

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
BENEFICIAL USE FIELD REPORT

A. GENERAL INFORMATION

Permit No: 57-7626

Exam Date: 12/13/2012

1. Current Owner: WARDS GREENHOUSES
1722 BANKS LOWMAN
GARDEN VALLEY ID 83622
(208)462-3846
2. Accompanied by: David Ward
Phone No: (208)880-5538
Address:
Relationship to Permit Holder: Owner

3. SOURCE

TRIBUTARY

GROUND WATER

B. OVERLAP REVIEW

1. Other water rights with the same place of use: none
2. Other water rights with the same point of diversion: 57-2249A (irrigation)

It appears that right 57-2249B shares the point of diversion. There is a condition on right 57-2249B that states it shares a point of diversion with right 57-85A and 23 other rights. However, all of the rights listed in the condition are Castle Creek rights and 57-2249B is from ground water. This condition is not on the partial decree for right 57-2249B. Carol Gilbert owns right 57-2249B

C. DIVERSION AND DELIVERY SYSTEM

1. LOCATION OF POINT(S) OF DIVERSION:

GROUND WATER SE1/4NW1/4 Sec. 10, Twp 05S, Rge 01E, B.M. OWYHEE County

Method of Determination: GPS and visual inspection

2.

PLACE OF USE:

[illegible]

Method of Determination:

3. X Delivery System Diagram Attached (required). Indicate all major components and distances between components. Indicate weir size/pipe as applicable.
- X Map Attached Showing Location(s) of point(s) of diversion and place(s) of use (required). Scale must be 1:24,000 or greater.
- X Aerial Photo Attached (required for irrigation of 10+ acres).
- X Photo of Diversion and System Attached

4. This is the information for the re-diversion pump that provides the in greenhouse irrigation water. The water is pumped from the small pond to the shed where it is mixed with fertilizer and plant food. No measurements were taken at this site.

Well or Diversion Identification No.*	Motor Make	Hp	Motor Serial No.	Pump Make	Pump Serial No. or Discharge Size
motor	Century	3	7-357571-01-0J	SM182JM	
pump	Unknown	1 ½	TPLS 2A03AI B5449 – 8 ½ inch impeller		

D. FLOW MEASUREMENTS

1.

Measurement

<u>Equipment</u>	<u>Type</u>	<u>Make</u>	<u>Model No.</u>	<u>Serial No.</u>	<u>Size</u>	<u>Calib. Date</u>
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2. Measurements:

Polysonic flow meter used to measure the well. A 10 minute average yielded 372 gallons per minute.

Average 372 gallons per minutes X 0.00223 = 0.83 cfs

The tape from the Thyme Flyte is attached

Recommended diversion rate for commercial: 0.83 cfs

E. FLOW CALCULATIONS

 X Additional Computation Sheets Attached

Measured Method:

F. VOLUME CALCULATIONS

1. Volume Calculations for Irrigation: no irrigation

$V_{I.R.} = (\text{Acres Irrigated}) \times (\text{Irrigation Requirement}) =$

$V_{D.R.} = [\text{Diversion Rate (cfs)}] \times (\text{Days in Irrigation season}) \times 1.9835 =$

$V = \text{Smaller of } V_{I.R.} \text{ and } V_{D.R.} =$

2. Volume Calculations for Other Uses:

SEE ATTACHED MEMO from Michele Edl

G. NARRATIVE/REMARKS/COMMENTS

Geothermal water is diverted from an artesian well in Township 5 south Range 1 east section 10 SE1/4 NW ¼ in Owyhee county, site tag A0018575. The temperature at the well was 143 degrees. The well provides enough pressure to deliver water through a 12 inch diameter pipe approximately 290 feet to the east up a small hill. At the top of the hill near a shed, a 2 inch pipe diverts water from the larger pipe to a small (0.02 acre) pond. The water from this pond is allowed to cool. A pump (description given on previous page) diverts the cooled water to the shed where it is mixed with fertilizer and plant food. This water is then piped underground to the greenhouses where it is used for irrigation.

