Geothermal Radiant & Ventilation System - Design Brief for Contractors

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1. Project Summary

This is a new 3,600 ft², four-story house in Cincinnati, Ohio. The owner intends to heat and cool the house entirely with hydronic radiant floors and a small number of chilled-water fan coils, served by a vertical-bore geothermal field and a water-to-water heat pump, with a balanced ERV ventilation system whose intake air is pre-treated by two water coils. The design goals, in priority order, are:

1. Indoor humidity control good enough for radiant cooling: indoor dew point held at or below 55°F in cooling season.
2. Quiet operation: no audible air noise in bedrooms and living spaces.
3. Low operating cost: night-time charging of the slab and buffer tank, direct free cooling from the bore field in shoulder seasons, and no ERV defrost.
4. Durability and serviceability: no hidden condensation, every wet surface drained and accessible.

The owner has done the concept work described here and is looking for a designer and installer to validate the loads, size the bore field and equipment, produce construction drawings, and install or supervise installation. The owner expects to self-perform some of the labor (tubing, plates, insulation, radial ventilation ducting) and would like proposals to separate design, professional-only installation, and optional full installation.

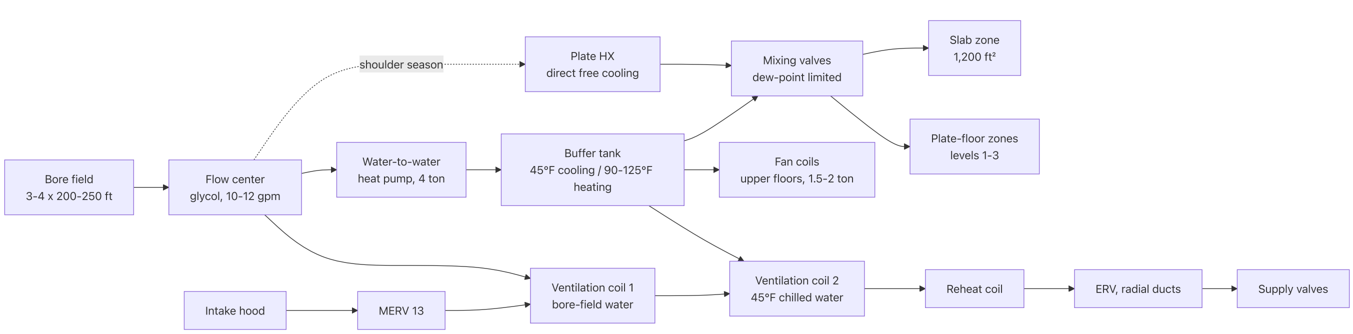
2. Design Basis

The figures below are the owner's estimates and are to be confirmed by a room-by-room Manual J and a bore-field model.

Item	Value
Location	Cincinnati, OH; ASHRAE climate zone 5A
Outdoor design, heating	5°F (99%)

Item	Value
Outdoor design, cooling	92°F dry bulb, 74°F dew point (roughly 55% RH); summer dew points 65-75°F
Ground	Interbedded limestone and shale; undisturbed ground about 55-57°F below 20 ft
Conditioned area	3,600 ft² over four stories, about 32,000 ft³
Estimated heating load	About 40,000 Btu/h at design; 65-80 MMBtu/yr
Estimated cooling load	3-4 tons sensible plus ventilation latent; upper floors carry the larger share
Indoor setpoints	70°F heating; 75°F / 50% RH cooling; indoor dew point 55°F max
Ventilation	150 cfm continuous, 250 cfm boost (ASHRAE 62.2 for 3,600 ft², 4-5 bedrooms), demand-controlled on CO2
Lowest level floor	1,200 ft² slab on grade, 6" 4,000 psi concrete, radiant tubing in upper third, insulated below and at edges
Levels 1-3 floors	2,400 ft² framed, radiant tubing in extruded aluminum transfer plates under the subfloor, insulated joist bays
Floor coverings	Solid hardwood, engineered wood, carpet in some rooms, tile in bathrooms
Foundation trench	Footer-level drainage trench, 200 ft long, 3 ft to 12 ft deep along a slope; available for the bore-field header
Rain cistern	2,500 gal on site; not part of the mechanical system
Electrical	Duke Energy Ohio; owner will evaluate the electric space-heating rate

