Hydrologic balance between surface waters and geothermal fluids in Dixie Valley, north-central Nevada, USA

Adam Jones
LAIKA LLC, Portland, Oregon, USA
adam@jonz.org

Abstract. Geothermal power production relies on elevated temperature, high-enthalpy and consistent transmissivity from the tapped geothermal system. The Dixie Valley power plant in north-central Nevada, has been in operation for the last 30 years with sustained fluid production and has experienced negligible temperature decrease. Indicating that the power plant has produced sustainably from the resource in that time. Chemical and isotope analysis does infer that the thermal fluids produced at the power plant are from meteoric sources yet the Dixie Valley hydrologic basin receives only an average total annual recharge of 28 million m³. The average annual fluid production at the power plant is more than 20 million m³, and would amount to a substantial portion of the total yearly aquifer recharge being produced by this facility. Mountain precipitation is suggested as the primary source for thermal fluid recharge. Mountain infiltration into regional aquifers ranges from 3-15% of precipitation and valley surface recharge is negligible due to roughly equivalent precipitation and evapotranspiration. It is unlikely that infiltration from mountain recharge is the primary fluid for this geothermal resource but rather a regional input from the broader subsurface saturated zone that supplies this system.

1. Introduction
Dixie Valley is perhaps the most studied geothermal system in the Basin and Range. Nearly a half century of research has provided the geothermal community with a broad dataset with which to study the exceptionally hot resources that exist there. The trend, despite opportunity for further development, currently hosts only one power station, the Dixie Valley power plant (DVPP). This facility began operations in 1988 and power generation has persisted for thirty years without substantial changes. The consistency and duration of production from this resource has allowed it to become a laboratory for the impacts of geothermal development on Basin and Range hydrothermal systems.

Despite the abundant data surrounding many of the thermal features of this region, there is still some question about the origin of the fluids produced at the power plant. The DVPP withdraws fluid from two geothermal cells via 22 wells with depths between 1.800 – 3.800 meters [1]. These wells are located mostly along a northeast-southwest line 1.6-2.4 km east and roughly parallel to the Stillwater range front [1]. Fluid withdraw comes from below the basin-fill sediments in pre-Tertiary deposits within Miocene basalts and fine-grained Jurassic meta-sedimentary rocks [1].
Geothermometric measurements indicate production fluids have thermally equilibrated at a temperature of 250°C and are believed to originate from a depth of 9 km \([4]\). Fluid infiltration to this depth is poorly understood as fractures and other permeable structures are hard to perceive under the conditions there. Apertures formed at this depth are considerably constricted by lithostatic overburden and rock creep, as such, intrinsic permeability almost certainly dominates. Stable isotope studies suggest that the fluid ages are 12-14 ka and originate from meteoric sources \([11]\). Fluid recharge is assumed to be via infiltration from mountain precipitation \([4]\), but this mechanism for recharge would requires exceptionally high downflow rates to reach a depth of 9 km, in that period. Infiltration in the mountain block is also quite limited because of complicated lithologies and anisotropic permeabilities. Much of the precipitation runs off into the valley during spring snowmelt.

Power plant production volumes range from 19.7-23.4 million m\(^3\) and reinjection of spent power plant fluids amounts to about 70-80\%. \([7]\). Relatively shallow, 1-3 km reinjection wells are used to maintain reservoir pressures in the production level aquifer \([10]\). Long-term chemical tracer studies assert that reinjected spent power plant fluid is contributing to the production volume \([11]\). Despite the continuous reinjection of power plant cycled water, which has had a considerable amount of its thermal energy diminished, production temperatures have not been significantly impacted. If these re-injection fluids were indeed contributing to the thermal fluid, then their descent to ~9 km to become equilibrated with the geothermal aquifer would have to be dominated by extremely fast, fracture dominated channelized flow. Otherwise we could assess that traces of the reinjection fluids must be mixing at some shallower depth, but not in volumes that are thermally quenching the production fluids. This suggests that they amount to an insubstantial part of the thermal fluids drawn by the DVPP. The lack of temperature degradation as well as the ambiguous volumetric and chemical integration of the production fluids with re-injectate at the DVPP suggest that the geothermal fluids are withdrawn from depths that are only loosely influenced by the near surface aquifer and that a deeper fluid source must be responsible for the hydrothermal resources in these cells.

