VILLA MALL

Alamosa, CO

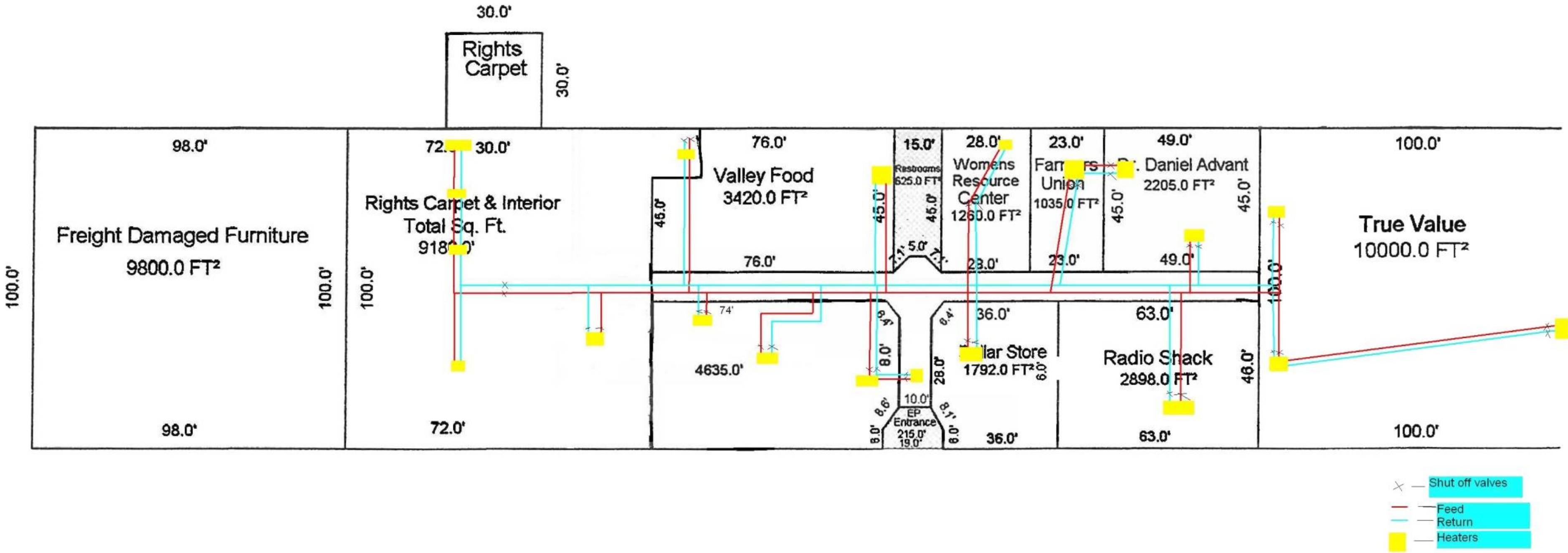
Gibsons, Town-n-Country Mobile Home Park Complex – 1970's

Gibson's Discount Store


Fan – Coil Unit




KRISTI



30.0'
Rights Carpet
30.0'
98.0'
Freight Damaged Furniture
9800.0 FT²
100.0'
98.0'
100.0'
Rights Carpet & Interior
Total Sq. Ft.
30.0'
100.0'
72.0'
45.0'
76.0'
Valley Food
3420.0 FT²
76.0'
74'
4635.0'
15.0'
Restrooms
45.0'
45.0'
5.0'
8.0'
28.0'
10.0'
EP Entrance
28.0'
Womens Resource Center
28.0'
36.0'
1792.0 FT²
36.0'
23.0'
1035.0 FT²
23.0'
45.0'
49.0'
2205.0 FT²
49.0'
45.0'
63.0'
Radio Shack
2898.0 FT²
63.0'
48.0'
100.0'
True Value
10000.0 FT²
100.0'
Shut off valves
Feed
Return
Heaters

Main Building Assessment

A survey of the existing geothermal heating system was conducted mid-January 2009 when the heating requirements of the building were relatively high.