From the diversion near the shed, the 12 inch pipe is buried and flows east approximately 150 feet where it turns north for 36 feet. The underground pipe extends the full length of the headhouse and provides heat for each of the 6 greenhouses. The water is not cascaded and each greenhouse has an individual valve in the ground near the entrance. The greenhouses are 110 feet long, 30 feet wide and have an arc length of 40 feet for the ceiling. Each has a heat exchanger and independent controls for temperature. The headhouse itself is not independently heated. After the water is used for heating, it is returned to the lower pond through a 6 inch pipe. The temperature at the discharge point was measured at 139.4 degrees.

During the field exam we noticed a 5 acre pond near the cooling pond. Water flows from the cooling pond downhill to the west into the larger pond. It appears there is no water right for this pond. The pond is visible on 1987 imagery.

Have conditions of permit approval been met? ☒ Yes ☐ No

H. RECOMMENDATIONS**1. Recommended Amounts**

<u>BENEFICIAL USE</u>	<u>PERIOD OF USE</u>	<u>DIVERSION RATE</u>	<u>ANNUAL VOLUME</u>
COMMERCIAL	1/01 to 12/31	0.83 CFS	48.0 AF
<u>Totals:</u>		0.83 CFS	48.0 AF

2. Recommended Amendments

☐ Change P.D. as reflected above ☐ Add P.D. as reflected above ☐ None

☒ Change P.U. as reflected above ☐ Add P.U. as reflected above ☐ Other

I. AUTHENTICATION

Field Examiner's Name Summa Paul Date 11/28/2017

Reviewer _____ Date _____

MEMORANDUM

Date: October 10, 2017
To: Water Right File 57-7626
From: Michele Edl
Re: Analysis of the geothermal heating system

I was asked to review the water right file, and the field examiner's notes from a 2012 site visit and to determine the quantity of water that the system could have beneficially used.

Background,

Permit 57-7626 authorized 2.93 cfs to be diverted from a geothermal well for commercial purposes in six greenhouses located near Oreana, ID.

The greenhouses were not in operation when IDWR examiners visited the site in Dec 2012. However, there was evidence that beneficial use had occurred during the development period of the permit.

There are no pumps on the system. The source of geothermal water is a flowing artesian well. The examiners measured the overall flowrate at 0.83 cfs.

The piping system uses a manifold design to provide first-use geothermal water to each of the greenhouses rather than cascading increasingly cooler water from one greenhouse to the next. After extracting some heat, the cooler geothermal water was collected into another manifold pipe and discharged to one of the local ponds.

Method

For this analysis, I created a series of spreadsheets which apply heat transfer equations to a hypothetical redesign of the greenhouse complex.

Estimating peak heating load

My analysis of the heat load for these geothermal greenhouses is based on the greenhouse design provided in Geothermal Direct-Use Engineering and Design Guidebook¹.

The basic equation for this type of heat transfer is:

$$q_t = q_1 + q_2$$

where q_t is the total heat output required and where:

q_1 = is the total transmission heat loss (BTU/h) = $(A_1 \times \Delta T \times U_1) + (A_2 \times \Delta T \times U_2) + \dots$ etc

q_2 = is the infiltration heat loss (BTU/h) = $ACH \times V_T \times \Delta T \times 0.018$ assumes that the winter infiltration meets winter ventilation requirements

A_1, A_2 etc = is the surface area of the various construction materials (ft²)

ΔT = is the design temperature difference (°F)

U_1, U_2 etc = is the heat transfer coefficient for the construction materials (BTU/h)

The result is the total greenhouse heating requirement in BTU/h and is also known as the peak or design heating load.

That design heat load then becomes an input for the following calculation which estimates the volume of water used.

Estimating volume of water used for heating

I calculated the volume of water used commercial heating based on an adaptation of a 1985 ASHRAE method for estimating heat energy use. The equation is: $Vol = (HL \times HDD \times \text{hr/day} \times Cd) / (\Delta T_1 \times K \times C \times \Delta T_2)$ where:

¹ Geothermal Direct-Use Engineering and Design Guidebook, 3rd ed, Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, OR, 1998.

