

MEMORANDUM

Date: October 4, 2016
To: Water Right File 37-8798
From: Michele Edl
Re: Analysis of the snow melting system

I was asked to review this water right file and analyze the snowmelting system to determine if the system could beneficially use the quantity of water which had been authorized by the permit.

Background

Permit 37-8798 authorized 0.35 cfs to be diverted from a geothermal spring for heating purposes. Based on conversations with the system operator, the heating uses have changed since the Proof of Beneficial Use statement was submitted in 1992. So although the current snowmelting system was not installed until 2008, I am assuming that the heating uses which were developed during the time that the permit was active, would have utilized the same quantity of heat (and water) as the current system. I also assumed that the temperature and pressure of the geothermal resource have remained relatively constant since 1992.

Method

My analysis of the snowmelting by this system was described in Pavement Snow Melting, by John W. Lund, Geo-Heat Center Bulletin (2000). The basic equation is:

$$q_t = q_s + q_m + A_r(q_e + q_h)$$

where q_t is the total heat output required and where:

q_s = sensible heat transferred to the snow to bring it to melting temperature (BTU/h ft²)

q_m = heat of fusion (BTU/h ft²)

A_r = ratio of snow-free area to total area (dimensionless)

q_e = heat of evaporation (BTU/h ft²)

q_h = heat transfer by convection and radiation (BTU/h ft²)

I created a spreadsheet which applies Mr. Lund's equations to weather, resource and heating plant parameters to calculate the quantity of heat needed for snow melting.

Results

The spreadsheet calculation that is attached to this memo represents successful snow melting. It indicates that the system can melt the snowfall experienced in a typical snow event. Scenarios depicting more extreme snow events (for example higher wind velocity or colder air temperature) indicate that the system would not be able to keep the area snow free.

The instantaneous flow rate for the current snow-melting system is limited by the capacity of the heat exchanger to 0.27 cfs. I understand that the geothermal spring source cannot continuously deliver the peak flow rate, but the snow melting system is sized to utilize it for the time period that is available.

It is reasonable that this snow melting system would be idling rather than completely shut down between snow storms. An idling system would supply some heat to the slab which would melt trace snow amounts and would mean less thermal shock to the concrete pavement at times of measurable snowfall. A reasonable but generous volume would be a volume based on the peak flow rate in continuous operation for the 130 days recommended by reviewer, Dan Nelson.

Recommendations

I recommend 0.27 cfs for the license rate

I recommend 69.6 afa for the license volume

WATER RIGHT 37-8798			
SUN VALLEY LODGE WALKWAY SNOW MELTING WITH GEOTHERMAL WATER			
Analysis based on a method described by John W. Lund, in Pavement Snow Melting, Geo-Heat Center Bulletin (2000)			
SCENARIO: INDIRECT FIRST USE OF GEOTHERMAL WATER;			
DESIGN CONDITION:			
Parameter	Value	Units	Comments
Zone area	26,136	ft ²	0.6 ac=26136 ft ² from revised snow melt shp one monolithic zone
Rate of snowfall, s	0.13	inches of wa	range is 0.01 - 0.18 Tesmar state most snow falls at density of 0.13 On avg snow density is 10% moisture
Air temperature, Ta	25	deg F	assumes snow temp = air temp; most snowfall starts at 34 & stops at 20 deg F; it is not correct to use design outside conditions applicable to a space heating use.
Wind speed, V	4	mph	January average wind speed at Hailey AWOS is 4.1 mph
Water film temperature, Tf	33	deg F	usually given as 33 deg F
Ratio of snow-free area to total	0.5	unitless	1 = all clear; 0.5 = half; 0 = snow covered; these are the only 3 practical values.
Resource temperature	140	deg F	resource temp is 145; applicant measured external pipe temp 140-143 deg F this temp should be what the glycol side sees
Effluent temperature	90	deg F	estimated from specs for this heat exchanger, (HE) 50 deg F = delta T
Background heat loss	10%		heat loss between hydronic pipe and background; 30 % if not insulated
			design surface temp usually 35-45 deg F
CALCULATIONS:			
Parameter	Value	Units	Comments
Vapor pressure of air, Pav	0.16	inch Hg	vapor pressure of water in the air at the temp; NOAA lookup http://www.srh.noaa.gov/epz/?n=wxcalc_vaporpressure
Heat of vaporization at film temp	1075.50	Btu/lb	enthalpy at 33 deg F (given film temp); see thermo text p 823 Cengel/Boles
Sensible heat, qs	2.70	Btu/hr/ft2	for hydronic systems, the equation reduces to 2.6 s (32-Ta); assumes temp of snow = temp of air
Heat of fusion, qm	96.98	Btu/hr/ft2	for hydronic systems, the equation reduces to 746 s
Heat of evaporation, qe	4.78	Btu/hr/ft2	Lund gives Pwv as 0.188 for hydronic systems; other constants are empirical;
Convective & radiative heat flux, qh	12.35	Btu/hr/ft2	constants are empirical
Unit heat required at the surface	108.25	Btu/hr/ft2	Tesmar states snow melt systems need about 50-100 BTU/hr/ft ² to operate properly; Engineering Toolbox states at least 100 BTU/hr/ft ² is needed
Unit heat required from pipes	120.28	Btu/hr/ft2	more than 150 BTU/hr/ft ² is too hot for concrete and pavers
Total heat required	3,143,563.06	Btu/hr	this HE can deliver 3MBTU/hr
Flow rate required	125.74252	gpm	WR is limited by the capacity of the HE on the geothermal water side (120 gpm)
	0.28	cfs	required flow converted to cfs
Snow melt System Operation	130.0	days	assumes 130 day operation (according to reviewer D Nelson)
Snow melt System Operation	24.0	hours/day	assumed the system is idling which melts trace snow & is less shock to the concrete slab
Diversion Volume required	72.24	afa	
	1		# zones
	72.24	afa	afa per zone
	72.24	afa	total afa
license recommendations	0.27	cfs	=120 gpm; max for this HE
	69.62085	afa	afa for this HE in this use