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A PRELIMINARY ANALYSIS OF THE SHALLOW RESERVOIR CHARACTERISTICS OF THE LIGHTNING DOCK GEOTHERMAL SYSTEM AS DETERMINED FROM PUMP TEST OF AMERICULTURE 1 STATE PRODUCTION WELL

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DISCLAIMER

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1.0 INTRODUCTION

1.1 Purpose

This report provides a preliminary analysis of the productivity of the shallow Lighting Dock geothermal reservoir, Animas Valley, Hidalgo County, in southwestern New Mexico (Figure 1). Several important constraints and properties of the reservoir are identified. A description of the shallow reservoir geology for the Lightning Dock Geothermal system, and a discussion of a 48-hour pump test of the AmeriCulture 1 State well are presented. Pump test estimates of reservoir transmissivity and storativity are used to calculate Theis model drawdowns at various distances from the AmeriCulture 1 State well for a shallow confined reservoir that is produced at rate of 1,000 gpm over twenty years. Recommendations for production and injection wells and a program of reservoir monitoring provide an initial framework for near future reservoir development at Lightning Dock.

2.0 RESERVOIR GEOLOGY

2.1 Geologic Setting

Elston and others (1983) present much information on the Tertiary and Quaternary geology of the Lightning Dock area. However, the keys to understanding this system are much broader. Four tectonic elements probably play a role in creating the local and regional geologic controls on the hydrogeology of the Lightning Dock geothermal system.

First, southwestern New Mexico and southeastern Arizona have a strong WNW structural grain that is characterized by several en echelon WNW bands of repetitive structural deformation with a predominant Precambrian through early Tertiary history (Titley, 1976).

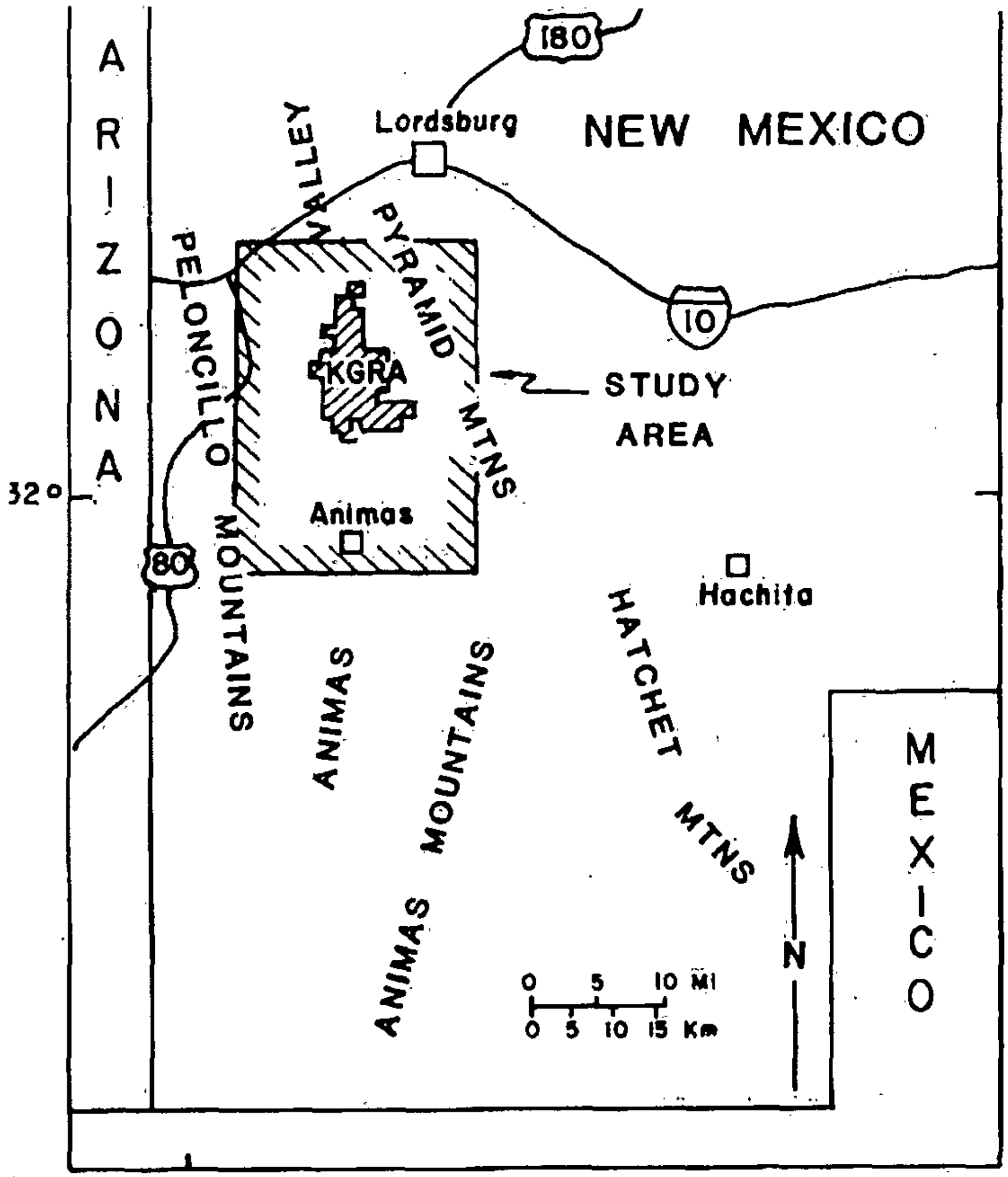

Figure 1. Location map of Lightning Dock geothermal area (Smith, 1978).

In the Late Paleozoic, the northern margin of the NW trending Pedragosa basin existed near the present day Lightning Dock location (Ross, 1978). During the upper Jurassic and Lower Cretaceous, NW trending rift zones extended across the area and appear to have reactivated older WNW Precambrian and Paleozoic faults (Lawton, 2000; Lawton and McMillan, 1999; Lucas and Lawton, 2000). Later, Laramide Orogeny deformation of the Late Cretaceous and early Tertiary reactivated the older rift structures and structurally inverted the rift basins into uplifts in a compressional stress regime (Lawton, 2000). The structural deformation along WNW zones is well displayed in the Granite Gap area in the Peloncillo Mountains southwest of the Lightning Dock area (Bayona and Lawton, 2000). Subsurface stratigraphy in the Steam Reserve Animas 55-7 well and the Cockrell 1 Federal Pyramid wells at Lightning Dock also show evidence for a major WNW basement structure with pre mid-Tertiary volcanism affinity (Figures 2 and 3). Precambrian basement is encountered at 6,858 ft depth in 55-7 and at 7340 ft depth in the Cockrell Pyramid well with only 482 ft of relative difference (files, New Mexico Bureau of Mines). However, Tertiary volcanics unconformably overlie the Mississippian Escabrosa at 5,795 ft depth in the Cockrell Pyramid well and Tertiary rhyolite unconformably rests on a problematic unit of Cretaceous or Pennsylvanian to Permian age in the Animas 55-7 well. The important point to make is that the Pennsylvanian Horquilla is present at 1,842 ft depth in Animas 55-7, but it is completely absent in the Cockrell Pyramid well. In other words, prior to deposition of Tertiary volcanic rocks at least several thousand feet of Paleozoic and Mesozoic sedimentary rocks have been removed either by erosion or have been tectonically eliminated from the section encountered in the Cockrell Pyramid well. With tectonic uplift and subsequent erosion, the older Mississippian Escabrosa in the Cockrell Pyramid well had to be at higher surface elevation than the younger Pennsylvanian Horquilla in the Animas 55-7 well prior to mid-Tertiary volcanism. Today, relative sea level elevation of the Mississippian Escabrosa is reversed. A major WNW trending basement structure is therefore implied beneath the Lightning Dock geothermal area (Figure 2 and 3).

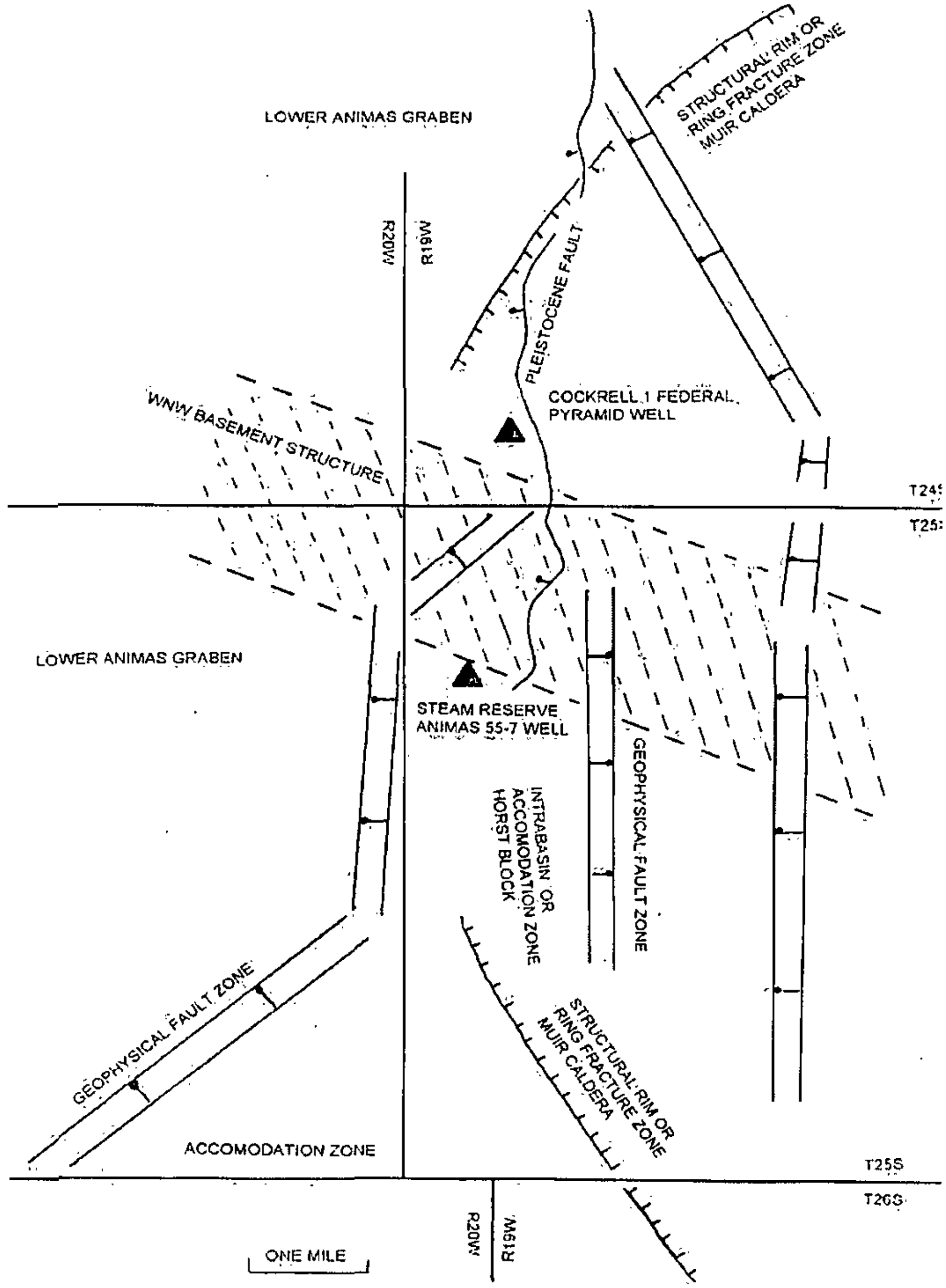

Figure 2. Summary geologic structure map of Lightning Dock geothermal area.

