McGinness Hills 3: A Successful Third-Phase Development

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ABSTRACT

Ormat expanded the McGinness Hills geothermal project with the addition of a third power plant in December 2018. Following commissioning of the third power plant, generation has increased from a nominal initial capacity of 90 MW net to 140 MW net. Production and injection are in two distinct grabens that appear to be linked at depth by intersecting faults within brittle basement rocks. Production temperatures have remained consistent, and the reservoir pressure near the production dropped modestly due to third phase production.

1. Introduction

Ormat's McGinness Hills Geothermal Project in Lander County, Nevada, has been operating for over six years. The first unit (MH-1) came on line in June 2012 with an initial planned nominal capacity of 30 megawatts (MW) net, which was exceeded (Ormat, 2012). The nominal capacity of MH-1 was revised to 36 MW net and the second unit (MH-2) came online in February 2015, bringing the project's nominal capacity to 72 MW net (Ormat, 2015). Since commencement of operation of the second plant, the project has again exceeded the nominal capacity, with an average output of 82 MW net. A third unit (MH-3) came online in December 2018, larger than each of the first two, with a nominal capacity of 48 MW net, with recent production exceeding the nominal capacity. This paper provides an update to the McGinness Hills project and details the resource performance before and after the Phase 3 startup.

2. Project Description

McGinness Hills is located in central Nevada, about 11 miles northeast of the town of Austin (Nordquist and Delwiche, 2013). The project now has 15 production wells and 8 injection wells (Delwiche, 2015). The McGinness Hills geothermal reservoir is contained within a fracture network associated with a series of NNE-striking faults. Hot and permeable wells have been drilled over a north-south distance of 2.8 miles and an east-west distance of ¾ of a mile. The fifteen production wells in the north produce brine averaging 335 ^{o}F from three highly permeable fault zones. Six injection wells in the south also have high permeability, and two hot wells in the center of the field (61-22 and 67-15) have moderate permeability. Interference testing shows high connectivity between all these wells. Two multi-well tracer tests, in 2013 and 2015, have confirmed the hydraulic connectivity between injectors and producers, though these tests also confirmed potential for thermal breakthrough is low through long response times and low peak concentrations (Lovekin, 2016). Brine fluids injected in the southern area return to the production wells to the north along deep and circuitous fracture pathways. This configuration allows for maximum heat recoverability of injected fluids while providing pressure support to the production wells (Lovekin, 2016).

2.1 Drilling

The five MH-3 production wells were drilled on two existing well pads adjacent to existing production wells. All five wells were drilled with geothermal specific rigs (Ormat Rig #1 and #3). Drilling started on October 12, 2017 on Well 28C-10 and finished on May 31, 2018 when 28E-10 was completed. All five wells had similar drilling plans and well constructs:

	28C-10	**28D-10**	**28E-10**	**36B-10**	**36C-10**
	KB = 21 ft.	KB = 28 ft.	KB = 28 ft.	KB = 21 ft.	KB = 21 ft.
Cemented Casing Strings					
30” Casing, 3/8” Wall B Welded Line pipe	101	108	108	101	101
22” Casing, 1/2” Wall B Welded Line pipe	402	401	400	402	404
16” Casing, 84# NT80DE BT&C ERW	1800	1810	1805	1808	1800
Hung Liner					
9 5/8-in. liner, 40# K-55 BT&C. Blank	1700 – 1888	1686 – 1883	1669 – 2721	1710 – 1820	1696 – 1900
9 5/8-in. liner, 40# K-55 BT&C. Slotted, 0.125” x 2.5”, 32/ft.	1888 - 3049	1883 – 3431	Open Hole 2721 – 3550	1820 - 2295	1889 - 2238

All three of the MH-3 wells drilled on the 28-10 pad (28C-10, 28D-10, 28E-10) intersected and feed at least in part from fractures associated with the Main Sinter Terrace fault. However, both 28D-10 and 28E-10 had to be deepened in order to encounter additional permeability, so these two wells, along with 28-10 and 25-10RD, share feed zones of variable depths associated with the Eastern Sinter Terrace fault (Figure 1).

