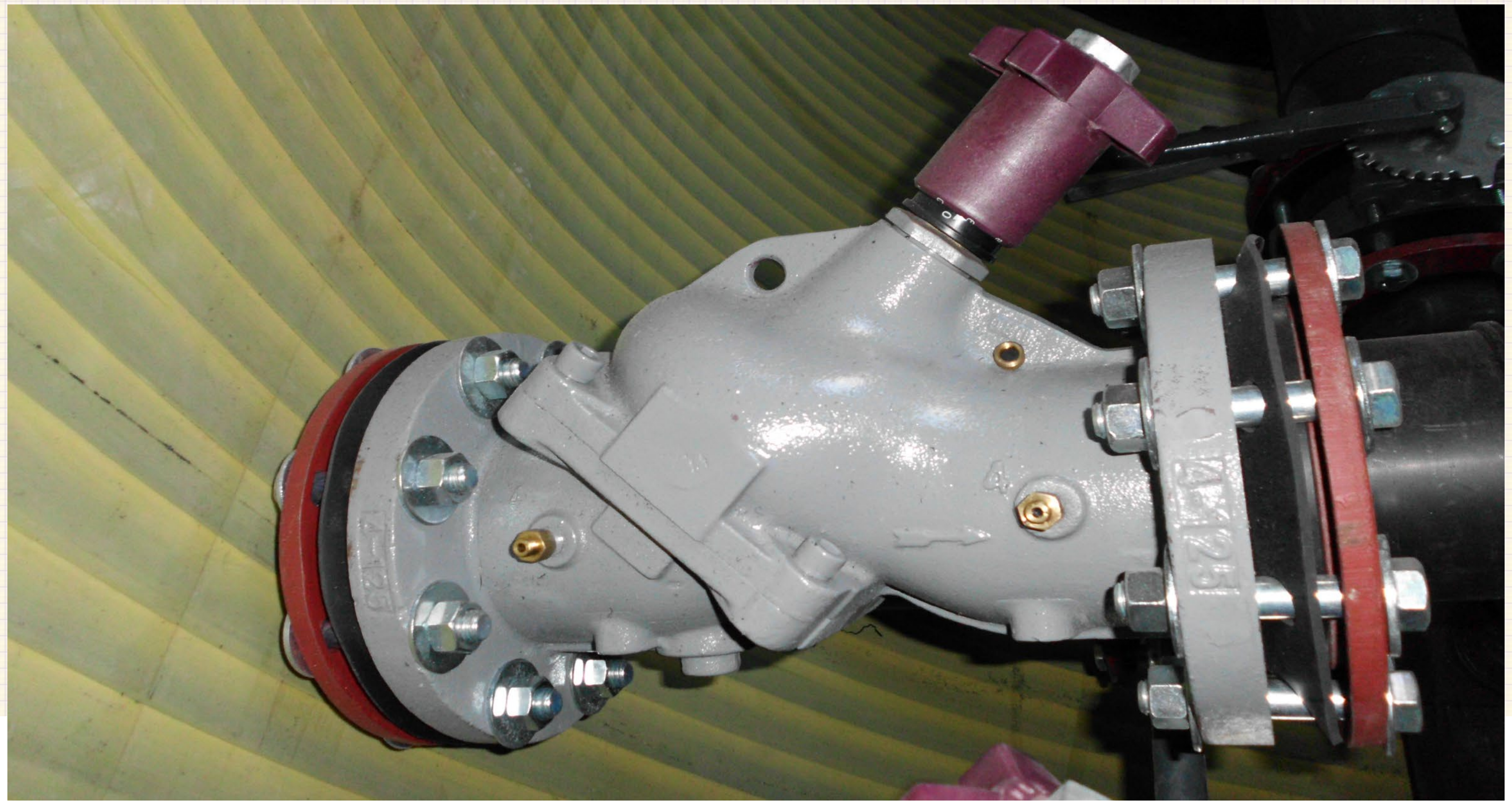
- Learn how vaults can reduce piping penetrations at the building.
- Discover how balancing valves can work with reverse return piping to help balance your design.
- Understanding how a bypass can separate your piping scopes.