2. Geology

The Basin and Range province, extends from the US state of Oregon and Idaho south along the edge of the Sierra Nevada mountain range and east into southern Nevada State. This extensional terrain with roughly parallel mountain ranges is interfingered with sedimented valleys. Deep normal faulting forms these valley grabens and tilting half grabens and are the result of Cenozoic rifting \([4]\). The rifting is activated by crustal extension in two phases, the first in the Miocene about 17-12 ma with roughly east-west extension. The second, with extension aligned to the northwest-southeast and began around 10 ma and continues today \([6]\). This shift in extension has likely added a dextral component to transcurrent fault geometry. Actively tectonic, the area is prone to somewhat large earthquakes near \(M_\text{w} 7\), some having occurred historically \([5]\). Several large pluvial lakes were present during the wetter Pleistocene. These lakes deposited lacustrine sediments typically dominated by clays and silts in lowland playas and salt marshes in the bottom of the valleys. Hot springs and fumarolic activity is somewhat common and epithermal mineral veins and disseminated metal deposits dot the region.

Dixie Valley in north-central Nevada is flanked by the Stillwater Range and the Clan Alpine range on the west and east respectively. The valley is in a region adjacent to a structural discontinuity that separates thicker crust to the east from thinner crust to the west \([5]\). Mesozoic orogenic events have consolidated an array of Triassic/Jurassic meta-sedimentary with Jurassic igneous rocks, Cretaceous granites and Tertiary intrusives. These bedrocks have in many cases been covered by further Tertiary volcanic deposits \([2]\) (see figure 2). The Dixie valley basin-fill is a combination of colluvium from both the Stillwater and Clan Alpine ranges. These basin-fill sediments are formed by coalescing alluvial fans as much as 2500 m thick, with increasing depth to the western side of the valley, adjacent to the Stillwater range \([4]\). Despite this differential in the subsurface, east to west, there doesn’t appear to be any significant tilting of the down-dropped grabens. Antithetical faulting and stepped subsidence contribute to this uneven subsurface. Though littered with faults, the most prominent is the Dixie Valley range-bounding fault zone on the west side of the valley and forms the highest displacement of
the bedrock (~5 km displacement in 8-15 ma). The range front fault and the adjacent piedmont fault dip steeply, greater than 60°, and extend to a depth of at least 16 km [4]. This part of the valley hosts the majority of high temperature hydrothermal resources.

Figure 1. From USGS, Garcia et al. [7], Dixie Valley, Nevada Hydrologic units.
3. Hydrology

Dixie Valley is an internally drained geographic depression with adjoining hydrologic basins, (Pleasant, Eastgate, Fairview, Stingaree, and Jersey Valleys) that contribute to the valley hydrographically (figure 1). The hydrographic area of the Dixie Valley flow system is 6164 km² with Dixie Valley occupying an area of 3400 km². The climate is arid with range front bajada that descends to a flat valley bottom. The minimum elevation is 1030 m on the playa surface and is the lowest point in the northern Nevada [5]. The playa is a remnant deposit of Pleistocene Lake Dixie whose greatest depth may have been 67 meters and paleo-shorelines are still apparent around the valley. Interlacing lake sediments of clays and silts dominate the playa deposit coarsening to gravels in the basin-fill up the valley slopes. There is very low-permeability in the playa aquifer and total dissolved solids in the playa aquifer may be greater than 200 times the freshwater in the basin-fill aquifer [7]. Occasional rain events flood the lowlands but only a small fraction of steam discharge reach this lowest elevation [10]. Subsurface flow and the recharge to groundwater from the surrounding basins contributes around 13.5 million m³ while the central Dixie Valley hydrographic basin accumulates 10.9 million m³. Annual precipitation ranges between 99-391 mm of mountain precipitation, generally increasing with altitude, and 99-218 mm on the playa surface [14]. Much of this precipitation occurs in the winter as snowfall [13]. During spring and summer months, sporadic convective storms may account for about 15% of total yearly precipitation [9].