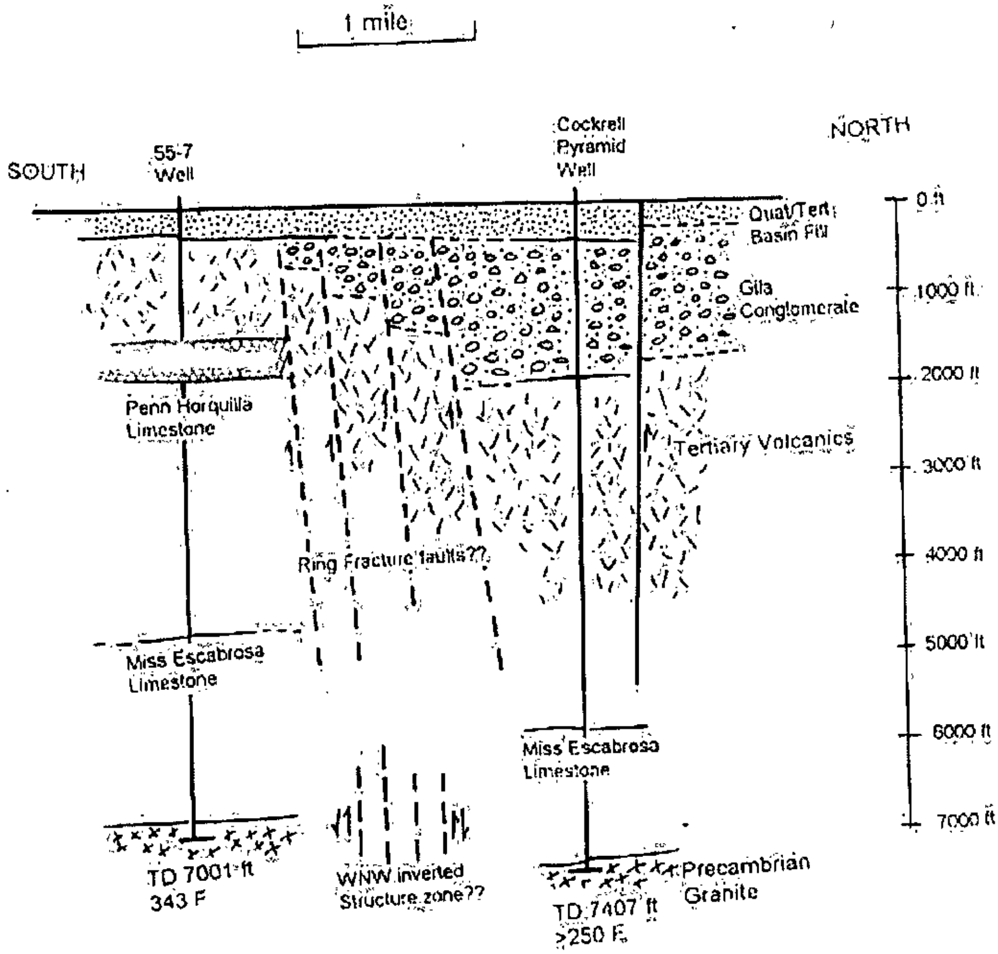

Figure 3. Geologic cross section of the Lightning Dock geothermal area. Deep subsurface control is from the Steam Reserve Animas 55-7 well and the Cockrell Pyramid well.

The age of this structure is pre -Tertiary volcanism and may have had multiple deformation events from Precambrian to Cretaceous. The similar depth to Precambrian basement in the wells that have different Tertiary subcrops confirms structural movements with opposing movement or inversion.

The second major tectonic element in the area is a large mid-Tertiary ignimbrite (silicic ash flow tuff) caldera, the Muir cauldron of Elston and others, 1983. The ring fracture zone of this feature is immediately adjacent or traverses the Lightning Dock geothermal anomaly (Figure 2 and 3).

The third major tectonic element consists of post Muir cauldron Basin and Range normal faulting which creates the Animas graben complex. The Lightning Dock area overlies a northeast-trending structure that separates the Upper Animas graben from the Lower Animas graben complex south of Cotton City and Animas. Gravity, resistivity, and refraction seismic data support this interpretation (Jiracek and others, 1977; O'Brien and Stone, 1984; Smith, 1978; and Preslar, 1976). Little detail is known about the divide other than it is structurally high and probably represents a rift accommodation zone that allows the transfer of strain between the deep Animas grabens to the north and south. Gravity and electrical resistivity data of Smith (1978), along with the rock units drilled by 55-7 indicate that the Lightning Dock geothermal anomaly is situated over the top of a local north-trending intra basin horst block within the accommodation zone. Gravity data indicates that a major northeast-trending normal fault separates the Lightning Dock anomaly from the lower Animas graben structure to the northwest. This fault could provide an important hydrogeologic boundary to the west and north of the AmeriCulture site. This structure apparently crosses the subsurface between the Animas 55-7 well and the Cockrell Pyramid well just north and west of the Lightning Dock anomaly. The Cockrell Pyramid well has 1,985 ft of basin fill overlying volcanics while the 55-7 well has only 145 ft of basin fill on top of the volcanics. However, a gamma log of the Cockrell Pyramid well indicates that the basin fill from 385 ft to 1,985 ft depth has a distinctly different character than the upper 385 ft of basin fill. This lower basin fill unit apparently represents an earlier phase of post volcanic sedimentation that is missing from the subsurface at 55-7. It is not clear if this unit is an early graben fill or if it is a post collapse caldera fill of the adjacent Muir cauldron of Elston and others (1983). The eastward embayment in the gravity data tends to suggest the later and provides evidence that a caldera ring fracture fault traverses the subsurface in the vicinity of the Lightning Dock geothermal anomaly.

The fourth key element is a north-trending late Pleistocene fault scarp with a southerly fault tip or end in the Lightning Dock geothermal area (Elston and others, 1983). This fault is the most recently active normal fault on the eastern boundary of the lower Animas graben and may be a young incipient structure that has only limited displacement and development in the Pliocene and Quaternary. Gravity and resistivity survey information indicate that other larger major normal faults, both synthetic and antithetic to the Pleistocene fault, exist between the Lightning Dock geothermal anomaly and the Pyramid Mountain front (Smith, 1978). However, an incipient Pleistocene fault tip is highly favorable for a zone of open shallow fracture permeability in the known thermal anomaly area.

2.2 Reservoir Hydrogeology

The Lightning Dock geothermal system is a blind system because there are no surface manifestations and the resource was fortuitously discovered during cable tool drilling of an irrigation well in 1948 (Summers, 1976). Since that time, limited geochemical sampling of fluids, electrical and gravity geophysical surveys, temperature gradient drilling, shallow production well drilling of the resource for direct-use heating in greenhousing and aquaculture, and a deep "wildcat" exploration hole has been done at the site (Cunniff and Bowers, 1988; Dellechaie, 1977; Elston and others, 1983; Norman and Bernhardt, 1982; Smith, 1978; Swanberg, 1978, Witcher, 1995). Information developed by these activities, when coupled with analysis of basic regional hydrogeologic and geologic data, provide information to develop a basic model for the Lightning Dock geothermal system.

Geologic and hydrogeologic information suggests that the system is the discharge of deeply-penetrating regional ground-water flow in bedrock. The heat source is most likely background regional heat flow, rather than basaltic magma or cooling intrusions as Elston and others (1983) have proposed. Basaltic magma in the shallow crust is generally not sufficiently voluminous in subsurface bodies with the proper geometries favorable for sustained heating of ground water. A constriction model of forced discharge out of the deep Animas basin fill to the south across and over the structural divide is not likely (Morgan and others, 1981). Lastly, a model for convection or advection that is confined to a graben or basin bounding fault zone is not likely. The Lightning Dock system is not located properly for either of the last two models because the reservoir is located in fractured bedrock of a local structure high or shallow "buried" horst block.

This system is not unlike other higher temperature systems in Arizona and New Mexico (Witcher, 1988). The system is in structurally high rocks and is contained in a small-buried intra graben horst block. A combination of Cretaceous and Tertiary uplift has allowed non-deposition or erosional stripping of regional aquitards to create a local "geohydrologic window" for discharge of fluids to form an upflow zone reservoir (Witcher, 1988). With a location at relative low elevation, it is in a favorable location for "forced" or advective discharge of fluid and heat from a regional bedrock ground-water flow system. Recharge for this system is no doubt from higher terrain, both mountains and valleys, to the south. Oxygen isotopes on the geothermal waters indicate that recharge probably occurred during wet periods during the latest Pleistocene to Recent (Elston and others, 1983). With a large regional flow system, the flow dynamics are buffered by the large volume of water that is in storage. The intersection of several major regional tectonic features provides the vertical fracture permeability to form a geohydrologic window for outflow from the deep regional bedrock ground water system. The details of specific structures for the upflow zone are not known.

2.3 Reservoir Thermal Regime

In order to make a heat and mass balance calculation, a dynamic three dimensional system is defined. Geothermal systems can be characterized for the purpose of this analysis as having a deep-seated bedrock upflow zone and a very shallow bedrock and/or alluvial aquifer outflow plume. One subsurface hydrogeologic boundary that is parallel to the earth's surface is located "deep" in the bedrock of the upflow area and allows the vertical mass and energy input to the system. "Deep" bedrock outside of the upflow zone is conservatively assigned a boundary with no vertical mass flow, but vertical heat input is allowed by the regional crustal conductive heat flux.

The outflow plume represents an area of shallow lateral flow of geothermal water from the upflow zone with a diffuse zone of lateral mixing with nonthermal water. Vertical boundaries, normal to the Earth's surface and above the "deep" basal boundaries, are open to heat and mass inflow or outflow in all cardinal directions. However, geothermal waters in the upflow zone will have different chemistry than any mixing nonthermal water. Geothermal heat is lost conductively above the water table to the surface over the upflow zone and over the entire extent of the outflow plume. Measurement of this heat loss gives the minimum total advective heat loss of the geothermal system. Conductive heat flow is defined by:

(1) $q_z = k(dT/dz)$,

- q_z conductive heat flow (mW/m^2)
- K thermal conductivity (W/mK)
- dT/dz temperature gradient in °C/km

In order to perform a heat and mass balance calculation, the total heat conducted out of the geothermal system is determined by integrating the vertical conductive heat flow over the upflow zone and outflow plume areas of the system:

(2) $Q = \int q_z dA - \int q_b dA$

- Q total advective heat output of the geothermal system in W
- dA area of the integration (km^2)
- q_b regional crustal heat flow

An 80 mW/m^2 value is used as the regional crustal heat flux for this region of the southern Basin and Range.

Vertical upflow zone geothermal fluid flow introduces heat to the system by advection. The amount of heat transported by advection (Q) depends on the difference in temperature between fluid discharging across the upflow zone area in bedrock (the base reservoir temperature or T_{gs}) and the surface mean annual temperature (MAT) and the fluid flow rate:

(3) $Q = \rho c V(T_{gs} - MAT)$

ρ fluid density

c specific heat of the fluid

T_{gs} base reservoir temperature (160 °C)

MAT mean annual temperature (16 °C)

V volumetric fluid flow rate

Fluid density and specific heat are conservatively assigned unity values of pure water at standard temperature and pressure even though the base reservoir temperature is around 160 °C.

Temperature, gradient and heat flow information for the Lightning Dock geothermal system, geographically defines the location the upflow zone and provides a few details for the near surface outflow zone. The total natural conductive heat loss can also be calculated with a degree of confidence. Total energy loss information, coupled with maximum reservoir temperatures from chemical geothermometer estimates on shallow well chemistry and temperature logs of the deep Steam Reserve Animas 55-7 well, allow an estimate of the natural total mass flux out of the outflow zone. With some cross section assumptions for the outflow zone, very rough estimates of "average" hydraulic conductivity can also be calculated.

A compilation of 84 temperature gradient measurements from 73 separate sites or wells in the Lightning Dock geothermal area and the broader Animas Valley region were used to determine the total conductive heat loss for the geothermal system (Figure 4).