Design to Reduce Penetrations & Excavation

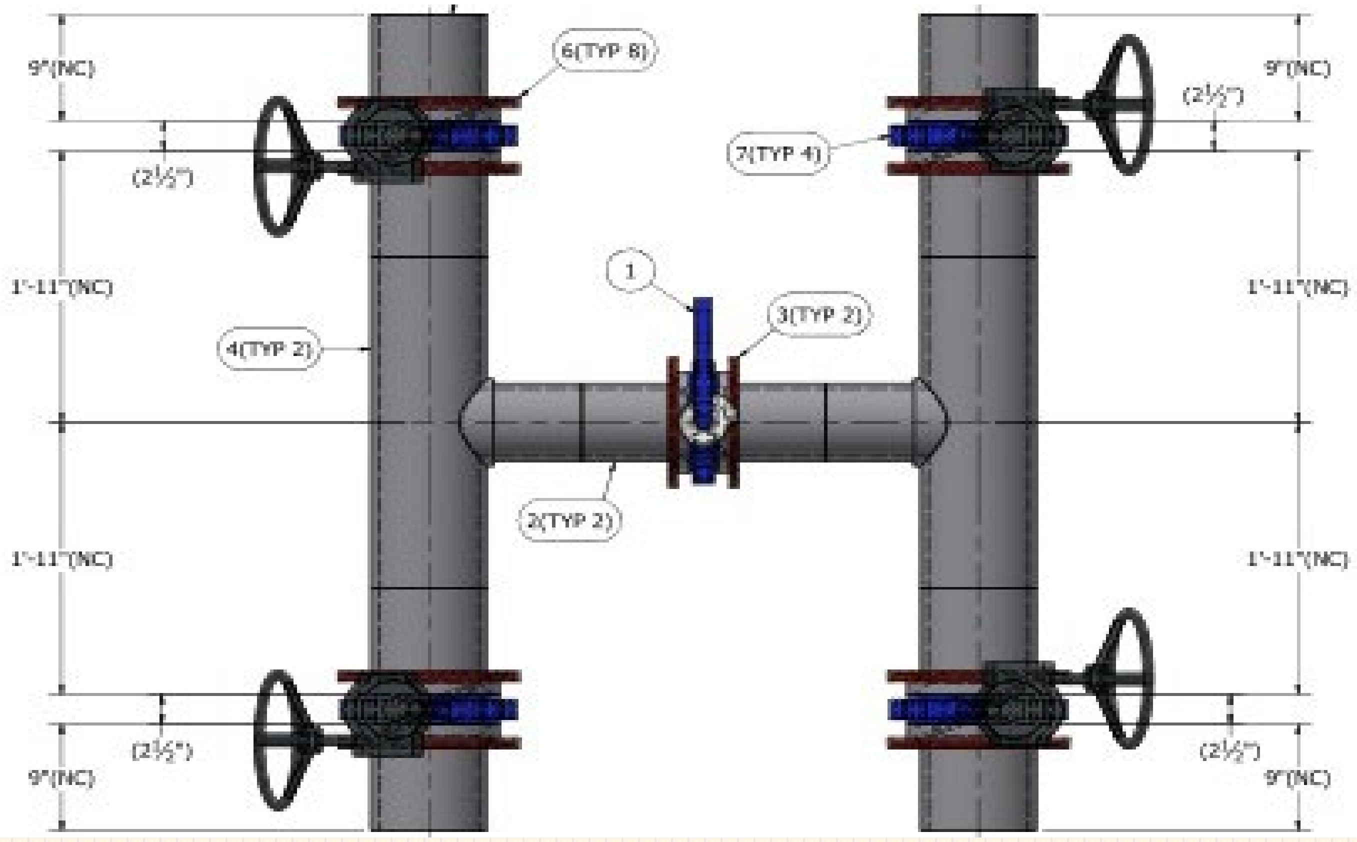
By consolidating and manifolding your circuit supply and return piping at a vault, you can reduce the number of piping penetrations and excavation to the mechanical room. Less is more when it comes to creating space.