3. System Concept



One bore field serves everything. A flow center circulates glycol through the heat pump and, in parallel, through a small precool coil in the ventilation intake and a plate exchanger for direct free cooling. The heat pump charges a single buffer tank that changes over seasonally; the tank feeds three mixed radiant zones (slab, and two or three plate-floor zones at a higher temperature), the upper-floor fan coils, and a second ventilation coil that dries outdoor air to a 50-52°F dew point. A reheat coil piped from coil 2's return warms the supply air before the ERV. The radiant floors carry the full heating load and the slab-level cooling load; the fan coils carry the upper-floor cooling peak and provide the bulk of the latent removal, with a ducted whole-house dehumidifier as backup.

4. Subsystems

4.1 Bore Field

Three or four vertical bores at 200-250 ft, 3/4" or 1" SDR-11 HDPE U-bends, thermally enhanced grout, reverse-return header run through the footer trench into the mechanical room. The field is to be modeled for both the heating load and the cooling load, including the summer heat rejection from the fan coils and both ventilation coils and the night-time tank-charging schedule, with a ten-year loop-temperature projection. Bores 15-20 ft apart and at least 10 ft from the foundation. All loops pressure tested at 100 psi for one hour before backfill.

4.2 Flow Center and Heat Pump

Pressurized flow center with variable-speed ECM pumps at 3 gpm per ton, 20-25% inhibited propylene glycol. A 4-ton two-stage or variable-speed water-to-water heat pump, reversible, capable of 45°F chilled water and at least 125°F hot water, with a desuperheater for domestic hot water. Branches off the loop: a balanced 3 gpm branch with its own circulator to ventilation coil 1, and a branch to the free-cooling plate exchanger.

4.3 Buffer Tank and Distribution

One insulated buffer tank, 500-800 gal, rated for 45-130°F, seasonal changeover by the controller. The tank serves: the slab zone through a mixing valve (95-105°F heating, 58-62°F cooling); the plate-floor zones through a second mixing valve (110-125°F heating, 58-62°F cooling); the upper-floor fan coils and ventilation coil 2 at full tank temperature. Every cooling-season supply to a floor is limited to indoor dew point plus 3°F and never below 55°F. All tank and cold-water piping insulated with closed-cell foam and a sealed vapor barrier.

4.4 Radiant Floors

Level	Construction	Coverings	Heating output	Cooling output
Lowest	6" slab, 1/2" PEX at 12" o.c., tubing 2" below surface, R-10 to R-15 below, R-10 edge	Tile / engineered	25-30 Btu/h·ft²	12-14 Btu/h·ft²
1-3 wood	Extruded aluminum joist plates, 1/2" PEX at 8" o.c., R-19 below	Solid hardwood, engineered	20-25 Btu/h·ft²	5-8 Btu/h·ft², surface 66°F min
1-3 carpet	Same plates; carpet plus pad limited to R-1.5	Carpet	10-15 Btu/h·ft²	Negligible; fan coil serves these rooms
Baths	Plates or slab	Tile	Full	Full

Manifolds with flow meters and balancing valves on each level; slab tubing sleeved at every control joint; hardwood installed at 6-8% moisture content with a ramped first heating season. A temperature/RH sensor in the coldest plate joist bay overrides the mixing valve if bay RH exceeds 80%.

4.5 Fan Coils

Hydronic chilled/hot-water fan coils totaling 1.5-2 tons on the top two floors (ceiling cassettes or a small ducted air handler), each with a trapped condensate drain, fed from the buffer tank with zone valves. They cover the upper-floor sensible peak that the plate floors cannot and remove latent load at 45°F water.