HEAT FLOW MAP OF THE LIGHTNING DOCK GEOTHERMAL SYSTEM

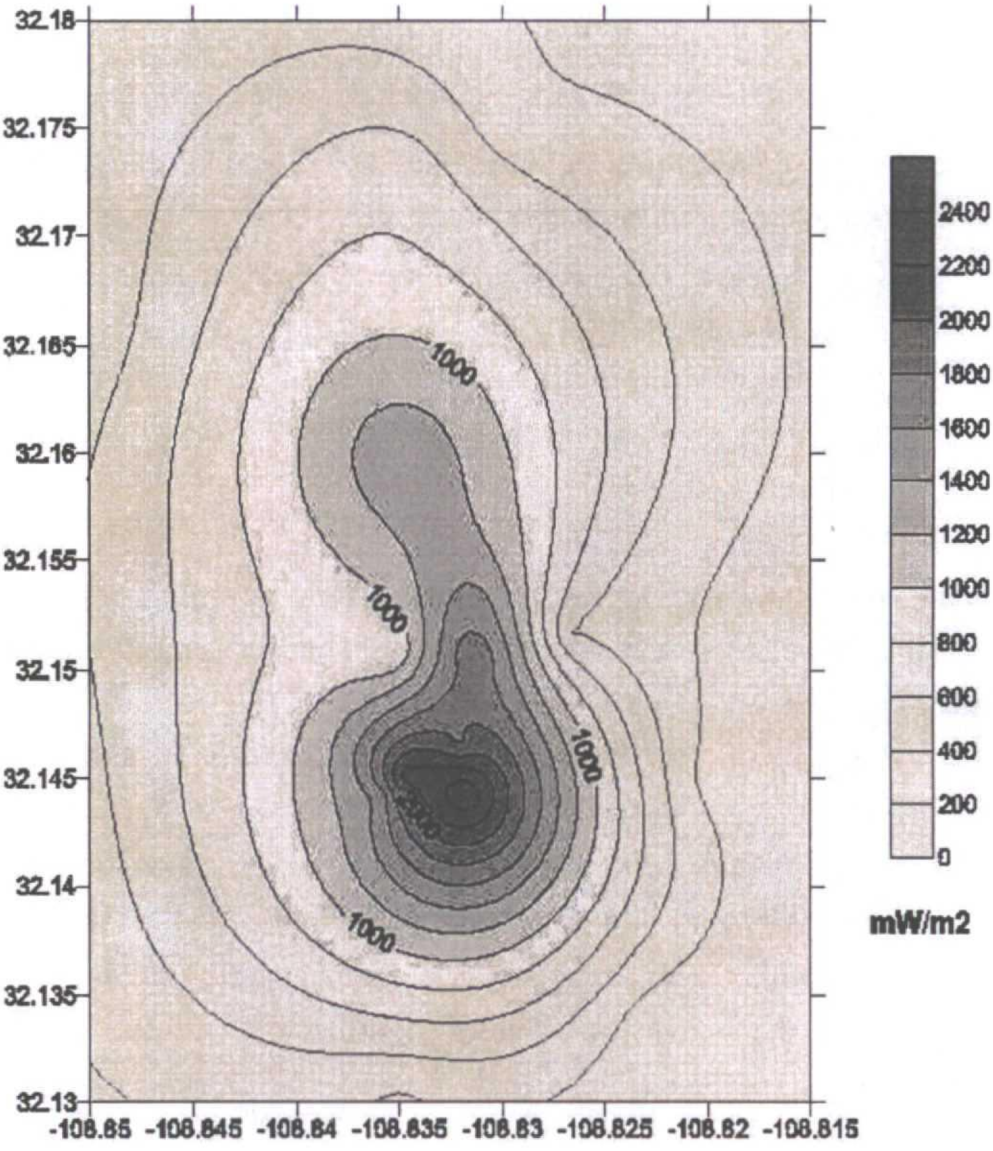

Figure 4. Heat flow map of the Lightning Dock geothermal system. Contour interval is 200 mW/m^2.

Only 4 sites in the area have rigorously measured thermal conductivity. The thermal conductivity for the remaining temperature gradient boreholes is estimated. Studies in the Rio Grande rift in the Las Cruces area for several hundred temperature gradient holes indicate that the use of estimated thermal conductivity for basin fill material is suitable for heat flow analysis and probably give site specific values with less than 20 percent error (Snyder, 1986). Measurements outside the Lightning Dock thermal anomaly are used to determine a background heat flow. The background flux is subtracted from the integrated total Lightning Dock thermal anomaly flux to determine the natural total heat loss for the system. The total heat loss for the Lightning Dock geothermal system is estimated with the heat flow data to be no more than 6 to 10 MWt (megawatts thermal). A range is given due to uncertainty in thermal conductivity. A natural mass flux is calculated as 210 gallons per minute (gpm) with a base upflow reservoir temperature of 160 °C and a thermal flux of 8 MWt. The base reservoir temperature is determined by chemical geothermometry.

With sustainable development, electrical power output for the area may conservatively be limited to less than 5 MWe (megawatts electric). Exploitation for electric power will involve the production of fluids in addition to the mining of heat stored in the shallow reservoir. Therefore, more extraction of mass and energy than is naturally recharging the shallow reservoir can be sustainable for a long period due to reservoir heat storage, especially with injection. Because of the inefficiency of power conversion and uncertainties in long-term reservoir behavior, the actual upper bound of electric power production for sustainability with current direct-use geothermal development is poorly defined and requires more definition of the reservoir beyond the test described in this report.

Elston and others (1983) estimate a base reservoir temperature of 200 °C by applying a mixing model and using a silica-enthalpy diagram. However, this estimate is problematic for the following reasons. Analysis of the silica concentration shows that the silica variation is probably due to equilibration with amorphous silica at or near measured sample temperatures and not mixing. A chloride-enthalpy diagram should have been used. With this diagram there is no systematic variation in silica concentrations with respect to chloride, suggesting the mixing does not occur. While the fluids are low total dissolved solids (1,100 mg/L), it may be a function of equilibration and flow through silicic rock such as rhyolite or granite as Dellechaie (1977) points out. We estimate the base reservoir temperature to be about 160 °C based upon the silica (quartz) geothermometer.

The heat loss out of the shallow outflow reservoir is largely defined by the size of the heat flow anomaly. A north-northeast flow is indicated by anomaly shape. The relatively sharp western and eastern boundaries of the anomaly are probably limited to some extent by fault zones that prevent lateral dispersion and mixing. Pump test data (discussed in detail later) shows that the western fault appears to form a flow boundary because the AmeriCulture Federal well west of the fault exhibited anomalously low drawdown.

The true geologic nature of the shallow outflow plume host is not known with precision. Several possibilities exist. Shallow production wells and the 55-7 well encountered "rhyolite" in the shallow reservoir. The rhyolite may represent an ashflow tuff cauldron fill if it is a single flow unit. The rhyolite may represent a composite of several ash flow tuff outflow sheets from several mid Tertiary calderas in the region. If the later is true, then the Lightning Dock geothermal system is located on the rim of the Muir cauldron just outside of the ring fracture zone. A third possibility is a ring fracture rhyolite flow and dome complex. If this is true, a fractured rhyolite feeder dike for the dome and flow may provide the upflow at the Lightning Dock geothermal system. A fourth possibility is that the rhyolite represents a silicified rhyolite litharenite that represents a late stage caldera basin fill or an early rifting basin fill. With future drilling, spot cores should be obtained at different depths to determine rhyolite petrology, paleomagnetism, chemistry, and radiometric age dates. This information would fingerprint the rhyolite and allow definitive interpretation with respect to its origin and geologic nature.

2.4 Water Quality

Chemistry of fluids of the AmeriCulture 1 State well show good quality (Table 1).

Table 1. Water chemistry of the AmeriCulture 1 State well (mg/L).

October 2000 — nd - not detected

Temp C	pH	TDS	Na	K	Ca	Mg	Sr	HCO3	SO4	Cl	F	Br	B	As	SiO2
111.0	8.1	1071	319	14.7	22.7	0	0.45	138.5	462	80	10	nd	0.4	nd	89.9

Most geothermal waters contain elevated arsenic concentrations. Lightning Dock waters show no elevated arsenic. Also, the sulfate concentration appears to be elevated and may reflect partial equilibration with Paleozoic units in subsurface flow paths. Gas chemistry for a Lightning Dock thermal well is reported by Norman and Bernhardt (1982) (Table 2). Concentrations of carbon dioxide and hydrogen sulfide are very low compared to most geothermal waters and should present little problem for power production equipment design. However, it should be pointed out that some gas loss may have occurred during sampling.

Table 2. Gas Concentrations of hot well at Lightning Dock.

Animas Valley Hot Well — nd – not detected — ppm – parts per million

	Temp	N2	O2	He	Ne	Ar	Kr	H2	H2S	S02	CO2	CH4	NO
percent	96 °C	6.6	0.18	13 ppm	17ppm	1100 ppm	0.77 ppm	0.2	nd	nd	91	180 ppm	61 ppm
cc/L		1.80E-02	5.00E-04	3.60E-06	4.90E-06	3.10E-04	2.20E-07	5.60E-04	nd	nd	0.26	5.00E-05	1.70E-05

volume gas STP 0.28 cc/L

REFERENCE: Norman and Bernhardt, 1982, p. 113

2.5 Discussion

The Lightning Dock geothermal system is contained in an intra basin or accommodation zone horst block on or adjacent to the intersection of a major WNW basement structure with the ring fracture zone of the Muir cauldron and at the southern fault tip of an incipient Pleistocene normal fault on the eastern border of the lower Animas graben. The upflow zone plumbing is not possible to detail with confidence. An unmapped subsurface fault zone or a buried mid-Tertiary ring fracture rhyolite dike or dome may play roles. Temperature logs and well lithology logs indicate that shallow and deep outflow plumes are present.

The shallow outflow plume is contained in the upper section of Tertiary volcanics. A deep outflow plume occurs in a "problematic unit" at the base of the Tertiary volcanic section that may represent a solution and collapse karst of Paleozoic limestone or a Jurassic or Cretaceous rift fanglomerate. This zone provides an excellent reservoir target for production of 150 °C fluids at Lightning Dock and the zone may be partially isolated from the shallow outflow plume utilized in current production.

Overall, the total energy output as inferred from heat flow studies indicates a total flux no greater than 10 MWt. As a result, an ultimate sustained electrical power generation capability in excess of 5 MWe may not be feasible without major drawdown to the currently produced shallow reservoir. An Enhanced Geothermal System (EGS) approach to development may reduce impact to the shallow reservoir that is used for greenhouse heating.

3.0 PUMP TEST OF AMERICULTURE WELL

3.1 Wells

Sustainability information on the shallow outflow reservoir was determined by conducting a 48-hour steady state 1,000 gpm pump test on the AmeriCulture State 1 well. This well, 399 ft deep, produces from a fractured rhyolite reservoir host in an open hole from 282 to 399 ft depth. Two wells, one 1,170 ft to the west and one 825 ft to the north-northeast were monitored for drawdown. The western monitor well, AmeriCulture Federal 1 (formerly Beall well) is completed in Tertiary-Quaternary basin fill between 60 and 223 ft depth. The northern monitor well, the Burgett 'A' State well is completed in the fractured rhyolite to a total depth of 440 ft.

At end of 24 hours, other wells were pumped. The first pump turned on was the Burgett 'C' State well, 255 ft southwest of Burgett 'A' State well and 645 ft north of the AmeriCulture 1 State well. The second pump turned on was the Burgett 'B' State well, 345 ft southwest of Burgett 'A' State well and 600 ft north of the producing AmeriCulture State 1 well. The Burgett 'C' well was pumped at 650 gpm while the Burgett 'B' well was pumped at 1,200 gpm. The Burgett 'C' State and the Burgett 'B' State producing wells have similar well construction and geology as the Burgett 'A' State monitor well. Because several wells were pumped in the last 24 hours of the test, it was possible to gain some insight into the impact of drawdown by several wells.

3.2 Well Test Approach

No previous reservoir pump test has been performed at Lightning Dock; however, existing shallow wells at Lightning Dock are capable of producing over 1,000 gpm with apparent minimal drawdown. Therefore, it was decided to perform a single 24-hour steady-state test rather than several small multiple-flow rate or step flow rate tests and then a "full" flow rate test of three to five hours. The "full" rate test flow was selected to match closely the initial design production rate of the power plant. A 24-hour steady-state test is more suitable at this site and allows the reservoir to be stressed greater and longer to provide knowledge of reservoir boundaries and long-term behavior. While multiple-flow rate tests can provide additional information on well efficiency and well losses, these parameters have low priority with the current state of knowledge at Lightning Dock. The most important reservoir properties, such as transmissivity and storativity and apparent long-term behavior, are addressed better by this approach.

The initial 24-hour steady-rate pump test was modified because a significant early October weather cold front entered the area near the end of the planned test. The AmeriCulture aquaculture facility and the adjacent Burgett Geothermal Greenhouse facility required geothermal heating. This facilitated extension of the test to 48 hours with the monitoring of additional drawdown stress on the shallow reservoir by two other production wells in the area.. On the downside, the post test geothermal pumping in the area eliminated the chance of obtaining useful recovery data from monitoring wells.

Two ideally spaced and oriented wells were available for monitoring drawdown. The very limited annulus between the well surface casing and pump equipment, required for a sustained flow of 1,000 gpm or more, made it difficult to monitor the production well drawdown with confidence. On the other hand, the monitor wells had no pumps installed and provided an opportunity to gather good drawdown data to determine reservoir behavior to the stress of production. With projected reservoir temperatures of about 110 °C, a nominal rate of about 1,100 gpm is required by the design power production. Short peak flow of 1,200 gpm, during the summer, is also desirable. A 290 horsepower Cummins 55 Diesel engine was used to drive a Randolph right angle 1:1 ratio drive to power the pump.