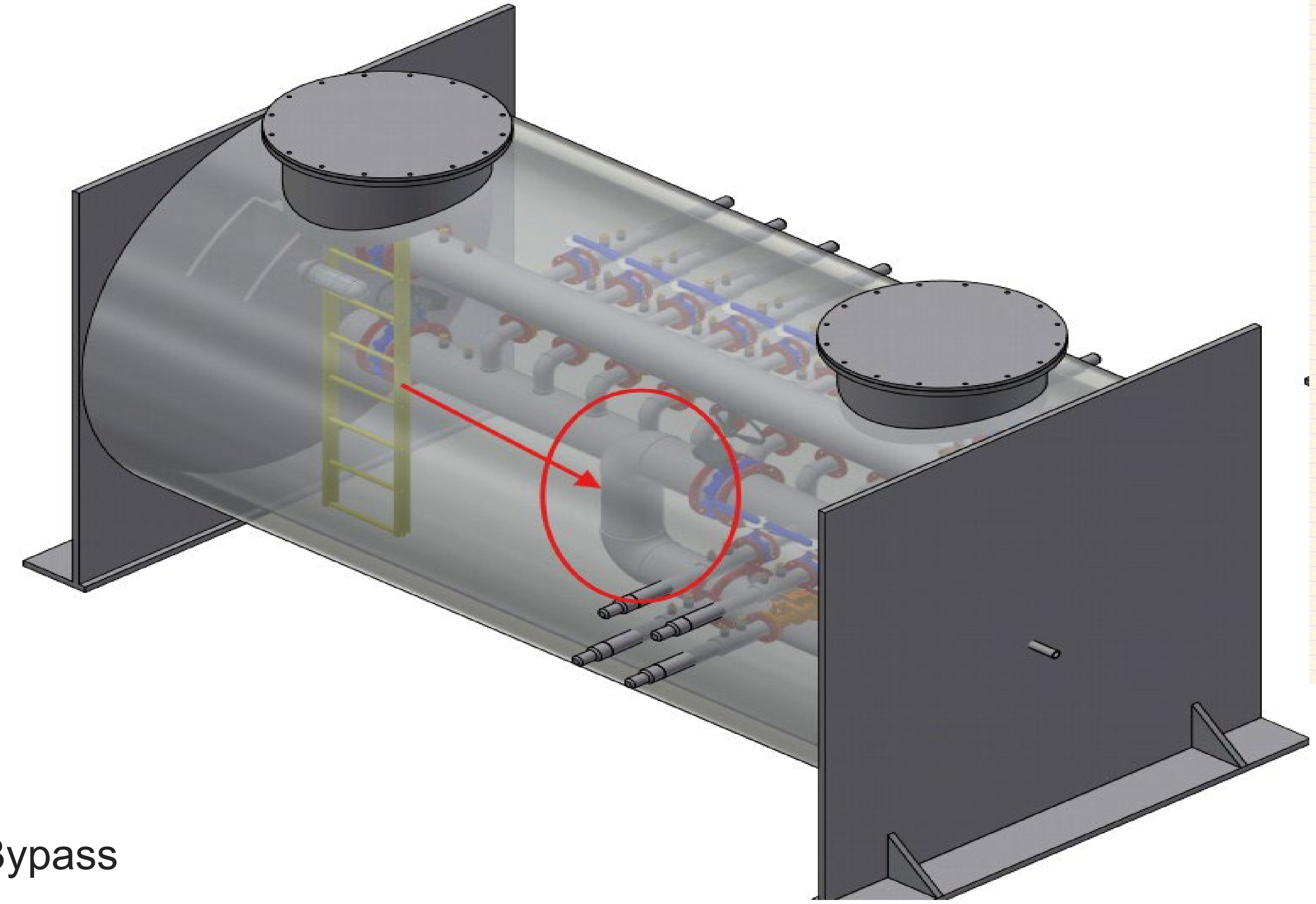




Reverse Return Piping

Reverse Return Piping - Equal water flow in GHX circuits equates to balanced heat extraction/rejection to optimize performance of the system. In a RR manifold, the first circuit that takes flow in is the last circuit to flow out on the opposite side of the manifold. Utilizing balancing valves within the vault or manifold further aids in balanced flow from the borefield.