The shallow groundwater-flow system is comprised of the basin-fill and playa aquifers. The basin-fill aquifer is mostly unconfined with vertical restrictions and flow obstructions from erosion detritus from the surrounding ranges and windblown material. Some Tertiary siliciclastic volcanic deposits are interbedded with basin sediments. Regionally, groundwater moves from the mountains towards the playa. Lateral flow is driven by a hydraulic head from elevated areas of recharge to lower areas of discharge. The shallow groundwater potentiometric surface ranges from about 130 m below land surface to 9 m above land surface and many lowland springs flow artesian. Vegetation is dominated by phreatophytes with small portions of shallow marshes occupied by xerophytes, namely in the Humboldt salt marsh and around perennial springs [7].

The majority of stream flow is ephemeral and typically does not persist for more than the spring melt or runoff during isolated storm events. Because of restrictive lithologies (phylites, meta-sediments and mafic igneous intrusions with low fracture density) infiltration in the mountains is quite limited and may only amount to 3-15% of total precipitation [8]. The remaining snowmelt collects into shallow groundwater paths and discharges into arroyos and stream channels where most streamflow is lost to infiltration in the basin-fill before reaching the playa. The basin-fill aquifer permeability is complex and the result of evolved and variable alluvial fan deposits that are littered with debris flow matrix-supported stratigraphy as well as better sorted less restrictive flow paths. Compaction and mineral cementation make infiltration more convoluted with depth. Although fresh, chemical analysis of salinity in the basin-fill aquifer suggests that geothermal brine fluid mixing is 10-25% of volume indicating substantial outflow from subsurface geothermal resources contribute to this aquifer [4]. Infiltration and aquifer recharge from precipitation falling on the valley floor is negligible as almost all is lost to evapotranspiration [8].
Geothermal Systems

Two particularly high temperature geothermal trends exist in north-central Nevada, the Humboldt and Dixie trends in Pershing and Churchill counties [15]. Both these trends show curiously higher resource temperatures than most other thermal features in the Basin and Range. The region is host to

Figure 2. From USGS Garcia et al. [7], simplified geologic map of Dixie Valley, Nevada.

4. Geothermal Systems

Two particularly high temperature geothermal trends exist in north-central Nevada, the Humboldt and Dixie trends in Pershing and Churchill counties [15]. Both these trends show curiously higher resource temperatures than most other thermal features in the Basin and Range. The region is host to
hydrothermal springs and fumarolic activity and somewhat common hot water resources. Fossilized evidence in hydrothermal outcrops, sinter deposits, and silicified outflow horizons shows that these circulations are common and episodic a few having persisted for quite some time (50-500ka) [2]. Dixie Valley and several surrounding valleys are known for their locally high geothermal crustal gradients [1]. Yet, despite these high gradients young volcanic activity is not apparent and there is little evidence for significant magmatic thermal input [2]. Dixie valley hosts at least 12 known geothermal features mostly along the east side of the Stillwater range. A 67 MW power plant produces about 20 million m³/year of 250°C fluid from two cells on the northern part of the valley [4], [10]. Fluid temperatures are controlled by the regional geothermal gradient and the depth from where they are thermally equilibrated [4]. With a temperature gradient of 28.4°C/km, measure in a well southeast of the DVPP geothermal field, fluids are sourced from 8-10 km below land surface [4], [15]. Hydrothermal features along the Stillwater range have resource temperatures from 200°C to 285°C implying that their thermal boundary depths are not necessarily contiguous and likely source from different hydrological structures. Since production started at the power plant there have been no obvious qualitative changes in character in other thermal features along the trend. (with the exception of the senator fumaroles who have a direct connection to the geothermal cell utilized by the power plant) [1]. By using these temperatures as depth constraints defined by the regional geothermal gradient, these features draw from thermal regimes in about a 3 km vertical section of the crust. Upflow is controlled primarily by differential pressures and temperature within the geothermal cell. Vertical permeability is facilitated by flow paths that are numerous and discrete along high angle normal or transcurrent dilations formed by fault step-overs, pull-apart basins, and areas of tension in the crust. These structures that allow fluids to flow to the surface in almost a geologic instant are obscured by their shallow broad thermal signatures of upflow and outflow into the basin sediments. The thermal imprint on the surrounding host rocks suggests that these Dixie Valley systems are long lived and persistent features [3]. The geometries of hydrothermal systems in fault-controlled circulations are not broad tabular bodies like shallow silicic intrusions. The geothermal cells on the west side of Dixie Valley do seem to have a narrow structural confinement that restricts their permeabilities to just a few tens of meters in some cases. Their specific geometries also vary but often appear as flower structures which are narrow at depth and broaden closer to the surface as a response to a decrease in the horizontal stress field in the dilation zones [3], [15].