3.3 Data Collection

A steady state flow was monitored in three ways. First, the rpm of the Diesel drive was monitored and kept at a constant rate. Second, discharge was monitored with an orifice plate mounted in the middle of the discharge line. Formulas for high temperature orifice metering were used to determine flow rate (Appendix 1). Pressure differences upstream and downstream of the orifice were used to determine flow. The upstream pressure measurement consisted of a 1/4 inch port 8 inches from the plate and the downstream pressure measurement consisted of a 1/4 inch port 4 inches from the orifice. The orifice consisted of a 6 inch by 1/4 inch flat edge steel plate opening that was centered across the 8-inch discharge pipe. The orifice plate was located 8 ft from the well and 10 ft from a discharge line valve that throttled flow to a 2,200 gallon steel weir tank. Third, a V-notch weir at the discharge end of the weir tank was also used as an additional method to monitor flow even though viscosities were not temperature corrected and the fluid temperatures exceeded 100 °C and steam loss occurred. Appendix 2 lists the orifice meter data for the AmeriCulture 1 State well production.

Drawdown measurement in the production well utilized a "bubble line" constructed with a copper tubing very carefully run along side the pump column. Drawdown in the monitor wells had to be measured with cord and float because the surface casing had floating oil from leakage of previous line shaft pumps. The oil made electric level measurement extremely difficult, if not impossible.

3.4 Burgett 'A' Well Drawdown

Figure 5 and Appendix 3 show the first 24-hour drawdown of the Burgett 'A' well. The Burgett 'A' well is discussed first because, the drawdown data from this well has the highest continuity, precision, and quality measured during the pump test. These data present a framework to interpret all other well drawdowns. Figure 5 shows pumping drawdown of the reservoir in feet compared to a log function of time versus distance squared from the pumped AmeriCulture 1 State well. Five slopes in the drawdown data are easily picked in the data. The early drawdown, slope 1, probably represents the combined effects of well bore storage being emptied and the local reservoir transmissivity and storage when considering that fracture reservoirs are notorious for high transmissivity and low storativity. As a result, several "boundary type" conditions may manifest themselves that can change drawdown rates. Slopes 2, 3 and 4 slopes are likely reservoir boundary conditions imparted in the fracture reservoir by storage properties of the reservoir. For instance fracture reservoirs are best characterized by "double porosity." Fracture porosity is of primary importance early in reservoir drawdown. During early drawdown, fluids in fractures nearest the well bore are produced. As hydraulic stress on the reservoir proceeds, small and less productive fractures also begin to supply water along with fluids from "block porosity" in the rock matrix between fractures.

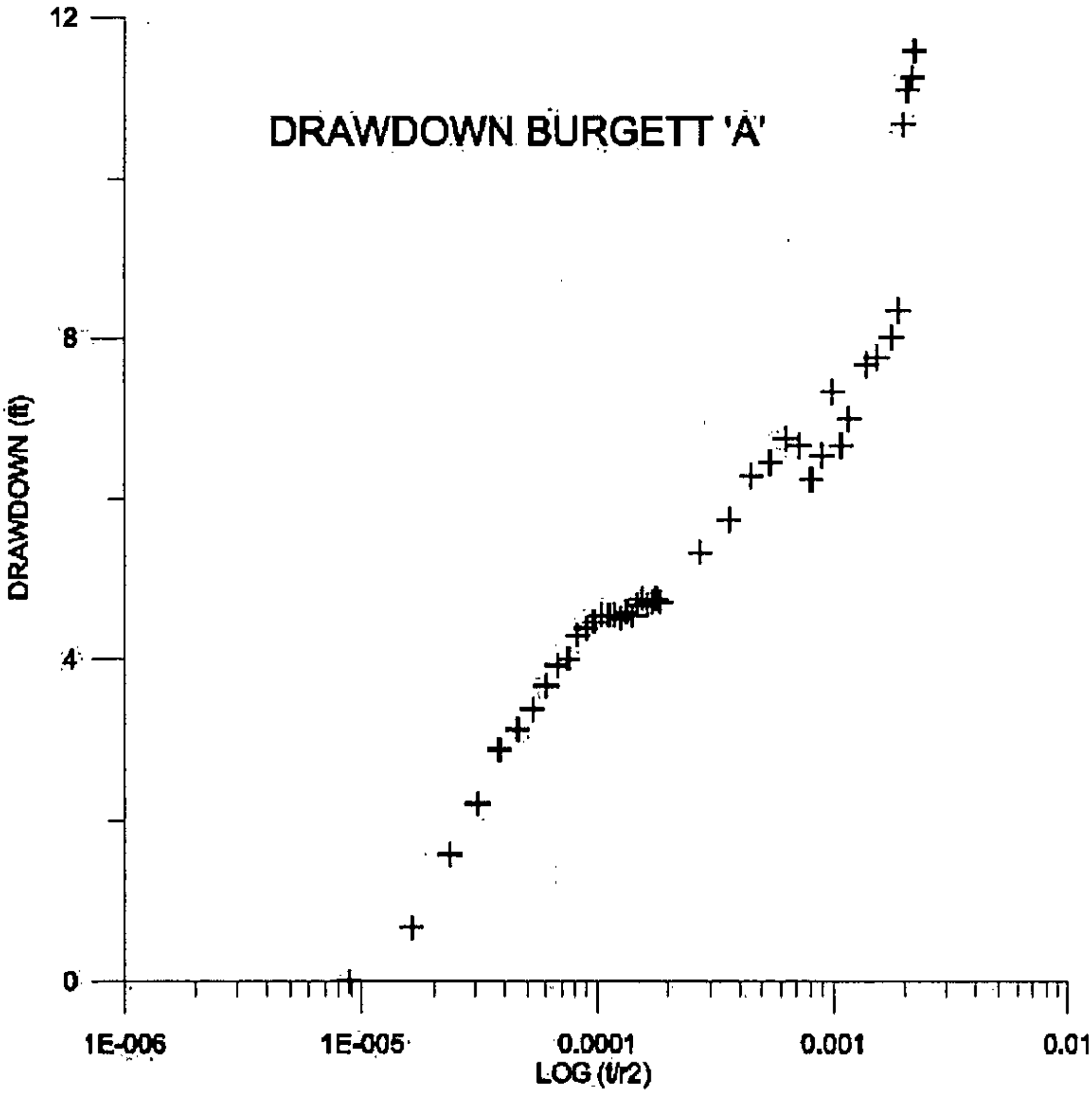

Figure 5. Burgett 'A' monitor well twenty-four hour drawdown. Drawdown is in ft versus the log ratio of time (minutes) and the distance (825 ft) squared from the producing AmeriCulture 1 State well.

The lower gradients of slopes 2, 3, and 4 could be the result of the cone of depression draining block porosity or intersecting a highly productive fracture zone. In either case, "recharge boundaries" may have been encountered in the reservoir. An alternative explanation would involve pump test "repair" or cleaning out of "formation damage" left from well drilling. Well efficiency would improve after cuttings and drilling products are removed from the formation. It may be notable that about a pound of formation material was found in the bottom of the weir tank at the end of the test. Sizes of material in the weir tank ranged from "pea gravel" to coarse sand.

Slope 5 may indicate that the drawdown cone encountered an important "impermeable" boundary. While, in reality an impermeable boundary is not strictly impermeable, such a boundary could limit long-term reservoir production capability and result in increased drawdown over the long term. The slope 5 drawdown gradient probably reflects unreported pumping of wells at the Burgett Greenhouse south of the Americulture 1 State well soon after the weather cold front passage. This interpretation is consistent with the behavior of drawdown observed when Burgett 'C' and Burgett 'B' wells are pumping. Figure 6 and Appendix 4 show 16 hours of pumping by both the Burgett 'C' well at 650 gpm and the AmeriCulture 1 State well at 1,000 gpm. The drawdown gradients are steep at first in the Burgett 'A' monitor well and then level out at about 13.5 ft. Likewise, pumping of Burgett 'C' and the AmeriCulture 1 State and the Burgett 'B' well at 1,200 gpm shows a short steep drawdown gradient in Burgett 'A' which then stabilizes at around 23 ft. The level recovers to about 22 ft when the Burgett 'C' well pump is turned off (Figure 7 and Appendix 5).

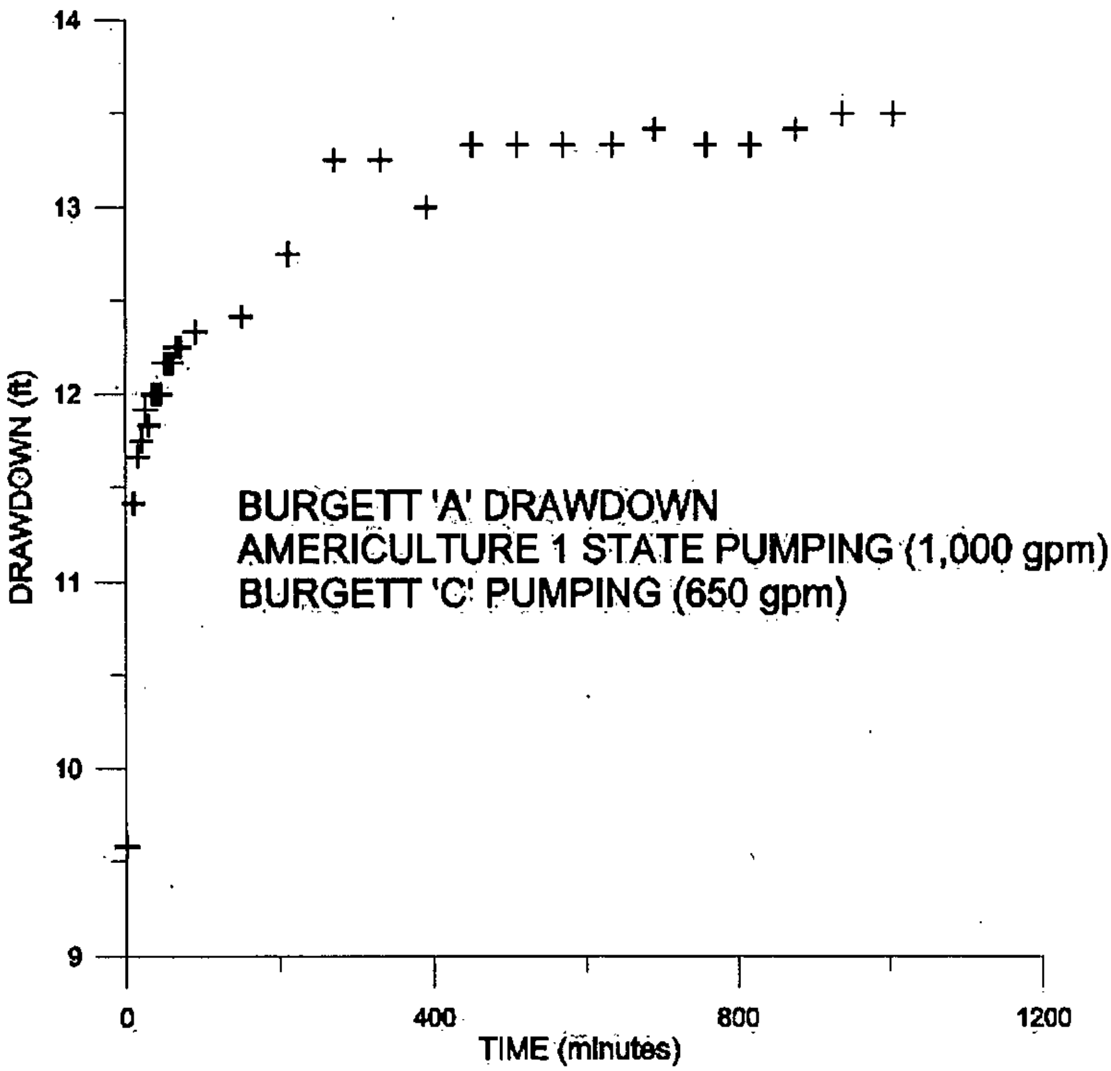

Figure 6. Burgett 'A' monitor well drawdown with AmeriCulture 1 State and Burgett 'C' wells pumping.