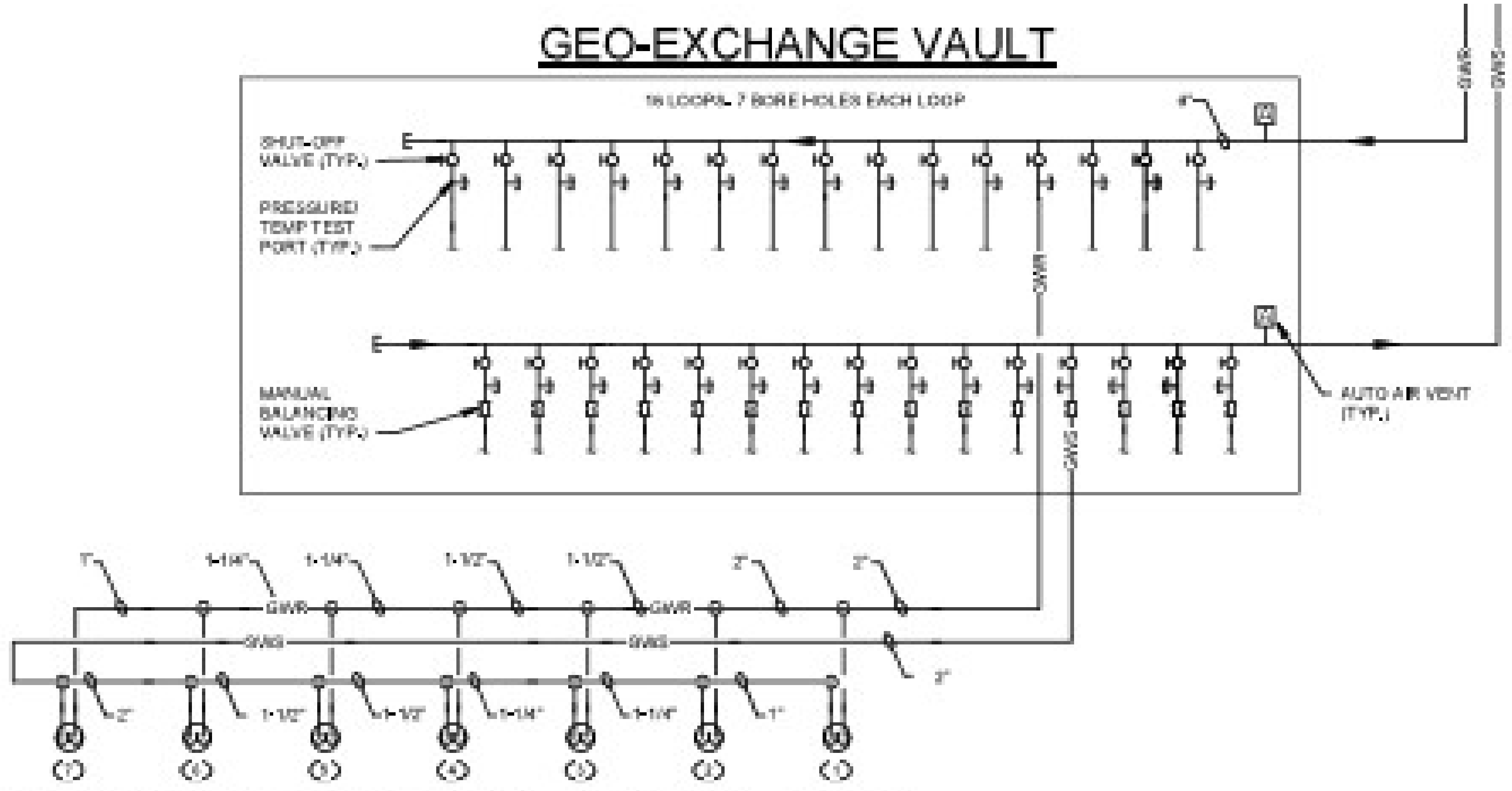


Utilizing a Bypass in Piping Designs to Separate Scopes

Incorporating a bypass allows the installer to separate scopes at the mechanical room or the vault.

Flush/purge the system while bypassing the building. A bypass allows you to isolate the GHX from the mechanical system.

Learning Assessment



7 BOREHOLE LOOP DETAIL (TYPICAL OF 16)

- What are some ways utilizing a vault can create more space and reduce excavation costs?
- How does reverse return piping work and are balancing valves required in reverse return systems?
- How do bypasses within a vault or mechanical room work to separate scopes?