HL = design heat loss including infiltration and ventilation in BTU/h
HDD = number of Base 80 °F heating degree days for the period (extrapolated from HDDs Base 50-65)
24 hr/day
Cd = 0.85 is Geo-Heat Center's recommendation for greenhouses
 $\Delta T1$ = Design indoor temperature minus design outdoor temperature
K = 0.9 correction factor for energy efficiency
C = 2720000 (a constant to correct for units)
 $\Delta T2$ = Source water temp minus discharge temp = 139 °F (which includes conveyance heat loss)
- 85 °F (estimate based on expected heat transfer)

Inputs are data from several sources. The closest weather station is NWS coop station 103760 (Grand View 4 NW). Scenarios depicting crops with high daytime heat requirements (for example Poinsettias or peppers), required extrapolation of the Base 65 HDD value to a Base 80 HDD value.

The geothermal resource's temperature and conveyance heat loss were measured during the field exam. ~ 4 °F worth of heat is transferred from the water to the ground surrounding the diversion and distribution piping simply by allowing water to run through the system.

The Ward family successfully operate a complex of geothermally heated greenhouses in Garden Valley Idaho. The Wards greenhouses in Oreana are modeled after the Garden Valley greenhouses but utilize a hotter source of water. Based on discussions with David Ward, I estimated the temperature of the discharged water from the Oreana greenhouses at 85 °F; which is 54 degrees less than expected temperature of the water entering those greenhouses.

Parameters representing the type of heat transfer were taken from tables provided in the Geo-Heat Center's design manual. (See Chapter 14 Greenhouses, by Kevin D. Rafferty, P.E.)

The result is an estimate of the quantity of heat needed for the growing the desired plants and the volume of geothermal water that would be required to supply that heat.

Results

The attached spreadsheets represent successful operation of the Oreana greenhouses. They indicate that the measured flow through the system can easily provide sufficient heat to maintain the 65 °F inside temperature needed for typical row crops.

There is sufficient heat available from the geothermal water for growing crops with 80+°F temperature requirements in the six greenhouses found onsite during the field exam.

At 139 °F even 1/6th of the flowrate the heated greenhouse soil will be too hot to stand on. The calculation predicts that there was a second heating system.

Recommendations

The instantaneous flow rate for the current system is limited by the flow rate from the well which was measured at 0.83 cfs during the field exam. Therefore, I recommend 0.83 cfs as the rate for heating use.

I recommend 48.0 afa as the volume of water for commercial heating use.

MEMORANDUM

Date: Oct 4, 2017
To: Water Right File 57-7626
From: Michele Edl
Re: operation data from Garden Valley

The Ward family successfully operate a complex of geothermally heated greenhouses in Garden Valley Idaho. The Oreana greenhouses were based on the Garden Valley greenhouse complex but the Oreana site has access to a hotter source of low-temperature geothermal water. On September 26, 2017, I phoned the office of Ward's Greenhouses in Garden Valley requesting some additional information about their greenhouse operations.

On September 28, 2017, I received a phone call from David Ward, the owner/operator of the Oreana greenhouses responding to my request. In that call, I confirmed that there were two heat extraction systems in each greenhouse. Unit heaters used the geothermal water first to warm the air. Then that water was recirculated to heat the ground (floor) of each greenhouse.

I also confirmed that each greenhouse has first use of the geothermal water and what crops were grown. Because the heat use design and demands of the two projects were similar, I asked for data from a typical night at the Garden Valley complex. David Ward provided that information in the attached FAX.

Ward greenhouses in Garden Valley extract 46 degrees of heat from their geothermal water. This is ~ 36% of that geothermal water's temperature. (The Ts equation in Application Processing Memo 23 uses 30% to estimate an appropriate flowrate for an application for permit).