4.6 Ventilation Air Path

Intake hood with bird screen, motorized damper, 4" MERV 13 media cabinet, then in a single cased section with a continuous sloped stainless drain pan: coil 1 (4-row, bore-field glycol, 3 gpm), coil 2 (4-6 row, 45°F tank water, 2-3 gpm), and a 1-2 row reheat coil piped from coil 2's leaving water. Coils piped counterflow, face velocity about 150 fpm at 150 cfm. All duct after coil 1 is R-8 wrapped with a sealed vapor barrier. Design intent: winter intake air leaves coil 1 at 40-45°F (no ERV frost); summer air leaves coil 2 at a 50-52°F dew point and the reheat coil at about 65°F.

4.7 ERV and Distribution

Zehnder ComfoAir Q350 ERV (or approved equal with certified recovery above 80% and a unit sound level under 45 dB(A)), wall-mounted on isolation mounts in the mechanical room, one wall and one door from any bedroom. Radial home-run distribution: 3" semi-rigid tubes from silenced supply and extract manifolds to 5" valves, face velocity under 250 fpm. Supply to every bedroom, living, family, office and top-floor living space; extract from every bath, the kitchen (not the range hood), laundry, mud room and mechanical room; door undercuts or transfer grilles on every door between. Demand control from CO2 sensors in the master bedroom and main floor. The range hood is a separate exhaust with makeup air.

4.8 Direct Free Cooling

A brazed plate exchanger between the ground loop and the floor circuit, with motorized three-way valves on both sides, engaged by a differential controller whenever loop supply is 3°F or more below the floor setpoint (expected May to mid-July and September-October). Floors then cool on circulators alone; the heat pump runs only for the fan coils and coil 2.

4.9 Dehumidifier Backup

A ducted whole-house dehumidifier of about 100 pints/day with its own return on the lowest floor and a 50% RH dehumidistat, independent of the heat pump. Expected to run mainly in shoulder seasons and after high-moisture events.

5. Sequence of Operations

Season	Bore field and loop	Heat pump and tank	Floors and fan coils	Ventilation
Winter	48-55°F to heat pump evaporator and coil 1	Heats tank to 90-125°F on outdoor reset; tank charged preferentially midnight-6 a.m.	Slab and plate zones on separate mixed supplies; fan coils in heating as needed	Coil 1 preheats intake to 40-45°F; coil 2 and reheat idle; ERV runs frost-free
Shoulder (May-mid July, Sept-Oct)	55-60°F; plate HX engaged when loop is 3°F below floor setpoint	Runs only for fan coils and coil 2 tank demand	Floors cooled directly by loop water via plate HX	Coil 1 precools; coil 2 dries to 50-52°F dew point; reheat to 65°F
Summer peak	60-65°F; absorbs rejection from heat pump, fan coils and coils	Tank at 45°F; charged midnight-6 a.m.; slab precooled 2-3°F overnight	Floors at 58-62°F limited by dew point; fan coils carry upper-floor peak and latent	Both coils active; supply air 65°F at 50-52°F dew point

Season	Bore field and loop	Heat pump and tank	Floors and fan coils	Ventilation
Any	Coil-1 branch balanced so it never starves the heat pump	Seasonal changeover by controller; DHW desuperheater year-round	Dehumidifier on its own 50% RH dehumidistat	Demand control 100-250 cfm on CO_2; bath boost

Required Interlocks

- Ventilation fan or ERV cannot run unless loop flow to coil 1 is proven (flow switch or pump current) and the intake damper end switch proves open. This is the coil freeze protection.
- Coil pan overflow float stops the ERV and closes the intake damper.
- Every cooling-season floor supply limited to indoor dew point plus 3°F and never below 55°F, from an indoor temperature/RH sensor on the lowest floor.
- Plate-floor cooling supply raised or stopped if any joist-bay RH sensor exceeds 80%.
- Free-cooling valves open only on a 3°F differential with 2°F hysteresis; never while the heat pump is in heating.
- Fan-coil condensate floats stop the associated zone valve on overflow.