Reducing Header Loop Field Design and interior header solution

An alternative to reverse return header and outdoor vaults

Jens Ponikau CGD

President, New York Geothermal Energy Organization

Buffalo Geothermal LLC

04-23-2025

BUFFALO GEOTHERMAL HEATING™

www.BuffaloGeothermalHeating.com

Learning Objectives

- Understand the flow and heat transfer impact of reverse header design
- Discuss the impact of a reducing header
- Discuss the benefits of borehole subgroup flow control from inside the building

Every loop field has a self balancing function

Pressure drop

- If a borehole has
  - a shorter run
  - lesser pressure drop
  - gets more flow, the higher flow will increase the pressure drop in a square function

  - and

  - all the other flow paths will reduce their pressure drop
  - due to lesser flow
  - also in a square function

Impact of length on pressure drop (linear function) (John Manning P.E.)

- 70% of the pressure drop in the boreholes and
- 30% of the pressure drop in the horizontal headers,
- this would only result in +/-10% imbalanced flow around the desired flow

	Closest Loop	Average Loop	Furthest Loop
Pressure Drop	Y	.5X + Y	X + Y
70% Rule	X = .3(X+Y) X = .3X + .3Y .7X = .3Y X = .3Y/.7 = .4286Y		
Pressure Drop @ $Q_{LOOP\text{-}DES}$	Y	1.214Y	1.4286Y
Actual Pressure Drop	1.214Y	1.214Y	1.214Y
Ratio of Actual vs. Design	1.2143	1.0000	0.8500
Square Root of Ratio	1.1019	1.0000	0.9220
Flow Rate Relative to $Q_{LOOP\text{-}DES}$	110%	100%	92%

Impact of 10% imbalanced headers (assuming turbulent flow)

John Manning P.E.

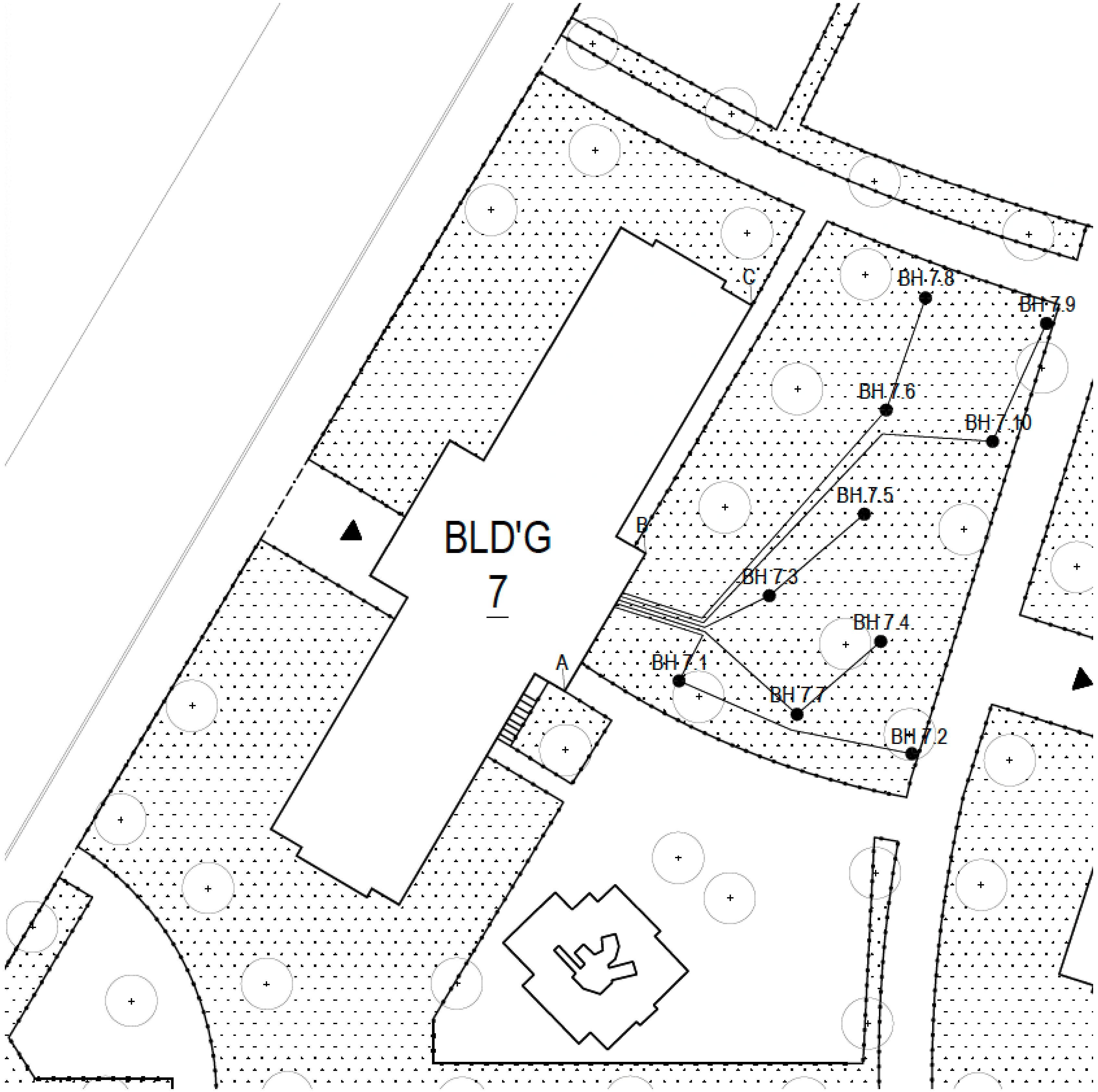
- Performance impact of a +/- 10% of average flow = 1-2%