- Water enters building heating system at 112°F
- Water exits building heating system at 106°F
- Average 40 gallons per minute (gpm) flowing through entire system
- Outside air temperature, Min -6°F, Max 28°F, average 11°F

- *120,168 Btu/h = 20,028 lbs/hr * 1 Btu/lb °F * (106 °F – 112°F)*

Btu/ft^2	Estimated Total Heat Energy Required (Btu/h)	Energy Supplied by Warm Geothermal Water (Btu/h)	Estimated Energy Deficit (Btu/h)
5	200,000	120,168	79,832
10	400,000	120,168	279,832
15	600,000	120,168	479,832
20	800,000	120,168	679,832
25	1,000,000	120,168	879,832

Table 3 – Heating capacity estimate of sample fan-coil unit

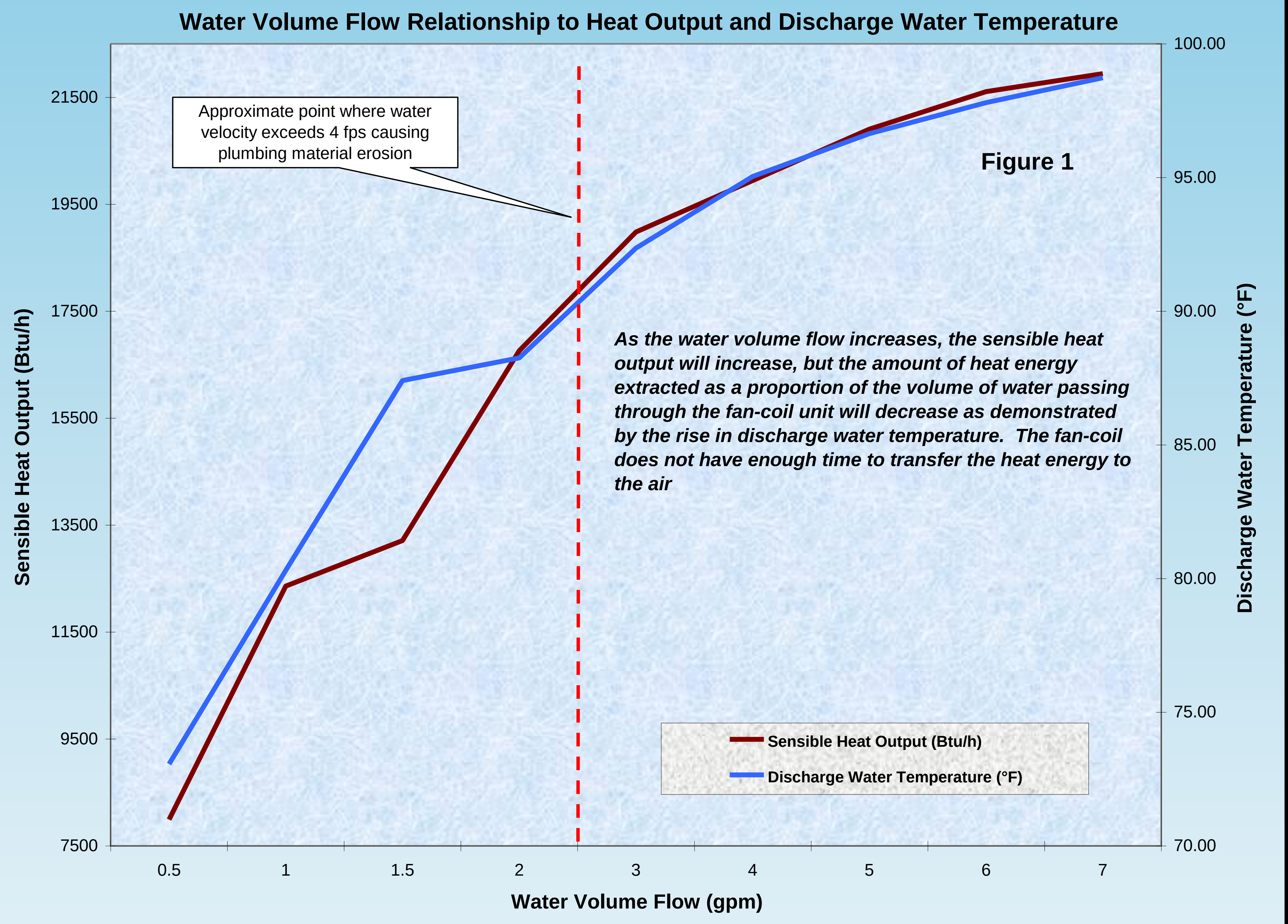
<table>
<tr><td colspan="3">McQuay TSC081 Fan-Coil
Heat Output
Heater Fan Setting – High</td><td>Entering Air
Entering Water
Temp Differential (ΔT)</td><td>68°F
112°F
44°F</td></tr>
<tr><td colspan="2">Flow Rate</td><td colspan="3"></td></tr>
<tr><td>Volume Flow (gpm)</td><td>Velocity (ft/sec)</td><td>Base Rating</td><td colspan="2">Sensible Heating Capacity (Btu/h)</td></tr>
<tr><td>0.5</td><td>0.817</td><td>216</td><td colspan="2">9,504</td></tr>
<tr><td>1</td><td>1.634</td><td>334</td><td colspan="2">14,696</td></tr>
<tr><td>1.5</td><td>2.451</td><td>357</td><td colspan="2">15,708</td></tr>
<tr><td>2</td><td>3.268</td><td>453</td><td colspan="2">19,932</td></tr>
<tr><td>3</td><td>4.902</td><td>513</td><td colspan="2">22,572</td></tr>
<tr><td>4</td><td>6.536</td><td>539</td><td colspan="2">23,716</td></tr>
<tr><td>5</td><td>8.170</td><td>565</td><td colspan="2">24,860</td></tr>
<tr><td>6</td><td>9.084</td><td>584</td><td colspan="2">25,696</td></tr>
<tr><td>7</td><td>11.438</td><td>593</td><td colspan="2">26,092</td></tr>
</table>