Monitoring

The owner will install a data logger; the controls contractor is asked to provide accessible sensor points for loop entering and leaving temperature, coil-1 branch temperatures, air temperature before and after each ventilation coil, tank top and bottom, slab temperature, indoor dew point, joist-bay RH, and heat-pump and pump power.

6. Decisions Made and Open Items

Owner Decisions (please Design to these)

- Hydronic radiant heating and cooling on all four levels; no forced-air heating.
- Vertical bore field and water-to-water heat pump, not an air-source unit.
- Two-coil ventilation pretreatment (bore-field coil then chilled-water coil) with reheat, upstream of the ERV.
- Balanced ERV with radial home-run ducting; noise at valves and in bedrooms is a hard requirement.
- 6" 4,000 psi slab with tubing in the upper third and full under-slab and edge insulation.

- Extruded aluminum transfer plates (not stamped plates or suspended tube) on levels 1-3.
- Indoor dew point control as the governing constraint for all cooling.
- Owner will self-perform tubing, plates, insulation and radial ducting if the contractor is willing to inspect and commission that work.

Open Items (please advise)

- Bore count and depth from a model using actual loads; whether three bores at 250 ft or four at 200 ft is preferable on this site.
- Heat pump make and model; variable-speed versus two-stage; minimum chilled-water setpoint; whether factory free-cooling is available.
- Buffer tank size (owner estimate 500-800 gal) and whether one changeover tank or separate hot and cold tanks is better with the fan coils and coil 2 needing 45°F water while floors are in shoulder-season heating.
- Fan-coil count, type and placement on the upper floors, sized to the upper-floor load minus plate-floor output.
- Whether the carpeted rooms should change covering or rely entirely on fan coils for cooling.
- ERV equal-or-better alternatives to the specified unit and whether its fans carry the full intake path or an inline fan is needed.
- Whether the whole-house dehumidifier is still warranted once fan coils and coil 2 are in place.
- Radon mitigation approach given the footer-level header trench.
- Applicability of the Duke Energy electric space-heating rate and any current state or utility geothermal incentives.

7. Requested Deliverables and Proposal Format

Proposals should be broken into three parts so the owner can mix them: (A) design only, (B) professional-only installation (drilling, header fusion and purge, heat-pump setting and startup, electrical, controls, ERV commissioning), and (C) full turnkey installation.

Design Deliverables

1. Room-by-room Manual J heating and cooling loads, with the ventilation latent load shown separately.

2. Bore-field design from GLD, LoopLink or equivalent: bore count, depth, spacing, grout, header layout, and a ten-year loop-temperature projection under the stated heating, cooling and night-charging profile.
3. Radiant design per zone: tube spacing, loop lengths, supply water temperatures, output per floor covering, manifold schedules, and the mixing and dew-point control strategy for the plate floors.
4. Fan-coil selection and placement with condensate routing.
5. Ventilation design: coil selections at 150 cfm and the specified water temperatures, static-pressure calculation for the full intake path, radial duct layout and valve schedule with per-room cfm.
6. Hydronic piping schematic showing the flow center, branches, plate exchanger, tank, mixing valves, circulators, expansion, air separation and all isolation and balancing points.
7. Sequence of operations and interlock wiring diagram.
8. Equipment schedule with model numbers and an itemized cost estimate.

Questions for the Contractor

- How many radiant cooling projects have you designed or installed, and may the owner speak with two of those clients?
- Which loop-design software do you use, and will the model include the cooling and night-charging profile?
- Who on your team holds IGSHPA accreditation or a Certified GeoExchange Designer credential?
- Are you a Zehnder-certified installer, or which ERV would you propose instead and why?
- What is your approach to commissioning and to verifying airflow, water flow and the interlocks before handover?
- Which parts of the owner's self-performed work will you inspect, and at what stages?