Based on the administrator's memo and the operation data from Ward's Greenhouses in Garden Valley, I estimate that the temperature of the water discharged from the Oreana greenhouses is approximately 85 °F; which is 54 degrees less than the temperature of the water exiting the well.

Edl, Michele

From: Rushing, Emalee
Sent: Wednesday, October 04, 2017 3:50 PM
To: Edl, Michele
Subject: FW: Fax Forward
Attachments: Fax.pdf

-----Original Message-----

From: idwr.fax@idwr.idaho.gov [mailto:idwr.fax@idwr.idaho.gov]
Sent: Wednesday, October 04, 2017 2:16 PM
To: IDWR Fax <IDWR.Fax@idwr.idaho.gov>
Subject: Fax Forward

Three steps above stone tablets, I present to you a fax from days gone by.

Attachment File Type: pdf, Multi-Page

Multifunction Device Location: Water Rights 8R904
Device Name: Copier_507

OCTOBER /4/2017

FAX TO: MICHELLE IN REGARDS TO GEOTHERMAL Fax# 1-208 287-6700

FAX FROM: DAVID WARD

Hi Michelle,

Thank you for getting back to me. Sorry it took me a few extra days to get this information. I told you I would gather the data on the evening of the day we spoke however we had fluctuating power here that day and the geothermal pumps shut off several times that evening.

I was able to collect the following data on Saturday, September 30. This information was collected at the greenhouses here in Garden Valley as we talked about. I submerged a thermometer into the water and waited for the indicator to stop rising then recorded the findings. The total volume of water listed here is a little bit of an estimate. We have a McCrometer water meter installed directly into the hot water line coming into the greenhouse. The GPM measurements grid lines on the face of the meter are increments of 20 gallons and for some reason the measuring needle swings back and forth between 110 and 130 gallons per minute. So I just figured half way in between was 120 GPM. Geothermal water does some weird things.

September 30,2017 6 a.m.

36 degrees F.....Outside air temperature at the time of measurement

120 Gallons Per Minute..... Estimated volume of water being pumped to the greenhouse.

127 degrees F Hot Springs Temperature at the Hot Springs before transportation to the greenhouse.

124 degrees F.....Water arriving to the greenhouse via pumps and pipes(3 degree loss)

124 degrees F.....Water going into the heat exchanging radiators turning hot water heat into warm air.

99 degrees F.....Water going into greenhouse underground floor heat pipes. (a network of 1" pipes about 1 foot underground, 1 foot apart. This water is water that has already been run into the greenhouse heat exchanging radiators that heat the greenhouse air. It then is returned and collected into a tank and pumped again into the greenhouse floors

81 degrees F.....Water temperature at final discharge into the Payette River. At this time we are finished extracting heat from the water for greenhouse heating purposes.

REF document: Geothermal Direct-Use Engineering and Design Guidebook, Chapter 14 Greenhouses				
Theoretical heat in greenhouses for licensing 57-7626 (Ward)				
created by Michele Edl				
The Ward Greenhouse site near Oreana has 6 of these type				
1 single-vault arch or quonset				
30 ft	width			
110 ft	length			
4.9 ft	knee wall ht			
40 ft	arc length	from web calculator		
			147	rectangular area
784 ft^2	area end wall (double poly)		245	segment area
1078 ft^2	area side walls (double poly)			
4400 ft^2	area roof (double poly film)			
3300 ft^2	floor area			
80	delT = design temp difference= Ti-To			
80	Ti = design inside temp	80 degF would be needed for Poinsettias		
0	To = design outside temp			
0.7	U1	glazing material U factor	double poly U	for wind speed of 15 mph +
0.7	U2	all double poly for Ward	double poly U	for wind speed of 15 mph+
qt = heat loss transmission				
350672 BTU/h	qt = (Apoly x delT x Upoly) + (Apoly x delT x Upoly)			
86240	V= volume = end wall area x length			
0.5	ACH= air change/hr		double poly 0.0-0.50	
qi = heat loss infiltration				
62092.8 BTU/h	qi=ACH x V x delT x 0.018			
412,764.80 BTU/hr	qt = qp + qi = total greenhouse heating requirement; the peak heat load			
125.0802424 BTU/ft^2	BTU per ft^2 of floor area			
2,476,588.80 BTU/hr	total for 6			