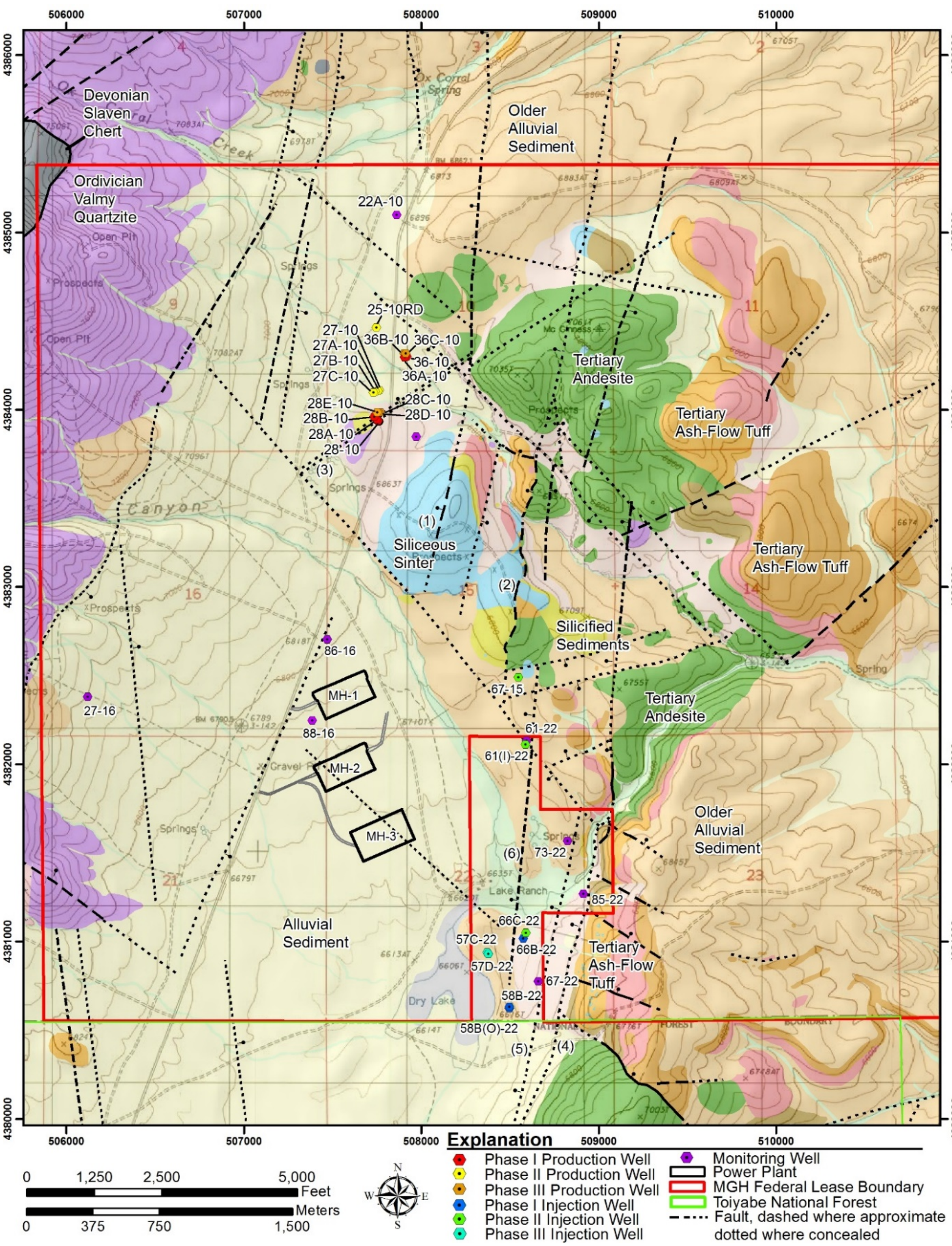

Figure 1: Geology and well locations at the McGinness Hills geothermal project. Faults numbered include (1) Main Sinter Terrace fault, (2) Eastern Sinter Terrace fault, (3) Silica fault, (4) Eastern Ridge fault, (5) Pediment Ridge fault, and (6) Steep fault.

Both MH-3 wells drilled on the 36-10 pad (36B-10 and 36C-10) intersected and feed from fractures associated with the Upper Main Sinter Terrace fault, like the 36-10 and 36A-10 wells. The variation in the depths of the feed zones is attributed to brittle deformation of the host rock in the hanging wall, partially to completely healed fracture zones, and possible cyclic transtensional and transpressional jogs of the fault zones. These characteristics result in correspondingly heterogeneous fault zones of variably distributed high fracture permeability.