![Figure 3](image-url)

**Figure 3.** Simplified diagram depicting Dixie Valley hydrologic flow. Minor amounts of Mountain precipitation infiltrates directly into the subsurface. Mostly, this precipitation runs off into the valley. Long term infiltration and downflow of these fluids into basin-fill or playa aquifers contributes to the broader permanently saturated zone where dilations may allow upflow of thermal fluids if these dilations intersect a geothermal collector structure with a pressure gradient and transmissivity that permits fluid flow.
Deep Crustal Fluids

Crustal scale fluid movement and permeability have been difficult to research and regions deeper than 5 km are very poorly understood. Zones where rocks are highly compacted and have low intrinsic permeabilities are hard to constrain a fluid flow mechanism that will stand up to scrutiny without more evidence. We do expect that there is water moving at this depth because of uplifted and exposed

Figure 4. From Blackwell et al. [4], Dixie Valley index map. Areas of drilling are shown in black italic (DVPF – Dixie Valley Producing Field, DVPP – Dixie Valley Power Partners, DM – Dixie Meadows). Canyons (CC – Cottonwood Canyon, WRC – Whiterock Canyon, JC – Job Canyon) are labelled and drawn along ridge. Red diamond symbols are well locations. Thick brown lines are the 1954 Dixie Valley Fault break. Thin brown lines are the range-front fault and valley faults.

5. Deep Crustal Fluids

Crustal scale fluid movement and permeability have been difficult to research and regions deeper than 5 km are very poorly understood. Zones where rocks are highly compacted and have low intrinsic permeabilities are hard to constrain a fluid flow mechanism that will stand up to scrutiny without more evidence. We do expect that there is water moving at this depth because of uplifted and exposed
mineral deposits as well as from the data collected at deep crustal exploration holes which have encountered fluid [13].

Fluid flow in the crust is either a response to a pressure or temperature gradient. Deformation, which changes the stress and strain in rocks is particularly linked to pressure gradients and thus fluid movement. Robb [13] discusses two mechanisms of fluid flow through the crust, pervasive and channelized flow. Pervasive flow addresses the where fluids infiltrate along grain boundaries and within the microcracks within a rock. Channelized flow describes movement that occur along fissures and interconnected permeable spaces. These may either be fractures due to faulting or dilations that allow distinct and contiguous channels of pore space in the formation. Near surface aquifers typically respond to pressure differentials by moving fluids downgradient along porous medium due to an elevated hydraulic head. In deeper aquifers the restrictions and intrinsic permeabilities are more likely to respond to the differential pressures between confined aquifers or those that are unconfined yet burdened by their hydrodynamic load.

Localized downflow in the range front fault of the Stillwater Range has been proposed as a fluid recharge pathway for geothermal systems. Permeability along limited sections of the fault may be higher than within the basin-fill aquifer but infiltration to depths necessary for thermal equilibrium would still take a considerable amount of time. The ages of the fluids flowing from the geothermal production wells have been estimated at 12-14 ka [11]. There is some concern as to the validity of groundwater age determinations with $^{14}$C isotope methods, however, if we accept that the age range of these fluids are a maximum age, a minimum average infiltration rate that would penetrate to a minimum resource depth of 8 km would be ~1.5 meters/day. These rates of fluid movement are impractically fast to support this type of localized recharge without very favorable permeability. Additionally, the thermal signature for such a localized downflow zone should appear anomalously low if compared to surrounding geothermal gradients, whether downflow occurs in the ranges or in basin sediments. No verifiable cool downflow zone has yet been identified to support this fault dominated or localized fluid recharge and, although few, temperature gradient holes within the Stillwater range are warm. Some shallow adits 6km southwest of the power station show temperatures in excess of 35°C with the warmest temperatures deeper in the range block [4], [15].