inputs	units	comment									
412764.8		heat load for one GH from previous page									
96	ft	length									
20.5	ft	width									
125.0802	BTU/ft^2	q/A heat loss per square ft floor from previous page; the peak heat need									
112.5722	BTU/ft^2	area of the floor which will be used for heating purpose (usually about 10% less than the actual floor area)									
		AUST=	area weighted average temp of unheated surfaces; for greenhouse are walls and roof								
		calc AUST	$IST=IDT - ((0.595/(1/U)) \times \Delta T)$								
	deg F	IST	inside surface temp								
80	deg F	IDT	inside design temp								
0.7	BTU/h ft^2 deg F	U1	glazing material U factor			double poly U = 0.7		for wind speed of 15 mph correct if necessary			
0.7		U2									
80	deg F	ΔT	design temperature difference			design Ti - design To					
80	deg F	Ti	design indoor temp			typical requiremts are in tables; 62 degree for seedings, 80 degree for Poinsettia					
0	deg F	To	design outdoor temp			refer to location weather tables; Boise is 2 deg F					
46.68		IST1	for double poly area			Ward GH are all poly					
46.68		IST2	for double poly area								
4400	ft^2	A1	area of double poly			from previous tab					
1862	ft^2	A2	area of double poly			from previous tab					
46.68	deg F	$AUST = (A1 \times IST1 + A2 \times IST2) / (A1 + A2)$									
85	deg F	Tf	85 deg F max recommended floor surface temperature								
80	deg F	Ta=Ti									
		solve	$q/A = 0.15 \{((Tf + 460)/100)^4 - ((AUST + 460)/100)^4\} + 0.32 \times (Tf - Ta)^{1.32}$								
	BTU/ft^2	q/A=	36.15235								
			a workable floor temp cannot meet the peak load								
88.92789	BTU/ft^2	supplemental heating must come from unit heaters									
		Based on conversation with David Ward 9/28/2017									
			air first then floor								
			each GH gets first use from a common manifold								
			each GH discharge to a common manifold								
			maybe 40 degrees stripped off								

GRAND VIEW 4 NW, IDAHO

Period of Record General Climate Summary - Heating Degree Days

Station:(103760) GRAND VIEW 2 W													
From Year=1909 To Year=2010													
Heating Degree Days for Selected Base Temperature (F)													
Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	1089	808	652	393	184	50	3	10	120	419	764	1056	5548
60	934	666	497	254	89	15	0	2	51	274	614	901	4297
57	841	582	405	182	50	5	0	0	27	197	525	808	3622
55	779	525	345	140	32	2	0	0	17	152	465	746	3204
50	624	386	208	60	7	0	0	0	3	66	322	593	2268

Heating Degree Day units are computed as the difference between the base temperature and the daily average temperature. (Base Temp. - Daily Ave. Temp.) One unit is accumulated for each degree Fahrenheit the average temperature is below the base temperature. Negative numbers are discarded. Example: If the days high temperature was 65 and the low temperature was 31, the base 50 heating degree day units is $50 - ((65 + 31) / 2) = 2$. This is done for each day of the month and summed.