Table 5 – Relationship between water flow rate and exiting water temperature of Heater 2

Observed Water Temp In (°F) = 105			Observed Water Temp Out (°F) = 92		
Volume Flow (gpm)	**Flow Rate (fps)**	**Water Mass (lb/h)**	**Sensible Heat (Btu/h)**	**Predicted Water Temp Out (°F)**	**Change in Water Temp - ΔT (°F)**
0.5	0.82	250.4	7,992	73	32
1	1.63	500.7	12,358	80	25
1.5	2.45	751.1	13,209	87	18
2	3.27	1001.4	16,761	88	17
3	4.90	1502.1	18,981	92	13
4	6.54	2002.8	19,943	95	10
5	8.17	2503.5	20,905	97	8
6	9.80	3004.2	21,608	98	7
7	11.44	3504.9	21,941	99	6

(Specific Heat of Water (Btu/lb °F) = 1

- *Water Temp Out (°F) = (-Sensible Heat (Btu/h) / Specific Heat of Water (Btu/lb °F) * Water Mass (lb/h)) + Water Temp In (°F)*



Water Volume Flow Relationship to Heat Output and Discharge Water Temperature
Approximate point where water velocity exceeds 4 fps causing plumbing material erosion
Figure 1
As the water volume flow increases, the sensible heat output will increase, but the amount of heat energy extracted as a proportion of the volume of water passing through the fan-coil unit will decrease as demonstrated by the rise in discharge water temperature. The fan-coil does not have enough time to transfer the heat energy to the air
Sensible Heat Output (Btu/h)
Discharge Water Temperature (°F)
Water Volume Flow (gpm)
21500
19500
17500
15500
13500
11500
9500
7500
100.00
95.00
90.00
85.00
80.00
75.00
70.00
0.5
1
1.5
2
3
4
5
6
7
Sensible Heat Output (Btu/h)
Discharge Water Temperature (°F)

Evidence Supporting Semi-Recirculating System

Table 6 – Heating performance of individual fan-coil unit utilizing re-circulated water