Steve Kavanaugh P.E.

- Calculated 0.1% - 0.2% performance penalty with 10% imbalance between worst and best borehole

- New 2025 IGSHPA/CSA standard does not require 10% max flow imbalance and reverse return headers
  - Increases costs and reduces performance due to
    - increased pumping costs and reduced performance if we are trying to balance all the flow circuits (boreholes).

NYCHA Header Design, Bronx NY (inside Manifold)

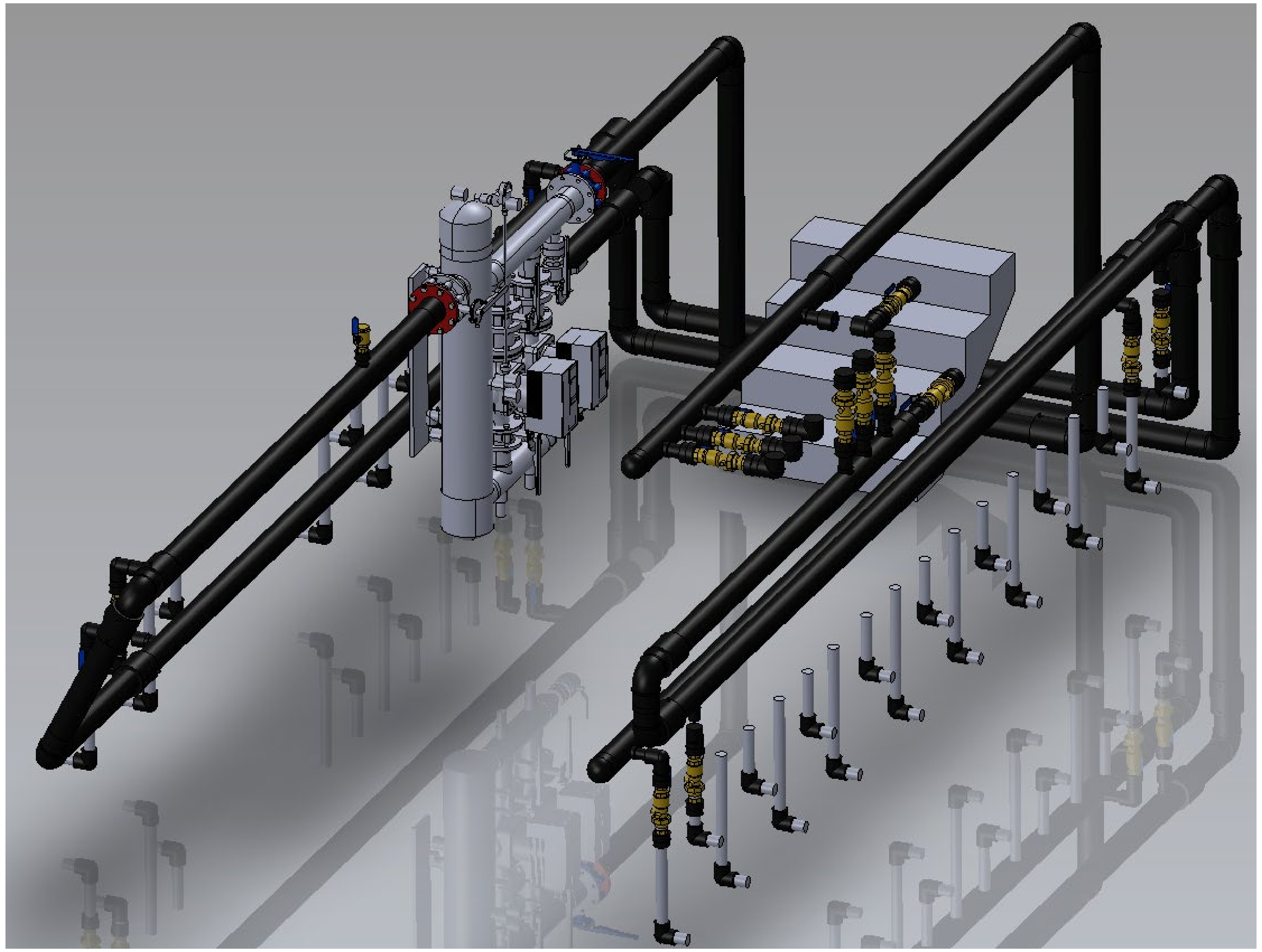


New Paltz NY

Mixed use, Net-Zero Energy Building: 63,320sf (2020 Completed)

Average total pumping power = 396 watt

Peak total pumping power = 598 watt



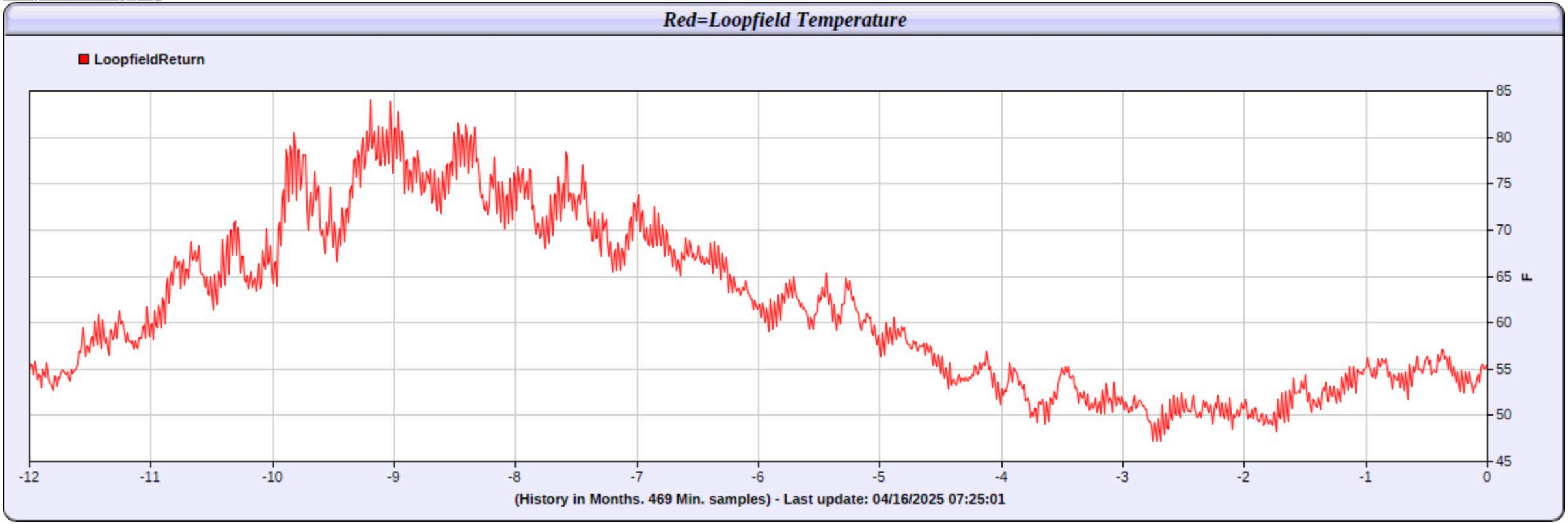
https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications