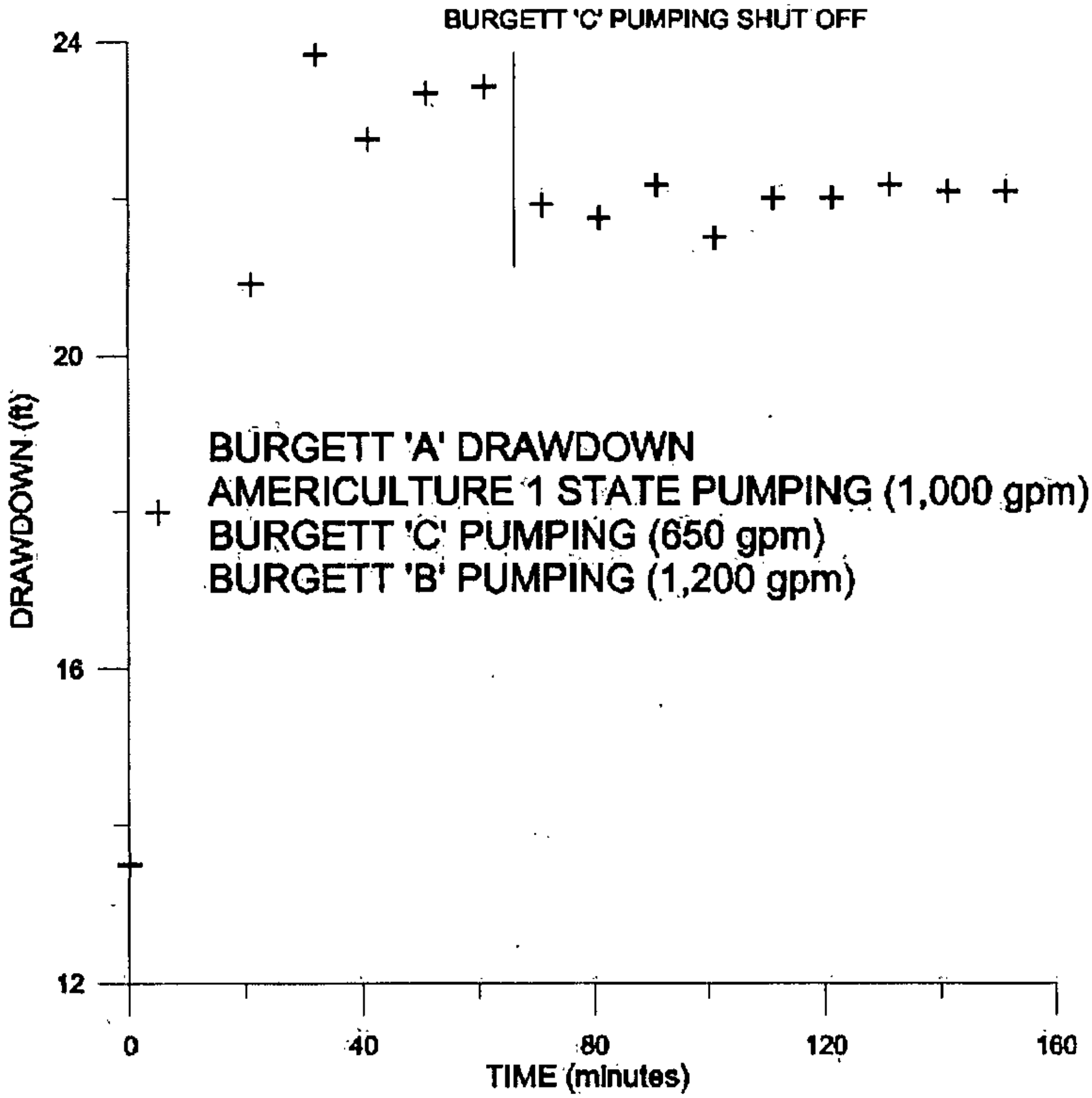

Figure 7. Burgett 'A' monitor well drawdown with AmeriCulture 1 State, Burgett 'B', and Burgett 'C' wells pumping.

3.5 AmeriCulture 1 State - Pumped Well

Like the Burgett 'A' well, a multi-sloped drawdown signature is also observed in the pumping AmeriCulture 1 State well (Figure 8 and Appendix 6). The signature appears similar, except that the boundaries or changes in drawdown are noted earlier in the test as would be expected if the boundaries represent the effects of "double porosity" rather than recharge fault zones. Figure 9 is a plot of the AmeriCulture drawdown with respect to the Burgett 'A' well. The drawdown data in this well is extremely noisy and presents a major obstacle in the interpretation of reservoir characteristics. This noise is reflective of the drawdown measurement method, a 'bubble line.' No steam pressure correction of the semi-sealed well head was used to correct the drawdown as after about 6 to 10 minutes this pressure remained fairly constant between 4 and 5 psi. However, a temperature pressure correction of the air line at water saturation is probably needed. This was not done. The result is a drawdown may be greater than what is actually occurring. However, since this is a first short-term analysis of the reservoir, a conservative or "lower bound" approach is taken in interpreting and analyzing the data.

3.6 AmeriCulture Federal Well

Drawdown in the AmeriCulture Federal Well did not occur until 9 hours into the pump test. When delayed drawdown did occur, the water levels fell much less than in Burgett 'A'. There is no doubt that a "shallow and impermeable" boundary occurs between the AmeriCulture Federal Well and the AmeriCulture production well. The limited data seem to indicate that the drawdown slope of the AmeriCulture Federal well is similar to the Burgett 'A' drawdown slope (Figure 10 and Appendix 7).

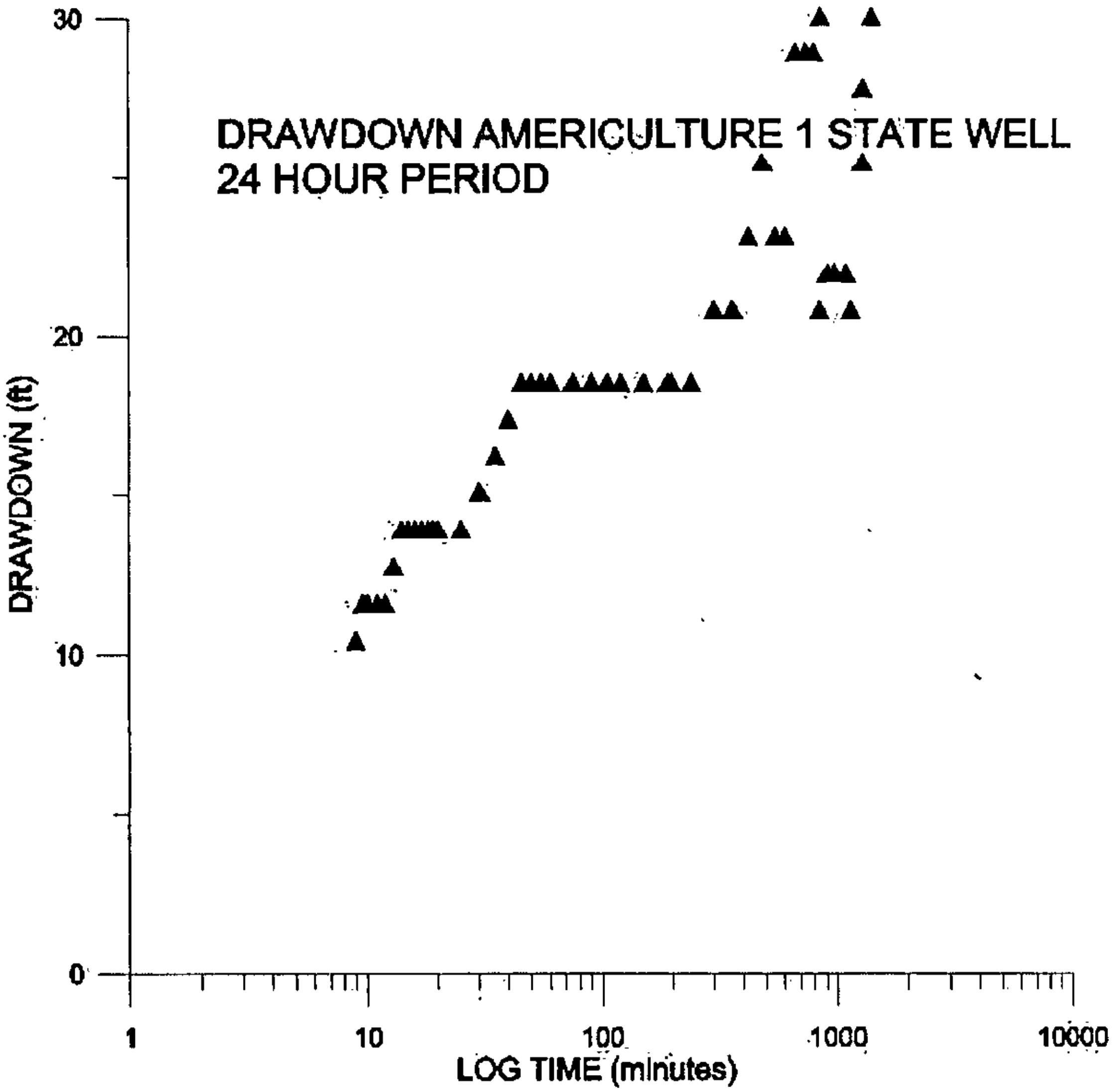

Figure 8. AmeriCulture 1 State pumping well twenty-four hour drawdown. Continuous pumping rate is 1,000 gpm.

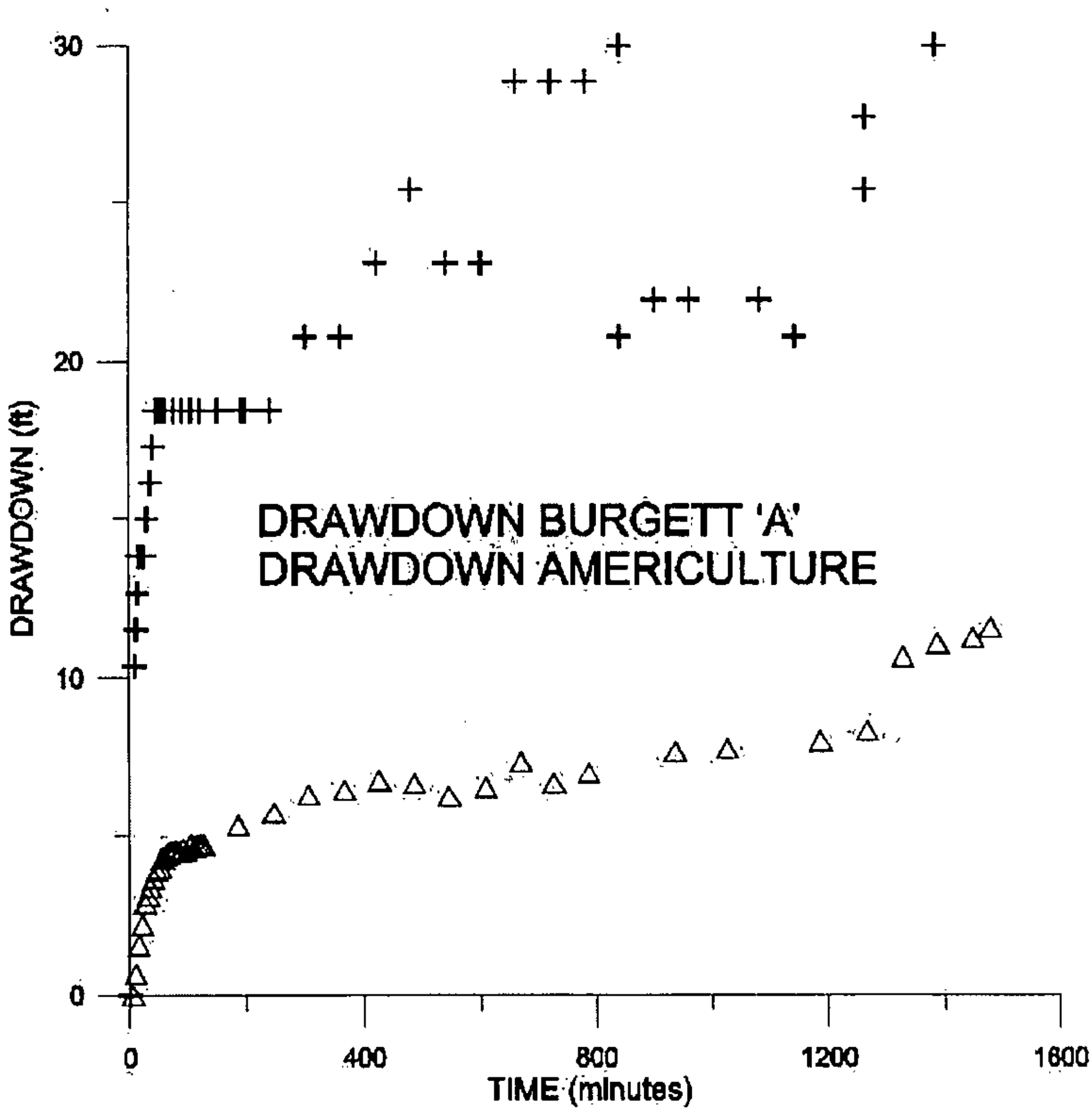

Figure 9. Comparative twenty-four hour drawdown for monitor well Burgett 'A' and pumping well AmeriCulture 1 State well. Crosses are drawdown in the AmeriCulture 1 State well. Triangles are drawdown in the Burgett 'A' monitor well.