All the production wells drilled in this campaign showed moderate to high permeability ranging from 3519.7 mD to 43,641 mD, and a very high Production Index (P.I.) ranging from a low of 924 gallons per minute (gpm) per pounds per square inch (psi) to a high of 2550 gpm/psi.

3. Project Performance

McGinness Hills 3 commenced delivery on December 5, 2018. As of March 2019, MH-3 has averaged 57 MW_e with more than 14,000 gpm from four production wells. This has brought the complex total to an average 157 NMW from about 44,000 gpm at 335°F as of March 2019. Figure 2 summarizes the McGinness Hills Complex production history.

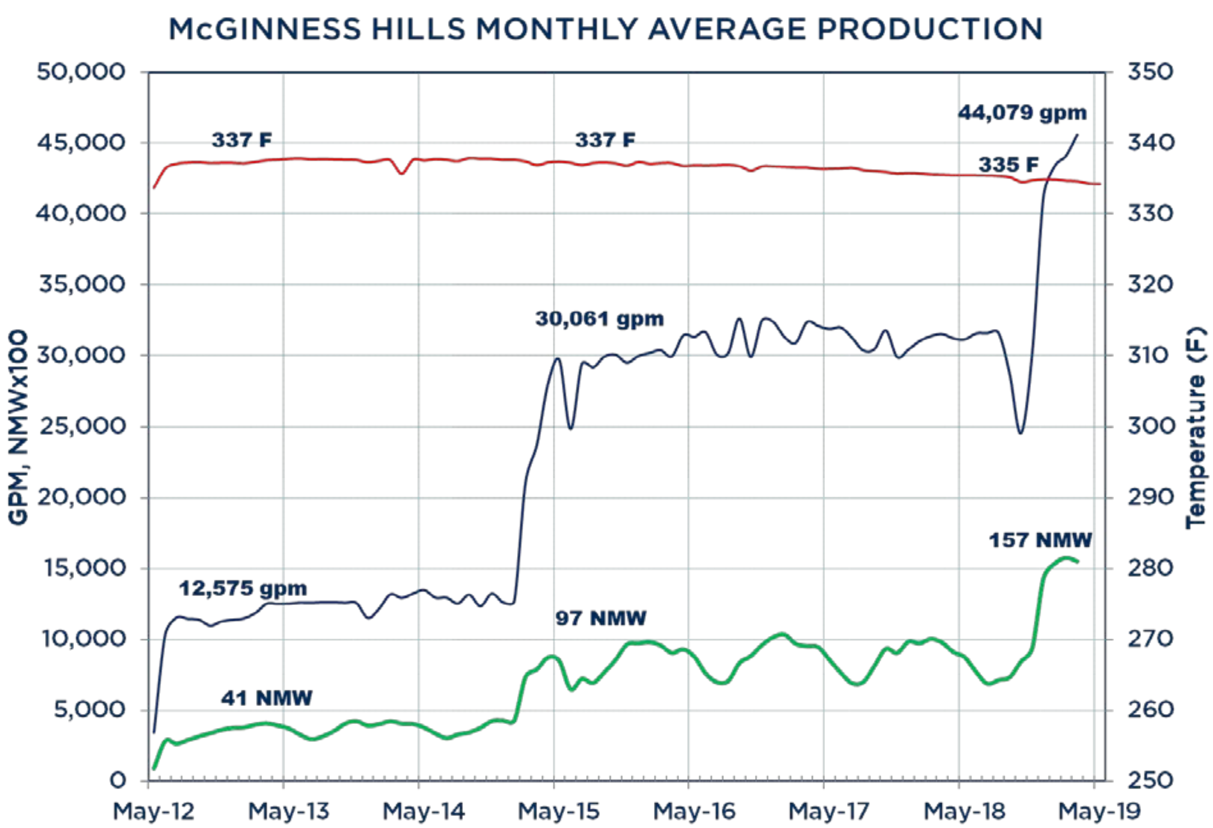

Figure 2: McGinness Hills Complex production summary.