McQuay TSC081 Fan-Coil Heat Output			1st Pass		2nd Pass	
			Entering Air	68°F	Entering Air	68°F
			Entering Water	112°F	Entering Water	106°F
Heater Fan Setting - High			ΔT	44°F	ΔT	38°F
Flow Rate						
Volume Flow (gal/min)	Velocity (ft/sec)	Base Rating	Sensible Heating Capacity (Btu/h)		Sensible Heating Capacity (Btu/h)	
0.5	0.817	216	9,504		8,208	
1	1.634	334	14,696		12,692	
1.5	2.451	357	15,708		13,566	
2	3.268	453	19,932		17,214	
3	4.902	513	22,572		19,494	
4	6.536	539	23,716		20,482	
5	8.170	565	24,860		21,470	
6	9.804	584	25,696		22,192	
7	11.438	593	26,092		22,534	

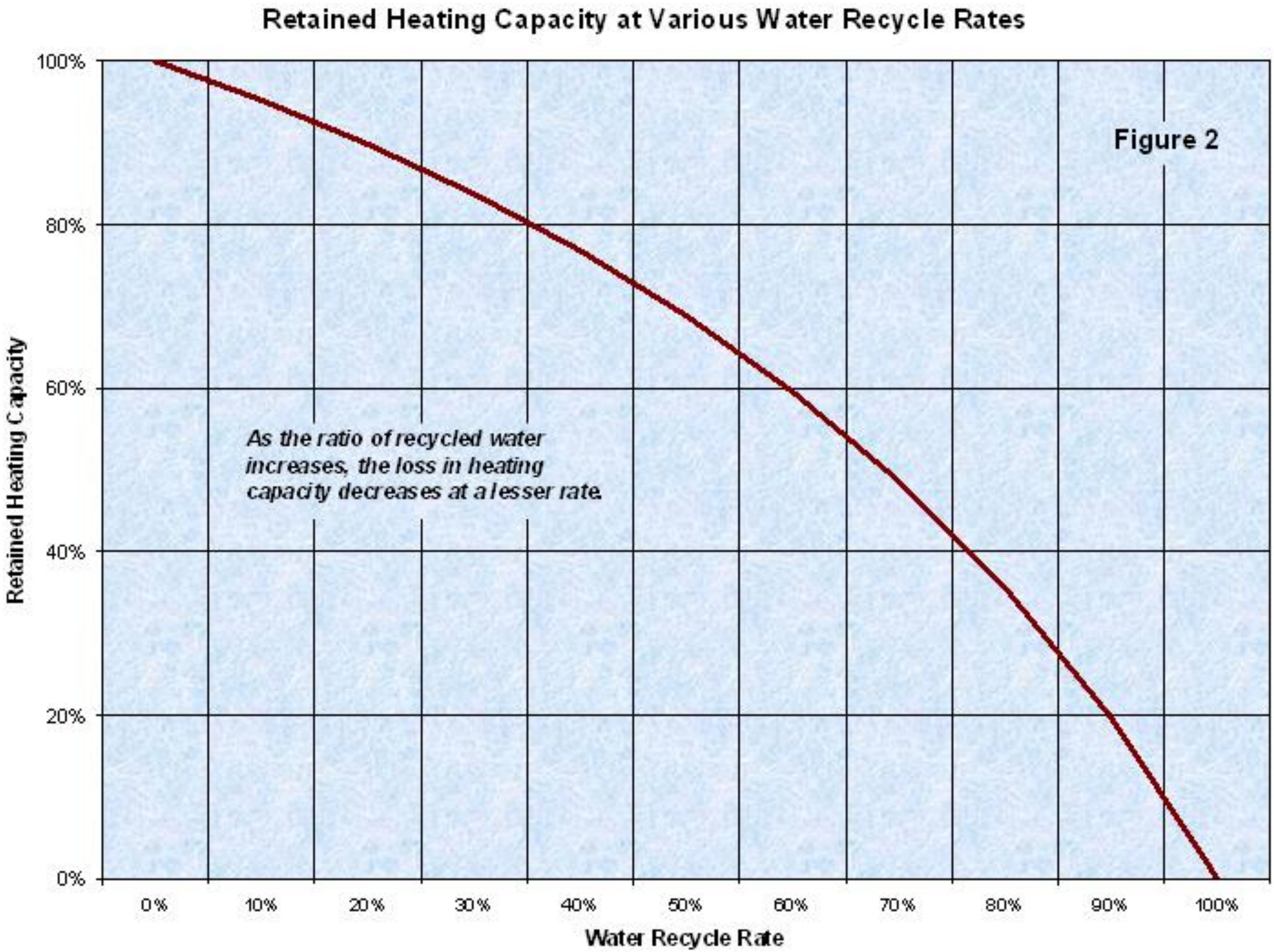
Table 7: Example of stable water temperature of one fan-coil unit at 50% recycle rate