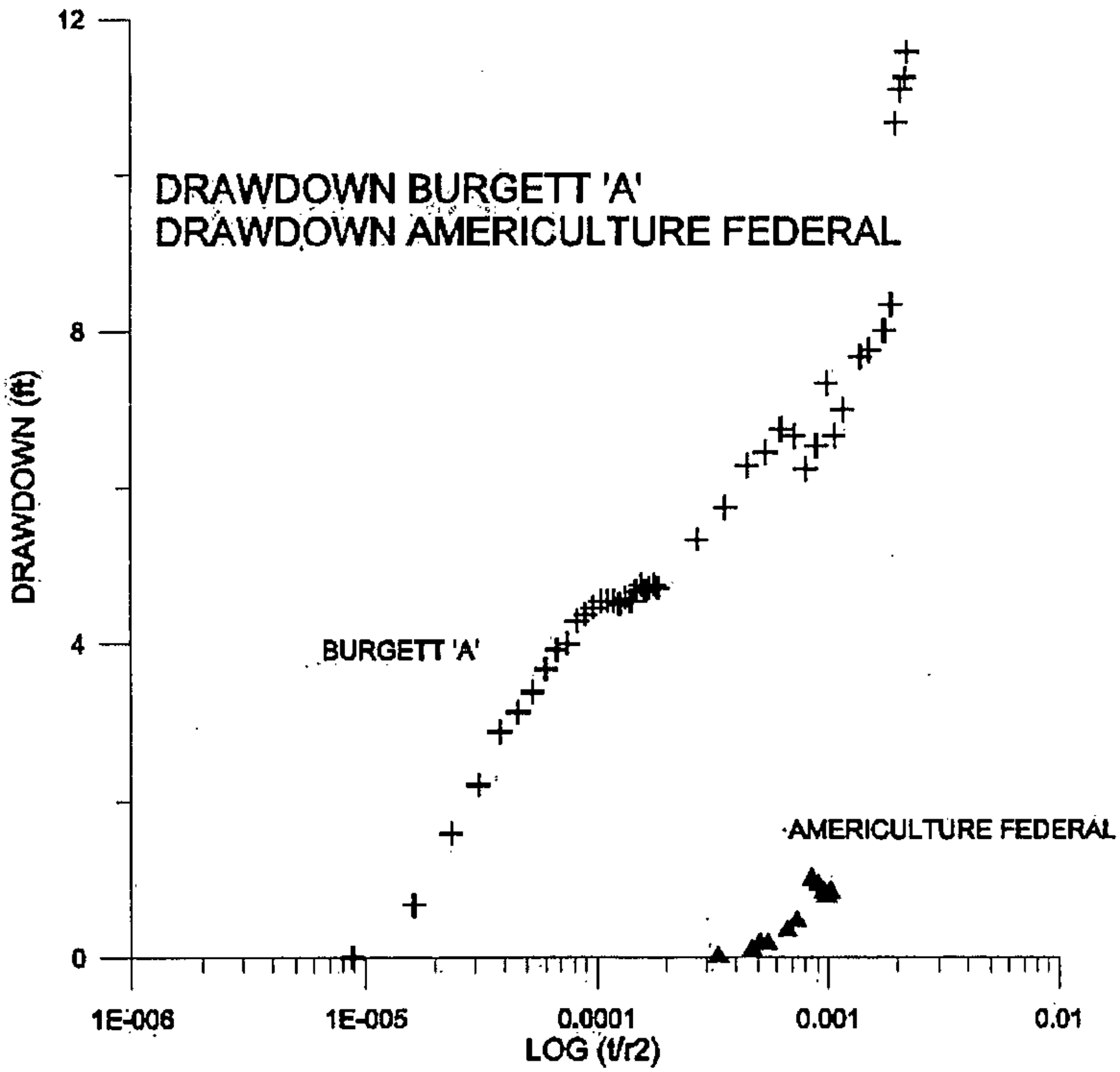

Figure 10. Comparative drawdown for monitor wells Burgett 'A' and AmeriCulture Federal. Drawdown in ft is plotted against the log ratio of time (minutes) and the distance (ft) squared from the pumping AmeriCulture 1 State well.

3.7 Steam Reserve Animas 55-7 Well

Very limited observation of water levels in the Animas 55-7 well show that the "near upflow zone" reservoir below 1,200 ft depth shows a response to pumping in the shallow outflow plume reservoir. These drawdowns are tabulated in Appendix 8. Drawdown over an approximate 3 hour period with the AmeriCulture 1 State well pumping 1,100 gpm, the Burgett 'B' pumping at 1,200 gpm, and the Burgett 'C' pumping at 650 gpm shows a 0.21 ft overall drawdown.

4.0 RESERVOIR ANALYSIS

4.1 Methods

The approach is a very conservative interpretation and analysis of drawdown data from the AmeriCulture 1 State production well and Burgett 'A' monitor well. The reservoir is assumed to be a confined. In reality, the reservoir is probably a semi-confined and leaky reservoir. A confined-reservoir will drawdown faster over a larger region than a leaky semi-confined reservoir. The project time frame, a lack of previous detailed long-term water level information, and no previous well pump tests require that a conservative approach be used.

The Cooper and Jacob (straight-line) method is used to evaluate well drawdown (Hall, 1996 and Lohman, 1972). This method is a practical variation of the standard Theis method to analyze confined reservoirs. Because the data collection methods have significant built in errors, the Cooper and Jacob method is very appropriate as opposed to computer or graphical curve-matching methods that are commonly applied with most other reservoir or aquifer analysis methods.

The Cooper and Jacob method has the following technique (Hall, 1996 and Lohman, 1972). First drawdown data are plotted as drawdown footage versus the logarithmic scale of the ratio of time (t) (minutes) and distance squared (r^2) from the producing well in feet. Second, the drawdown per log cycle is determined, and third the intercept of the ratio (t/r^2) with zero drawdown is determined. These parameters are plugged into the following formulas to determine transmissivity and storativity:

(4) $T = 264\ Q/\ (h_o - h)$

and

(5) $S = (T/4790)/(t/r^2)0$

T	transmissivity (gpd/ft)
S	storativity (dimensionless)
Q	producing well steady-state flow rate (gpm)
h_o	drawdown reference level (ft)
h	drawdown (ft)
t	time (minutes)
r	radial distance from production well (r)

In order to predict drawdown or water-level declines in the shallow Lightning Dock Reservoir over a long period of production, the Theis model is used (Kresic, 1997). This approach is also very conservative. The Theis method assumes that the only production is from the AmeriCulture well and that no injection wells are being used. Theis model projections of drawdown used the following formula:

(6) $u = 1.87\ S\ r^2/(T)(t)$

and

(7) $h_o - h = (114.6Q/T)W(u)$

T	transmissivity (gpd/ft)
S	storativity (dimensionless)
Q	producing well flow steady flow rate (gpm)
h_o	drawdown reference level (ft)
h	drawdown (ft)
t	time (minutes)
r	radial distance from production well (r)
u	dimensionless variable of integration
W(u)	well function of u interpolated from tables of Lohman (1972) (p. 16)

This model is also applied to minimum and maximum estimates of transmissivity in the AmeriCulture and Burgett 'A' wells to compare with actual short-term drawdown information in the Burgett 'A' well.

4.2 Assumptions

Several assumptions apply when confined reservoir models are used to examine a reservoir quantitatively. These assumptions apply to both the Cooper and Jacob method of well drawdown data and the Theis theory of reservoir drawdown which are based on exact mathematical descriptions of an ideal reservoir behavior.

1) The reservoir is vertically confined and of infinite radial extent.
2) The reservoir thickness is uniform over the area influenced by the test.
3) The well fully penetrates the fracture reservoir.
4) The pumping rate is constant.
5) Prior to pumping, the piezometric surface is horizontal over the area test.
6) Flow to the well is in unsteady state.
7) Water removed from storage in the reservoir is instantaneous with a commensurate decline in hydraulic head.
8) Ground water density and viscosity are constant.
9) Ground water flow can be described by Darcy's Law.
10) Fracture permeability in large reservoir volumes has characteristics of homogeneity and isotropicity.

Realistically, none of these assumptions are absolutely met by the shallow Lightning Dock reservoir. There are several very important violations of these assumptions. First, the reservoir is not of infinite radial extent. Second the AmeriCulture well and monitor wells probably do not penetrate the full extent of the reservoir. Certainly, the nature of reservoir fracture permeability is unknown. Fracture permeability distribution and character may be the key to understanding this reservoir. The Cooper and Jacob method and Theis model applied to this analysis are theoretically derived for confined aquifers with intergranular porosity and permeability that is isotropic, homogeneous, and 'infinite' in extent. In layman terms, isotropic means that water flows with equal ease in all directions at any given point in the reservoir. Likewise, homogeneous means that the aquifer has the same water holding characteristics at each point in the reservoir and the ease that water moves through the reservoir does not change from place to place.

4.3 Transmissivity and Storativity

As a preamble for reservoir properties to be analyzed, transmissivity is a groundwater term that describes the ability of a reservoir to transmit fluid and is dependent upon fluid viscosity, which is highly temperature dependent. Transmissivity is the flow rate through a unit of reservoir width under a unit of hydraulic gradient. Transmissivity is similar to the "thickness-permeability" product (kh) that is used in the oil field and with multi-phase high temperature geothermal reservoirs except that the thickness-permeability product is independent of fluid viscosity. With the intrinsic permeability as k, the reservoir thickness as h, and *u* as viscosity, Transmissivity is kh/*u*. Storativity indicates the amount of water released from storage per unit area of reservoir per unit change in head. Transmissivity provides the best initial measure of the properties at Lightning Dock, especially considering that wells around the AmeriCulture 1 State Well have similar discharge temperatures.

The AmeriCulture well drawdown data are highly variable. Noise in the data is probably a function of the 'bubble' line method of drawdown monitoring. However, two 'trends' in the data are apparent. The overall trend in the 24-hour data suggest that a 27,650 gpd/ft transmissivity applies (Appendix 9). This value is tentatively used to calculate a pessimistic and low value reservoir transmissivity value for long-term reservoir behavior. It is important to point out that the drawdown data for the AmeriCulture well are suspect and most likely underestimate true reservoir behavior.

The Burgett 'A' well drawdown data are systematic and include the influence of pumping for the Burgett 'C' and Burgett 'B' wells in addition to the pumping drawdowns from the AmeriCulture 1 State well. Initial 24 hour drawdown data for pumping of the AmeriCulture 1 State well are use to calculate "best estimate" aquifer properties. Of the five apparent drawdown slopes in the Burgett 'A' data, the second slope is used to calculate reservoir transmissivity and storativity. (Figure 11 and Appendix 10) lists the results of the drawdown calculation. A transmissivity of 62,393 gpd/ft and a storativity of 1.17 E-4 are estimated with the Cooper and Jacob straight line method.

4.4 Long-Term Reservoir Behavior

Theis model drawdowns are used to predict long term behavior of the reservoir over a 20 year period of time with constant pumping of only the AmeriCulture 1 State well with no injection or other producing wells. Two analyses are performed. The first analysis uses the 27,650 gpd/ft estimate in the AmeriCulture 1 State well with an assigned storativity of 1.17 E-4 as derived from the Burgett 'A' data. Drawdown at the Burgett 'A' well with a radial distance of 825 ft is estimated for a maximum two-day period (Appendix 11). The results show that with the lower transmissivity value, the drawdowns in the Burgett 'A' well are more compatible with the drawdowns observed with pumping Burgett 'C', Burgett 'B', and the AmeriCulture well simultaneously rather than only pumping the AmeriCulture well alone. Therefore, the 27,650 gpd/ft estimate is probably to low and underestimates the long-term reservoir behavior.

Therefore, the higher 62,392 gpd/ft transmissivity data obtained with the Burgett 'A' monitor well are probably more representative of reservoir properties. Figure 12 (Appendix 12) provides the Theis model drawdowns for various times and distances from the AmeriCulture State 1 well. The model shows that the cone of depression from the AmeriCulture 1 State well will be drawndown by 42.6 ft at 10 feet radial distance after 20 years and drawndown by 25.7 ft at 1,000 ft radial distance.