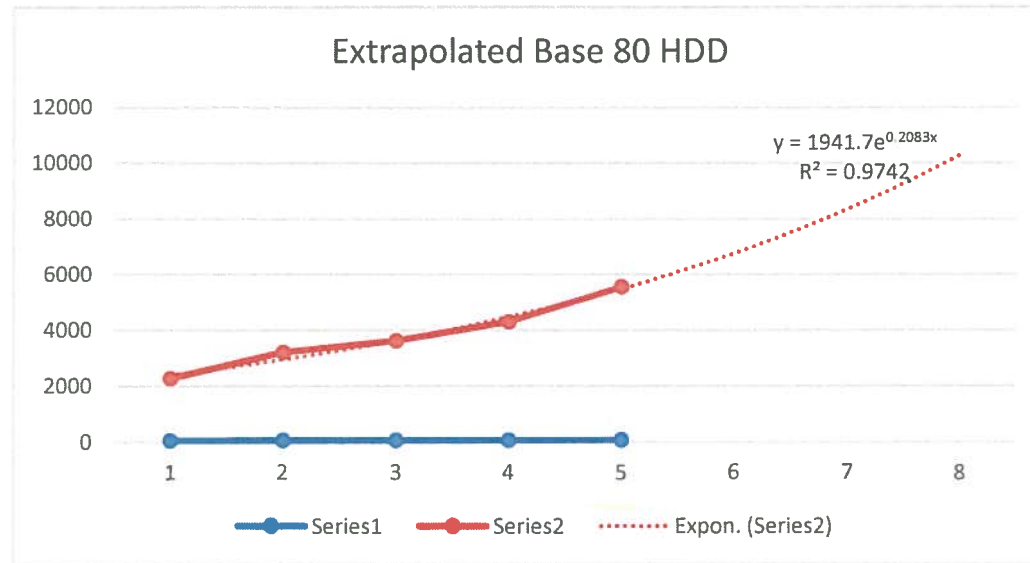
Table updated on Oct 31, 2012

Months with 5 or more missing days are not considered

Years with 1 or more missing months are not considered

Western Regional Climate Center, wrcc@dri.edu

50 2268
55 3204
57 3622
60 4297
65 5548
70
75
80



OUTER DIAMETER
12.800 IN

PIPE MATERIAL
? CS-53

WALL THICKNESS
0.4030 IN

INNER LINING
? NO LING

KIND OF FLUID
? ANOTHER

SOUND VELOCITY
1550 M/S

SENSOR MOUNTING
? U

TYPE OF SENSOR
? SMALL

DATA CHANGE
? NO

SPACING
10.989 IN U

ZERO MODE
? AUT ZERO

ZERO MODE
? CLEAR

ZERO MODE
? AUT ZERO

ZERO MODE
? ZERO OFF

12-13 15:5300 *R
+002.10 % AI2

MODE SELECT
? TO CHECK

0432.5 MMSEC
100.16 % T0

15:57+347.650E 00PM 00R
+00000 *10 G 00R
-00000 *10 G 00R

15:58+355.575E 00PM 00R
+00035 *10 G 00R
-00000 *10 G 00R

15:59+385.691E 00PM 00R
+00072 *10 G 00R
-00000 *10 G 00R

16:00+375.388E 00PM 00R
+00108 *10 G 00R
-00000 *10 G 00R

16:01+405.240E 00PM 00R
+00145 *10 G 00R
-00000 *10 G 00R

16:02+355.575E 00PM 00R
+00183 *10 G 00R
-00000 *10 G 00R

16:03+392.559E 00PM 00R
+00220 *10 G 00R
-00000 *10 G 00R

16:04+366.142E 00PM 00R
+00256 *10 G 00R
-00000 *10 G 00R

16:05+351.084E 00PM 00R
+00292 *10 G 00H
-00000 *10 G 00H

16:06+375.388E 00PM 00H
+00328 *10 G 00R
-00000 *10 G 00R

16:07+390.446E 00PM 00R
+00364 *10 G 00R
-00000 *10 G 00R

OUTER DIAMETER
12.800 IN

PIPE MATERIAL
? CS-53

WALL THICKNESS
0.4030 IN

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1550 M/S

SENSOR MOUNTING
? U

TYPE OF SENSOR
? SMALL

DATA CHANGE
? NO

SPACING
10.989 IN U

ZERO MODE
? AUT ZERO

ZERO MODE
? CLEAR

ZERO MODE
? AUT ZERO

ZERO MODE
? ZERO OFF

12-13 15:5300 *R
+002.10 % AI2

MODE SELECT
? TO CHECK

0432.5 MMSEC
100.16 % T0

15:57+347.650E 00PM 00R
+00000 *10 G 00R
-00000 *10 G 00R

15:58+355.575E 00PM 00R
+00035 *10 G 00R
-00000 *10 G 00R

15:59+385.691E 00PM 00R
+00072 *10 G 00R
-00000 *10 G 00R

16:00+375.388E 00PM 00R
+00108 *10 G 00R
-00000 *10 G 00R

16:01+405.240E 00PM 00R
+00145 *10 G 00R
-00000 *10 G 00R

16:02+355.575E 00PM 00R
+00183 *10 G 00R
-00000 *10 G 00R

16:03+392.559E 00PM 00R
+00220 *10 G 00R
-00000 *10 G 00R

16:04+366.142E 00PM 00R
+00256 *10 G 00R
-00000 *10 G 00R

16:05+351.084E 00PM 00R
+00292 *10 G 00H
-00000 *10 G 00H

16:06+375.388E 00PM 00H
+00328 *10 G 00R
-00000 *10 G 00R

16:07+390.446E 00PM 00R
+00364 *10 G 00R
-00000 *10 G 00R

Average 372

Dec 13, 2012

System Diagram for Water Right 57-7626



Geothermal water is diverted from an artesian well (yellow dot) in Township 5 south Range 1 east section 10 SE1/4 NW ¼ in Owyhee county, site tag A0018575. The temperature at the well was 143.7 degrees. The well provides enough pressure to deliver water through a 12 inch diameter pipe approximately 290 feet to the east up a small hill. At the top of the hill near a shed, a 2 inch pipe diverts water from the larger pipe to a small (0.02 acre) pond. The water from this pond is allowed to cool. A pump, shown as a green dot above, rediverts the water to the mixing shed through a pipe shown as yellow line, where it is mixed with fertilizer and plant food. This water is then piped underground, red dashed line, to the greenhouses where it is used for irrigation.