At greater than 8 km depth, where the DVPP draws fluid from, the geothermal resource is well within the permanently saturated groundwater zone. Downward infiltration of the production volume of fluid would need an extensive fracture network and high conductive heat flow to support the fluid temperatures and flow rates produced from this resource. At these depths, the fracture density of the surrounding rock is hard to imagine beyond what we would expect from a well consolidated granite. Permeability for tectonically active zones of the near ductile crust requires a healthy imagination. Yet, it may be these very tectonics that allow the collection and movement of these fluids. The pressures balancing in extensionally reactivated thrust planes or during fault pumping may result in physical accommodations that could collect fluids that are pressurized to that of the lithostatic load in a 5-10 km aquifer [13]. Fluid movement may be the least energetic mechanism to shift pressures at this depth. Transmissivity within these structures may provide enough fluid volume for these production rates at the DVPP by tapping the intrinsic permeability of the broader saturated zone at this depth [15].

6. Discussion
Total water budget for the basin is almost certainly out of balance if you perceive that geothermal recharge is only due to mountain range meteoric input. Precipitation minus evapotranspiration for the Dixie Valley hydrologic area is on average 409 million m$^3$/yr [12], [14], and production from the DVPP is roughly 20 million m$^3$/yr. This would amount to 5% of the total yearly precipitation for the entire 6164 km$^2$ basin being withdrawn for geothermal production. Nearly one out of 20 drops that fall onto this surface. By only considering geothermal recharge by subsurface aquifer recharge, which is on average 28.3 million m$^3$/yr, this percentage rises to 70%. A more relevant measure. Surface precipitation, even in a closed basin does not participate in the groundwater system until it downflows through the capillary fringe and into the permanently saturated zone.
Assertions that spent thermal water from re-injection wells has made its way to the depth and thermally equilibrated with the formation is unlikely. Evaluations of chemical tracers injected into the thermal reservoir are selective and inconclusive as they are not substantiated by thermal degradation. If fluids were recirculated through this formation, by some assertions sweeping the estimated fracture volume by a highly uncertain 5 to 48 times [1]. The system would then be limited by the available heat flow from the total fracture volume permeability and it is likely that there would be a decline in production temperature as heat is systematically removed from the system. Producing 20 million m$^3$ of thermal fluid a year also demands that whatever mechanism for recharge can accommodate this rate of withdraw. Mountain recharge would require vertical transmissivities that are not easily conceived to move fluids to this depth, on average ~1.5 m/day for the roughly 9 ka age of hydrothermal reservoir fluids. Production from the two geothermal cells feeding the power plant are very likely sourced from long term regional meteoric input via long term infiltration through regional surrounding aquifers.

Some have suggested that Pleistocene Lake Dixie has contributed to a substantial portion of the thermal reservoir [11]. Although chronologically consistent and perhaps a partial source, influence surely has waned and is and ever diminished by the yearly meteoric input. In many ways lake water is indiscernible from past recharge from precipitation as they both arrive from the same origin and infiltration paths. This large and obvious source also distracts from the real uncertainties of fluid movement by dismissing the current circulation and its continuing evolution.

7. Conclusions

Hydrologic balance of geothermal systems often relies on the inference from chemical signatures of the hydrothermal resource and their proximity to likely recharge candidates. Accounting for these is difficult to assert as data from meteoric input to fossil fluid in the formation can take a significant amount of time and resource disturbance to assess confidently. Hypothesis of fluid flow in geothermal systems depict time constrained and measurement characteristics that often over generalize the resource and do not infer the dynamics and evolution of these systems over time. From inception, the structural and hydrodynamics of geothermal circulation demands careful consideration regarding fluid supply, flow paths with the heat capacity and transmissivity of the cell. These factors contribute to the lifespan and the attitude of each geothermal resource. It would greatly benefit our understanding of geothermal outflow in Dixie Valley if shallow groundwaters were continuously monitored for the response of potentiometric surface, impacts on salinity and ion concentration with the flow rates from individual rain events. These datasets would be useful to integrate infiltration rates with geothermal fluid mixing and the basin-fill aquifer response.