3.1 Pressure Response

Pressure readings have been taken daily at each production well since MH-3 production came on line. The 28-pad wells averaged 10 psi drawdown, the 27-pad wells averaged 12 psi drawdown, the 36-pad wells averaged 19 psi drawdown, and the 25-pad well had 20 psi drawdown. This observed drawdown is less than the numerical model prediction of about 45 psi. The new production wells saw a range of drawdown from 38 psi up to 114 psi based on the well productivity.

Two observation wells have been utilized to monitor reservoir pressure with stainless steel tubing set downhole and surface pressure recorders. The historical pressure decline trend has been on the order of 3 to 5 psi/year. When MH-2 came on line, observation well pressures decreased about 10 psi over six months, then initially re-established the same long-term decline rates as previously observed (Lovekin, 2016). Since mid-2015, the pressure decline has stabilized to less than 1.5 psi/year. When MH-3 came on line, the pressure in 22A-10 declined about 10 psi over three months.

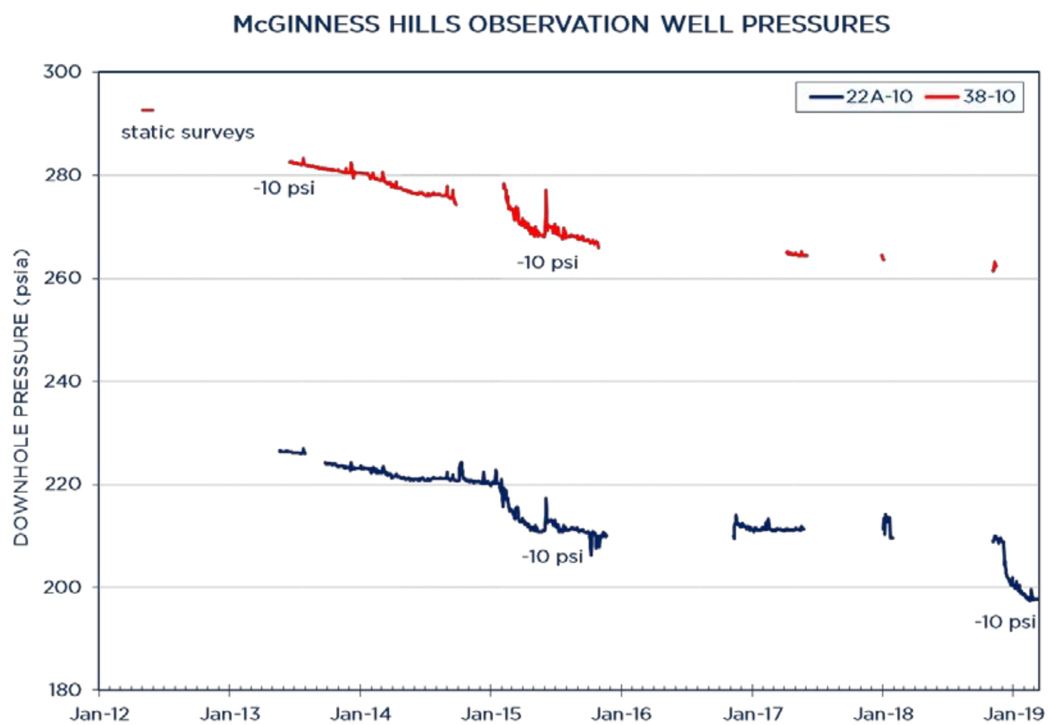

Figure 3: McGinness Hills observation well history.

3.2 Temperature Response

After four months of production, the temperatures have been unchanged from the startup temperatures for the MH-3 production wells. In March 2019, the flow-weighted average for the four operating production wells is 334.8°F. The numerical model has predicted an increase in decline of about 0.5°F/yr and will be calibrated following additional data and a new tracer study.

3.3 Pump Performance

A 9-stage Ormat-manufactured production pump was installed in each of the five MH-3 production wells, all set at 1105 feet below ground level. Since continual operation, all pumps are performing as expected. The production pumps are all operating with at least four hundred feet of fluid above the pump inlet.

4. Summary

Early indications from performance monitoring of the third plant at McGinness Hills has showed that the expansion was as successful as the first two plants, a result of careful and continuous monitoring of the resource combined with a phased-development approach.

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