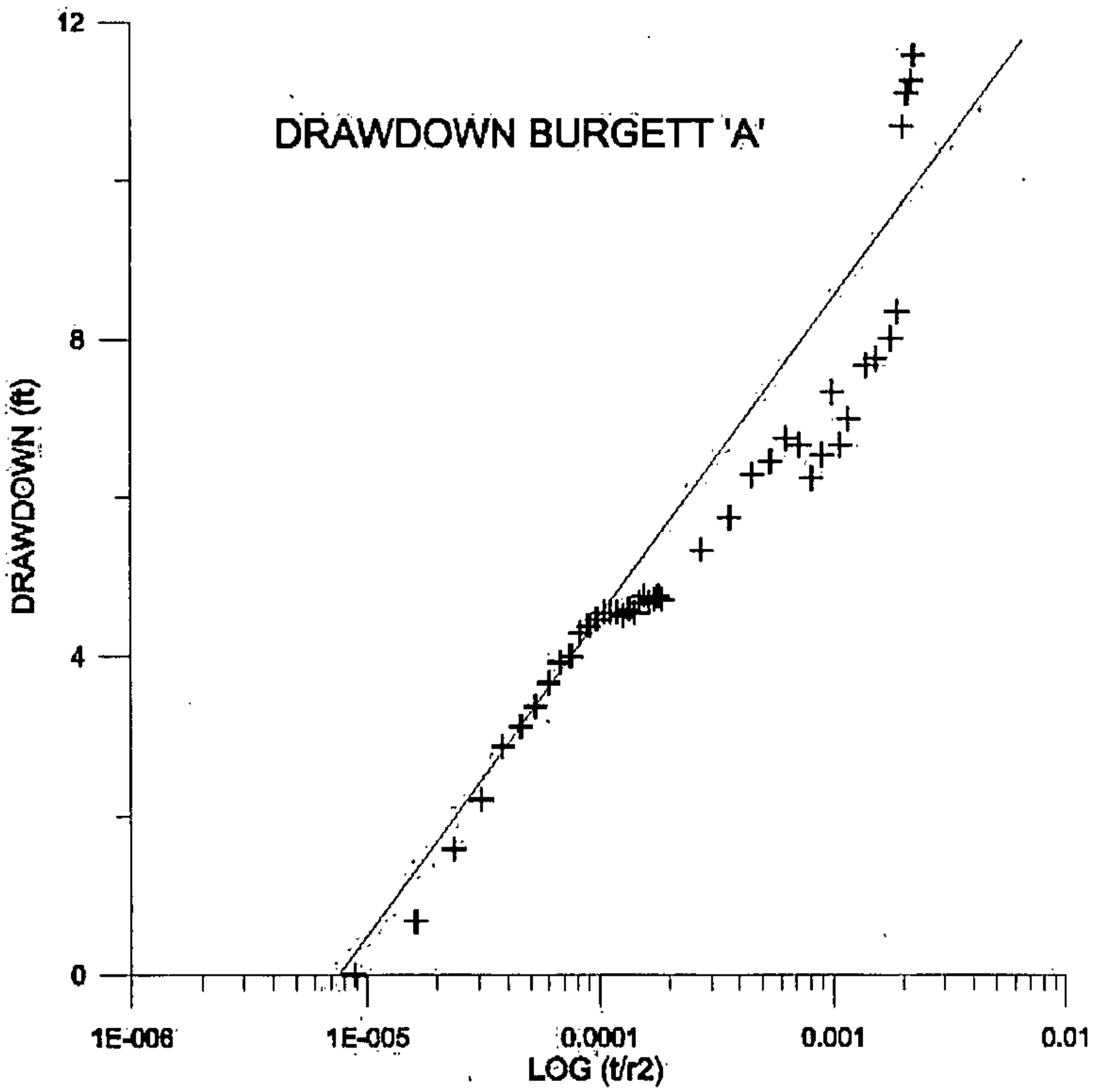

Figure 11. "Best Pick" straight line drawdown for the Burgett 'A' monitor well. Drawdown in feet is plotted against the log ratio of time (minutes) and the distance (825 ft) squared from the pumping AmeriCulture 1 State well.

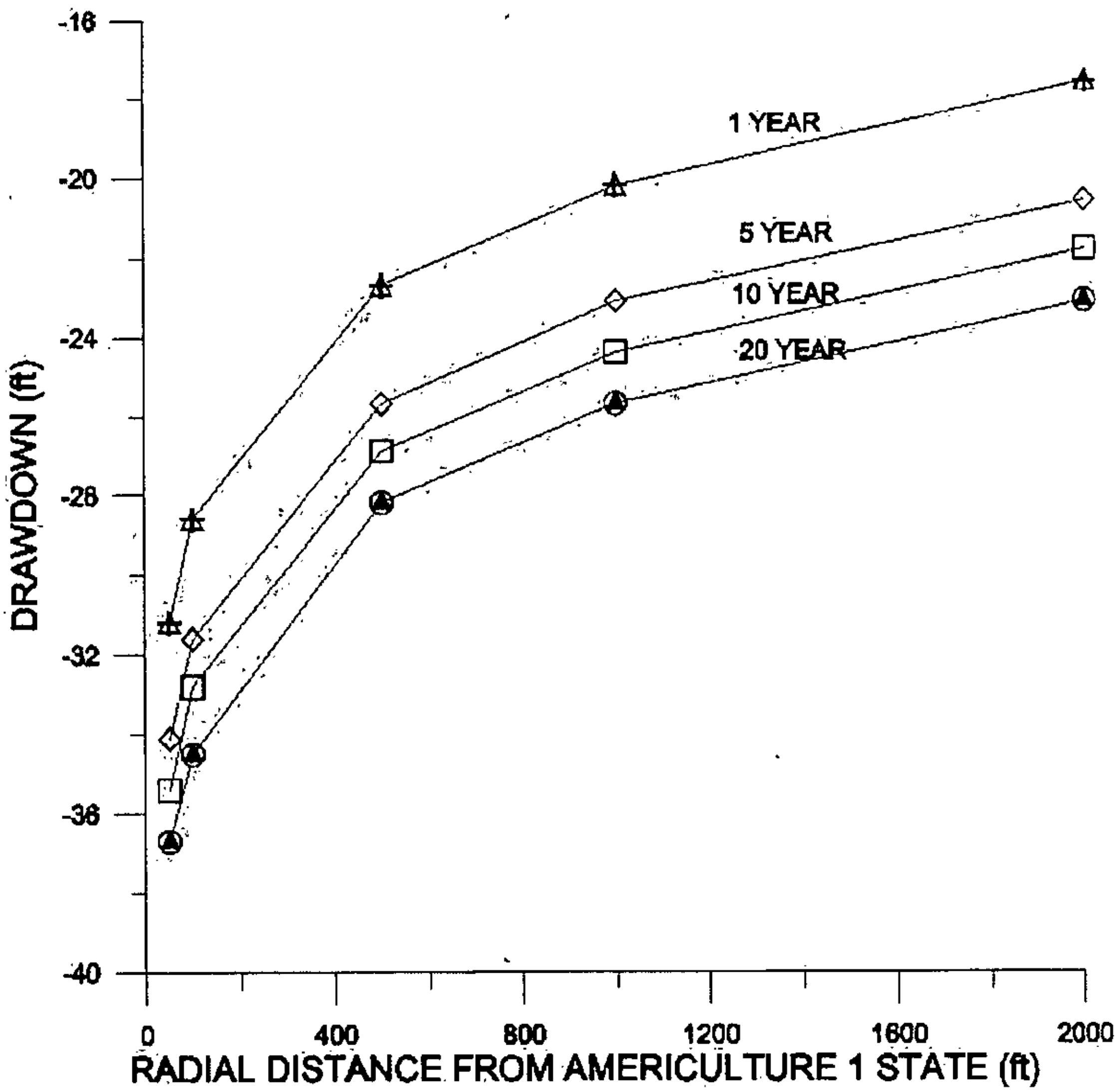

Figure 12. Theis model drawdowns for the Americuture 1 State well at various times and radial distances.

The AmeriCulture 1 State well will have a drawdown of 61 ft at one foot radial distance after 20 years if pumping is done continuously at 1,200 gpm. Minimum head needed to sustain production is calculated as follows:

(8) $H_I = NPSHR - H_a/S_g + H_{vp}/S_g + H_f$

H_I	minimum required head above first impeller (ft)
NPSHR	net positive suction head required (20 ft)
H_a	surface atmospheric pressure head (29.2 ft at 4,000 feet elevation)
H_{vp}	vapor pressure head at pumping temperature (49.8 ft) 111 °C or 232 °F
H_f	friction head loss (estimated 2 ft)
S_g	specific gravity H_2O at 111 °C or 232 °F (0.95)

With a net positive suction head required (NPSHR) of 20 ft, and a temperature of 111 °C, a static water level of 75 ft, and a drawdown of 61 ft at 1,200 gpm production for 20 years, a first stage impeller set at 260 feet inside the suface casing with a depth of 280 ft, a safety factor in drawdown of 80 ft is estimated. Figure 12 model drawdowns indicate that if the Burgett 'B' well were pumped at 1,000 gpm continously for 20 years that an additional 30 ft of drawdown could occur in the AmeriCulture 1 State well. Thirty ft is definitely within the 80 ft margin of drawdown safety.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The Lightning Dock geothermal reservoir(s) is contained in a small intra graben horst block at the intersection of four regional tectonic features: 1) a major WNW striking basement structure zone with repetitive compression and extensional deformation since Precambrian; 2) a mid-Tertiary caldera ring fracture zone; 3) a small intra graben horst block in the Animas graben complex; and 4) a young incipient normal fault ends in the area of the thermal anomaly. This Pleistocene fault tip may enhance or open previous fracture permeability.

A mid-Tertiary rhyolite dike or dome may host the shallow upflow zone. The shallow outflow plume is contained in fractured rhyolite. A potential deep outflow plume is hosted in a "problematic unit" that may represent Paleozoic karst at the top of the Paleozoic carbonate section or a Jurassic-Cretaceous rift fanglomerate with solution and fracture permeability..

Shallow outflow is to the north. Heat flow and temperature gradient data indicate a total heat loss for the system at about 8 MWt. A base reservoir or upflow zone temperature of 160 °C is determined from silica geothermometry and the temperature profile of the Steam Reserve Animas 55-7 well. A total natural mass flux of about 210 gpm of 160 °C water into the base of the upflow zone is estimated by energy and mass balance of the Lightning Dock heat flow anomaly.

A "best estimate" transmissivity of the shallow reservoir is 62,393 gpd/ft with a storativity of 1.15 E-4, using a Cooper and Jacob straight line method. A small, but un-quantified, drawdown occurred in the Steam Reserve Animas 55-7 well. Maximum 24-hour drawdown in the pumped AmeriCulture 1 State well was 30 ft and in the Burgett 'A' monitor well was 11.6 ft. Maximum drawdown in Burgett 'A' monitor well with AmeriCulture 1 State pumping at 1,000 gpm and Burgett 'C' pumping 650 gpm and Burgett 'B' pumping at 1,200 gpm was 23.4 ft during the second 24 hour pumping time frame. Differences in drawdown curves *in Burgett 'A' and AmeriCulture 1 State may indicate that the AmeriCulture 1* State well has low well efficiency from "formation damage" during drilling, incomplete penetration of the reservoir, or improper match of pump test equipment with existing well construction. Formation damage will likely heal with time as the well is pumped. However, most of the drawdown difference between the wells is attributed to poor characterization of drawdown in AmeriCulture 1 State by the "bubble line" water level measurements.

The Theis model long-term drawdown indicates that the AmeriCulture 1 State well will drawdown about 60 ft after 20 years of pumping continuously at 1,200 gpm and over 26 ft at 1,000 ft radial distance with a constant pumping rate of 1,000 gpm for 20 years. No other production wells or injection wells were accounted for in the Theis model. A peak flow of 1,200 gpm, during the summer, is easily accomplished by the AmeriCulture well and reservoir productivity. However, parasitic power requirements may increase due to an assumed less than optimal well efficiency. A sufficient margin of excess head appears to exist above the minimum head to insure and account for any additional long-term drawdown contributed by other wells in the area.

Temperatures during the test remained at 111 °C or slightly higher for the last 40 hours of the test. It is not possible to reliably predict temperature changes many years into the future. However, with proper injection well location, thermal breakthrough will be mitigated. Also, monitoring of reservoir temperature and chemistry over time will facilitate recognition of any trends in decreasing or increasing temperature.