Constants	
Volume Flow (gpm)	2
Percent Water from Well	50%
Percent Re-Circulated Water	50%
Mass of Water (lb/h)	1001.4
Source Water Temperature (°F)	112
Fan-Coil Base Rate (from manufacturer reference)	453
Ambient Air Temp (°F)	68

Iteration Cycle	Starting Water Temperature (°F)	Mixed Water Temperature (°F)	Air / Water ΔT (°F)	Sensible Heating Capacity (Btu/h)	Returning Water Temp (°F)
1	112	112.0	44	19932	92.1
2	92	102.0	34	15424	86.6
3	87	99.3	31	14189	85.2
4	85	98.6	31	13851	84.7
5	85	98.4	30	13759	84.6
6	85	98.3	30	13733	84.6
7	85	98.3	30	13726	84.6
8	85	98.3	30	13725	84.6
9	85	98.3	30	13724	84.6
10	85	98.3	30	13724	84.6
11	85	98.3	30	13724	84.6
12	85	98.3	30	13724	84.6
13	85	98.3	30	13724	84.6
14	85	98.3	30	13724	84.6

Table 8 – Mixed water temperature and heating capacity at various recycle ratios

Water Recycled gpm	Water Recycled %	Mixed Water Temperature (°F)	Sensible Heating Capacity (Btu/h)	Returning Water Temperature (°F)	Heating Capacity Retained	Heating Capacity Loss
0	0%	112.0	398,640	92.1	100%	0%
4	10%	109.9	379,560	90.9	95%	5%
8	20%	107.5	358,140	89.6	90%	10%
12	30%	104.9	333,900	88.2	84%	16%
16	40%	101.8	306,280	86.5	77%	23%
20	50%	98.3	274,480	84.6	69%	31%
24	60%	94.2	237,500	82.4	60%	40%
28	70%	89.4	193,940	79.7	49%	51%
32	80%	83.7	141,900	76.6	36%	64%
36	90%	76.7	78,600	72.8	20%	80%
40	100%	68.0	0	68.0	0%	100%



Retained Heating Capacity at Various Water Recycle Rates
Figure 2
As the ratio of recycled water increases, the loss in heating capacity decreases at a lesser rate.
Retained Heating Capacity
100%
80%
60%
40%
20%
0%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Water Recycle Rate

Table 9 illustrates the substantial water savings possible by utilizing a semi re-circulation design.

Table 9 – Water usage and potential savings at various discharge rates

Fill Rate (gpm)	Circulation Rate (gpm)	Discharge Rate (gpm)	Gallons Used per Day	Water Savings	Gallons Saved per Day	Acre Feet Save per Month
40	40	40	57,600	0%	0	0
30	40	30	43,200	25%	14,400	1.33
20	40	20	28,800	50%	28,800	2.65
10	40	10	14,400	75%	43,200	3.98
0	40	0	0	100%	57,600	5.30

Table 10 – Estimated cost of equivalent energy commodities

	Btu/h Rate	Natural Gas (per month)	Electricity (per month)
Observed	120,168	$371.04	$720.62
Maximum	400,000	$1,190.14	$2,331.78

Table 11 – Current system improvement options

Option	Estimated Cost	Benefit	Disadvantage
Do Nothing	$0	No expenditure	Continue to struggle with poor heat distribution in building and excessive discharge water
Balance Water Flow	$3,490	Improved warm water distribution to all heat units. Reduced erosion of plumbing system. Increase occupant comfort	Cost
Semi-Recirculation System	$3,400	Conserve water and reduce discharge	Cost
Convert to Natural Gas System	$10,000	Closed system, no discharge water to manage	High annual expense to operate. Must still balance flow and construct re-circulation system
Ground Re-injection System	$70,000	Discharge water is returned to aquifer	Extremely expensive to develop. Water must be treated. Complicated regulations and expensive system monitoring


CRESLINE