From the diversion near the shed, the 12 inch pipe is buried and flows east approximately 150 feet where it turns north for 36 feet. The underground pipe extends the full length of the headhouse and provides heat for each of the 6 greenhouses. The water is not cascaded and each greenhouse has individual valves and controls at the entrance. The greenhouses are 110 feet long, 30 feet wide and have an arc length of 40 feet for the ceiling. Each has a heat exchanger and independent controls for temperature. The headhouse itself is not independently heated. After the water is used for heating, it is returned to the lower pond through a 6 inch pipe. This pipe shares the trench with the delivery pipe. The temperature at the discharge point was measured at 139.4 degrees.

PHOTOGRAPHER AND DATE OF PHOTOS: Sandy Thiel, December 13, 2012



This photo shows the point of diversion for the geothermal water supply for the greenhouses.



Temperature readings were taken at the open valve.



Site tag: A0018575



Point of diversion

Looking west from the shed



The artesian well provides enough pressure for water to flow up toward the shed. A smaller pipe diverts water to the upper pond for irrigation



The upper pond supplies water for irrigation within the greenhouses



Upper and lower ponds

The roof of the pump house is visible between the ponds



Pump



Pump house



Water supply, from the pump, to the mixing station, which is located in the shed

The pump is located below the pond in the background



Inside the shed:

Feeding station for irrigation water - to add fertilizer and plant food



Heating unit for the shed



The pipe provides geothermal water for the heating system in the greenhouses. No pump is required for the heating system.



The heating supply water pipe is buried on the side of the shed.



Location of the
underground pipe

Looking west



Location of the
underground pipe

Looking east



Each of the six
greenhouses has a valve
for irrigation and one for
geothermal heat. The
valve on the left is
irrigation



Controls inside the greenhouse



Inside a greenhouse

Heat exchanger shown
lower right

Dimensions:
110 feet long
30 feet wide
40 arc length



Control panel inside the greenhouse



The water from the greenhouses discharges into the lower pond

The smaller pipe on the right is overflow from the upper pond



The temperature returning to the lower pond is 139.4 degrees Fahrenheit