12 Month Annual Entering Water Temperatures

2/18/2022 -2/18/2023 Thermal Battery Zero Place

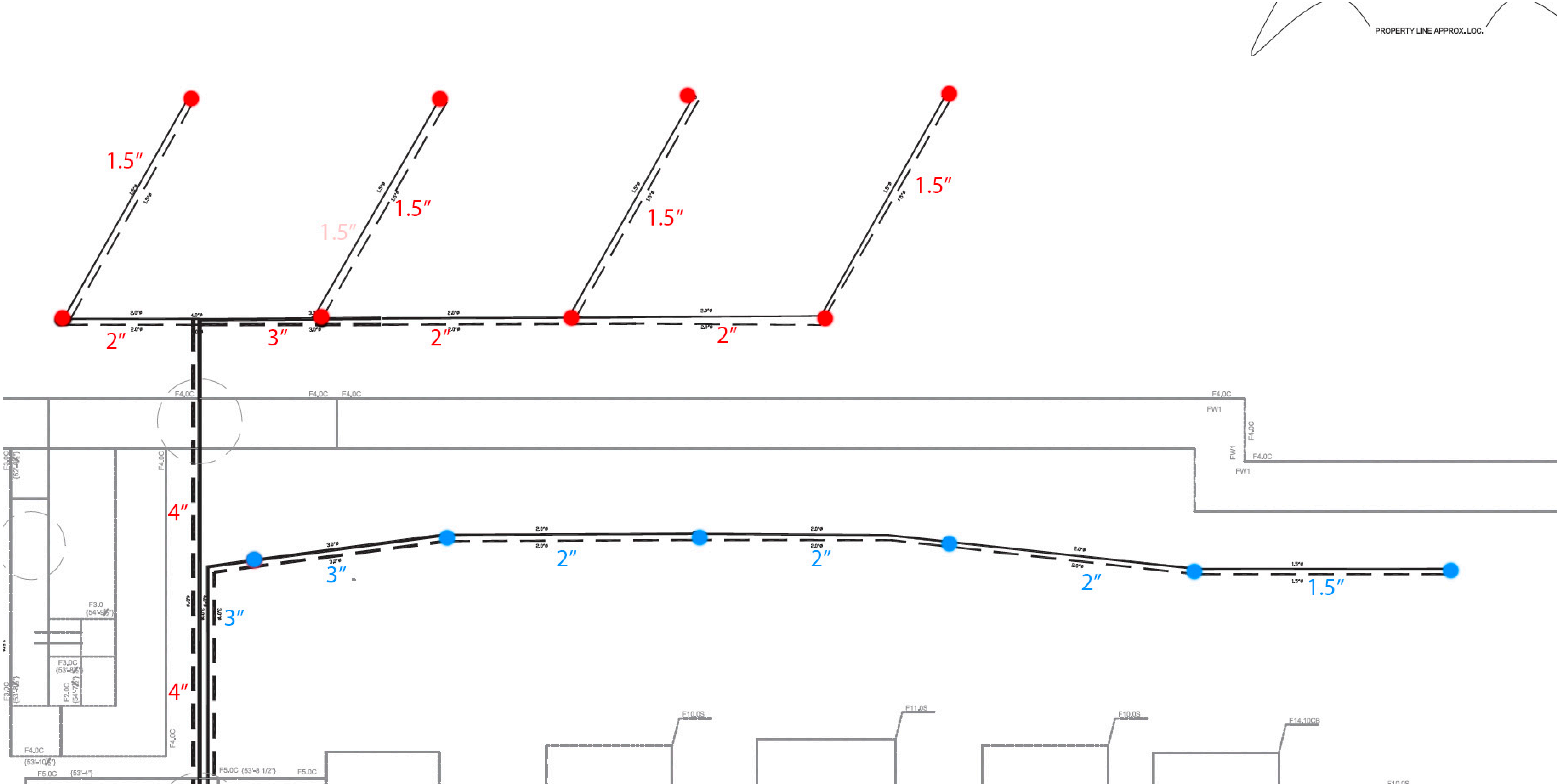
- Heating up the ground
  - Storing summer A/C rejection in the ground
  - Reusing it in the winter

LoopfieldYearly.png



Outside Header Details

Designing an outside reducing header



Header Control in Basement

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