Water chemistry does imply that the thermal fluids produced at the power plant are from meteoric sources. The age of these fluids predates the Anthropocene, with certainty and may be from the Miocene to Pleistocene. Fossil waters are unlikely to perpetually sustain the fluid volumes required to operate the DVPP at a production rate of 20 million m$^3$/yr. Neither would the available recharge into the Dixie Valley hydrographic area alone. The withdraw would amount to a substantial portion of the total yearly hydrologic recharge to the basin, somewhere around 28.3 million m$^3$/yr, being withdrawn from only 22 wells in a small section of the valley. Mountain infiltration does not contribute substantially to this balance either as the majority of precipitation that falls in the ranges does not infiltrate into the subsurface and runs off into the basin-fill aquifer. Even if local basin infiltration is the only fluid source for this geothermal resource the infiltration time needed for fluids to replenish the thermal aquifer would be too long to support perpetual hydrothermal production. Rather, the broader subsurface saturated zone and its intrinsic permeability is the likely source for these fluids.

The potential for geothermal production in Dixie Valley is arguably much larger than what is being currently utilized from the two producing cells. The trend of high enthalpy geothermal cells in this region offer a real opportunity to understand the hydrologic nuance of deeply sourced non-magmatic geothermal systems. Although important, the outflow and extraction end of the geothermal cycle is merely the end of a complicated and intriguing hydrologic problem. Better understanding the source
and flow paths of these crustal fluids will enable researchers and developers to quantify the total scope of these formations and provide boundaries and recommendations for their utilization.

References
[1] Benoit D 2011 The Geothermal Systems in Dixie Valley, final report to the BOR Dixie Valley water resources study team, January 20, 2011
[2] Blackwell D D, Smith R P and Richards M C 2007 Exploration and Development at Dixie Valley, Nevada: Summary of DOE Studies, Proceedings, Thirty-Second Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, January 22-24, 2007
[3] Blackwell D D, Smith R P, Waibel A, Richards M C and Stepp P 2009 Why Basin and Range systems are hard to find II: Structural model of the producing geothermal system in Dixie Valley, Nevada, Proceedings, Geothermal Resources Council Trans, 33, 41-446
[4] Blackwell D D, R P Smith and M C Richards, eds 2014 Dixie Valley Synthesis, SMU Geothermal Laboratory
[5] Thompson George A, Meister Laurent J, Herring Alan T, Smith Thomas E, Burke Dennis B, Kovach Robert O, Salehi Iraj A and Wood M Darroll 1967 Geophysical Study of Basin-Range Structure Dixie Valley Region, Nevada. Part IV. Geophysics Department Stanford University, Stanford, California, 35p
[6] Colgan Joseph P, Dumitru Trevor A, Reiners Peter W, Wooden Joseph L and Miller, Elizabeth L 2006 Cenozoic Tectonic Evolution of the Basin and Range Province in northwestern Nevada: American Journal of Science, Vol. 306, October, 2006, P. 616 – 654, DOI 10.2475/08.2006.02
[7] Harrill J R and Hines L B 1995 Estimated natural ground- water recharge, discharge, and budget for the Dixie Valley area, west-central Nevada: U.S. Geological Survey Water- Resources Investigations Report 95-4052, 12 p., http://pubs. er.usgs.gov/publication/wri954052
[8] Huntington J M, Garcia C A and Rosen M R 2014 Hydrogeologic Framework and Occurrence, Movement, and Chemical Characterization of Groundwater in Dixie Valley, West-central Nevada: U.S. Geological Survey Scientific Investigations Report 5152, 59 p
[9] Interflow Hydrology, Inc. and Environmental Simulations, Inc., 2010, Work Plan for Numeric Flow Model Development for BOR - Churchill County Dixie Valley Water Resources Study, December 8, 2010, 17 p
[10] Nimz G, Janik C, Goff F, Dunlap C, Huebner M, Counce D and Johnson S 1999 Regional hydrology of the Dixie Valley geothermal field, Nevada: Preliminary interpretations of chemical and isotopic data, Lawrence Livermore National Laboratory Report UCRL-JC-135417, 9 pp
[11] Oregon State University PRISM Group, 2006, United States Average Monthly or Annual Precipitation, 1971-2000: Oregon State University
[12] Robb L 2012 Introduction to ore-forming processes. Blackwell Publishing Company, 373 pp
[13] USGS, National Water Census - Data Portal, Water budget. Hydrologic code unit - 16060001, Watershed - Dixie Valley. https://cida.usgs.gov/nwc/#!waterbudget/huc/16060001
[14] Waibel A 2017 The Humboldt and Dixie Valley high-temperature geothermal trends, Nevada, U.S.A. Proceedings, 42nd Workshop on Geothermal Reservoir Engineering, Stanford University, 238-254