The following recommendations are appropriate with results of this study: 1) it may be advisable to hang a production liner at the base of the surface casing; 2) if a new or backup well is drilled in the future, larger diameter and greater depth is advisable to increase overall well efficiency; 3) a program of detailed water level measurements and water chemistry should be instituted. Existing and new production or monitor wells in the area should be surveyed to 0.01 to 0.1 ft accuracy and precision for surface or well head reference elevation. This will facilitate detailed spatial and temporal monitoring of reservoir behavior over a broad area. Regular chemical analysis of selected production wells should include major cations and anions and silica, lithium, boron, fluoride, pH, temperature, and stable oxygen isotopes ($^{18}O/^{16}O$) ratios. All of these data are essential to understand reservoir behavior and identify any long-term trends in the reservoir.

An injection well located in the area of the AmeriCulture Federal monitor well would best insure that no thermal breakthrough occurs. A thermal breakthrough is a term used to describe a "reservoir short circuit" where cooled injection fluids travel rapidly back to the production well through a fracture or set of fractures without being reheated by the bulk reservoir formation. Design of the injection well should be similar to the production well except that a larger diameter may be desirable if the injection well has shallower depth. The pump test identified an "impermeable" boundary between the AmeriCulture State 1 production well and the AmeriCulture Federal monitor well. It may be desirable to locate other secondary injection wells south and north of the AmeriCulture well at distances over 1,000 ft. Before secondary injection wells are located and installed, much monitoring of the reservoir behavior is required.

If possible, pump tests should be performed on other wells or any new wells drilled at Lightning Dock. This data would augment a long-term monitoring of the reservoir. High temperature and high precision pressure transducers should be employed in addition to traditional wire line and "bubble line" water level measurements. Water level precision was a significant drawback of this study. Also, longer tests without pumping interference are highly recommended to fully understand reservoir boundary conditions. Ideally, a 3,000 to 4,000 ft continuous wireline core hole should be drilled over the upflow zone of known maximum heat flow and temperature gradients. Without such a hole the true nature of the system may not be characterized. Surface geophysics and shallow drill hole data alone are inadequate to delineate the deep subsurface with confidence.

Existing and new boreholes should be geophysically logged. At a minimum, temperature, gamma and neutron wireline logs should be done. With any new drilling, drill cuttings at 5 or 10 ft interval should be saved and archived. These data will prove invaluable for a reservoir monitoring program or to solve a reservoir problem should one arise.

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APPENDIX 1
HIGH TEMPERATURE ORIFICE FLOW METER FORMULA
from Wendall T. Howard, The Resource Group

Hot Water Orifice Meter

Program:#2

Model: $Wn = Cn\,(hw)^{1/2}$

Input Parameters:

$D := 1.5$	Pipe diameter, in	
$d := 0.42$	Orifice diameter, in	
$P_1 := 1000$	Pressure, psia	
$\Delta P := 500$	Meter pressure differential in psi	
$\gamma_L := 57.263$	Specific weight of water, lb/ft³	
$Fm := 1$	Manometer factor for Hg=0.962, BF=0.992, psi=1	
$hw := \dfrac{\Delta P}{0.0362}$	Meter pressure differential in inches	one inch of water = 0.03606 psi
$Ks := 8.34$	Unit conversion factor, 8.34 for Wn in lbs/hr	

Defined input parameters:

$\beta := \dfrac{d}{D}$	$\beta = 0.28$	
$S := 0.598\,\beta^2 + 0.01\cdot\beta^3 + 0.00001947\,\beta^2\,(10\beta)^{4.425}$	$S = 0.047$	Flow rate factor
$T := F + 459.67$	$T = 539.67$	Degrees Rankine, °R
$Fa := (T - 100)\,(0.000014375) + 1.0009$	$Fa = 1.007$	Thermal expansion factor
$Gf := \dfrac{\gamma_L}{62.4}$	$Gf = 0.918$	Water specific gravity at flowing temp.
$Cw := 340\cdot S\cdot D^2$		
$Cn := Ks\,Cw\cdot Fa\cdot Fm\cdot\sqrt{Gf}$	$Cn = 290.903$	Meter factor

Find hot water rate:

$$Wn := \left(Cn\cdot\sqrt{hw}\right)\cdot\frac{lb}{hr} \qquad Wn = 34189.1\ lb\cdot hr^{-1}$$

APPENDIX 2
ORIFICE PLATE DISCHARGE DATA AMERICULTURE WELL

Date	Time	Minutes	OUT psi	IN psi	delta psi	Temp C	Drive rpm	Notes
10/7/00	11:34	10	7.5	9.5	2			V weir 11inches
	12:14	40	7.5	10.1	2.6			
	12:59	71	7.5	10.2	2.7	108.9	1800	V weir 11inches
	1:13	145	7.8	10.5	2.7	110		
	3:35	300	8	11	3		1800	
	3:53	318					2000	
	4:35	360	7.8	10.5	2.7			
	5:35	420	7	10	3	108	1800	
	15:35	960	8	11	3			
	19:30	1195	7.2	10	2.8			
10/8/00	13:00	1465	7.5	10.2	2.7			
	15:18	1603	7.5	10	2.5		1800	
	16:18	1663	7.5	10	2.5			
	18:00	1765	7.6	10.1	2.5			
	19:00	1825	7.5	10.1	2.6			
	20:00	1885	7.6	10.1	2.5			
	21:00	1945	7.5	10.1	2.6		1800	
10/9/00	7:18	2192	7.8	10.3	2.5			
	10:52	2347	7.5	10.2	2.7			
	11:45	2399	7.2	10	2.8			

APPENDIX 3
DRAWDOWN DATA FOR BURGETT 'A' WELL

Date	Time	Minutes	Drawdown (ft)	Notes
10/7/00	11:30	6	0.0	AmeriCulture well on 11:24
	11:35	11	0.7	(1000 gpm)
	11:40	16	1.6	
	11:45	21	2.2	
	11:50	26	2.9	
	11:55	31	3.1	
	12:00	36	3.4	
	12:05	41	3.7	
	12:10	46	3.9	
	12:15	51	4.0	
	12:20	56	4.3	
	12:25	61	4.4	
	12:30	66	4.5	
	12:35	71	4.5	
	12:40	76	4.5	
	12:45	81	4.5	
	12:50	86	4.5	
	12:55	91	4.6	
	13:00	96	4.5	
	13:05	101	4.7	
	13:10	106	4.8	
	13:15	111	4.7	
	13:20	116	4.7	
	13:25	121	4.8	
	13:30	126	4.7	
	14:30	186	5.3	
	15:30	246	5.8	
	16:30	306	6.3	
	17:30	366	6.5	
	18:30	426	6.8	
	19:30	486	6.7	
	20:00	546	6.3	
	21:02	608	6.5	
	22:04	670	7.3	
	23:01	727	6.7	
10/8/00	0:00	786	7.0	
	2:30	936	7.7	
	4:00	1026	7.8	
	6:40	1186	8.0	
	8:00	1266	8.3	
	9:00	1326	10.7	
	10:00	1386	11.1	
	11:00	1446	11.3	

Date	Time	Minutes	Drawdown (ft)	Notes
	11:30	1476	11.6	AmeriCulture well off at 11:33
	11:35	1481	10.7	change oil in prime drive
	11:40	1486	8.8	
	11:45	1491	7.9	AmeriCulture well on 11:48
	11:50	1496	9.1	(1000 gpm)
	11:55	1501	10.2	
	12:00	1506	10.0	
	12:05	1511	9.8	
	12:10	1516	9.8	
	12:15	1521	9.7	
	12:20	1526	9.6	
	12:25	1531	9.8	
	12:30	1536	9.7	
	13:00	1566	9.7	
	14:00	1626	9.7	
	15:00	1686	9.6	
	16:00	1746	9.6	
	16:40	1786	11.4	Burgett 'C' on 16:30 (650 gpm)
	16:45	1791	11.7	
	16:50	1796	11.8	
	16:55	1801	11.9	
	17:00	1806	11.8	
	17:05	1811	12.0	
	17:10	1816	12.0	
	17:15	1821	12.0	
	17:20	1826	12.2	
	17:25	1831	12.2	
	17:30	1836	12.2	
	17:35	1841	12.3	
	17:40	1846	12.3	
	18:00	1866	12.3	
	19:00	1926	12.4	
	20:00	1986	12.8	
	21:00	2046	13.3	
	22:00	2106	13.3	
	23:00	2166	13.0	
10/9/00	0:00	2226	13.3	
	1:00	2286	13.3	
	2:00	2346	13.3	
	3:05	2411	13.3	
	4:00	2466	13.4	
	5:02	2533	13.3	
	6:00	2591	13.3	
	7:00	2651	13.4	
	8:01	2712	13.5	
	9:07	2778	13.5	
	9:24	2795	18.0	Burgett 'B' on 9:19 (1200 gpm)

Date	Time	Minutes	Drawdown (ft)	Notes
	9:40	2811	20.9	
	9:51	2822	23.8	
	10:00	2831	22.8	
	10:10	2841	23.3	
	10:20	2851	23.4	Burgett 'C' off 10:20
	10:30	2861	21.9	
	10:40	2871	21.8	
	10:50	2881	22.2	
	11:00	2891	21.5	
	11:10	2901	22.0	
	11:20	2911	22.0	
	11:30	2921	22.2	
	11:40	2931	22.1	AmeriCulture well off at 11:33
	11:50	2941	22.1	
	11:52	2943	22.0	Burgett 'B' off at 11:52
	11:54	2945	17.9	
	11:56	2947	16.2	
	11:58	2949	14.8	
	12:00	2951	13.4	
	12:02	2953	12.8	
	12:04	2955	11.8	
	12:06	2957	11.6	
	12:08	2959	11.2	
	12:10	2961	10.3	
	12:12	2963	10.0	
	12:14	2965	9.5	
	12:16	2967	9.4	
	12:18	2969	9.3	
	12:20	2971	8.7	
	12:22	2973	8.9	
	12:24	2975	8.9	
	12:26	2977	8.9	
	12:28	2979	9.0	
	12:30	2981	8.8	
	12:32	2983	8.7	
	12:34	2985	8.3	
	12:36	2987	8.3	
	12:38	2989	8.3	
	12:40	2991	8.3	
	12:42	2993	8.4	
	12:44	2995	8.3	
	12:46	2997	8.3	
	12:48	2999	8.3	
	12:50	3001	8.3	
	12:52	3003	8.2	
	12:54	3005	8.3	AmeriCulture well on briefly for
	12:56	3007	9.3	water sample collection

Date	Time	Minutes	Drawdown (ft)	Notes
	12:58	3009	10.0	
	13:00	3011	8.7	
	13:02	3013	8.3	
	14:00	3071	8.0	
	15:00	3131	8.0	
	15:45	3176	7.3	
	16:15	3206	6.8	
	18:00	3311	7.3	
	19:00	3371	6.9	
	21:00	3491	8.4	
10/10/00	8:00	4151	9.3	Burgett 'C' on 8:00
	12:00	4391	7.7	Burgett 'C' off 12:00
	21:00	5051	7.3	

APPENDIX 4
DRAWDOWN DATA FOR BURGETT 'A' WELL
BURGETT 'C' AND AMERICULTURE 1 STATE WELL PUMPING

Date	Time	Minutes	Delta Time	Delta Minutes	Drawdown (ft)	Notes
10/8/2000	16:30	1776	0	0	9.6	
	16:40	1786	10	10	11.4	Burgett C on 16:30 (650 gpm)
	16:45	1791	5	15	11.7	
	16:50	1796	5	20	11.8	
	16:55	1801	5	25	11.9	
	17:00	1806	5	30	11.8	
	17:05	1811	5	35	12.0	
	17:10	1816	5	40	12.0	
	17:15	1821	5	45	12.0	
	17:20	1826	5	50	12.2	
	17:25	1831	5	55	12.2	
	17:30	1836	5	60	12.2	
	17:35	1841	5	65	12.3	
	17:40	1846	5	70	12.3	
	18:00	1866	20	90	12.3	
	19:00	1926	60	150	12.4	
	20:00	1986	60	210	12.8	
	21:00	2046	60	270	13.3	
	22:00	2106	60	330	13.3	
	23:00	2166	60	390	13.0	
10/9/2000	0:00	2226	60	450	13.3	
	1:00	2286	60	510	13.3	
	2:00	2346	60	570	13.3	
	3:05	2411	65	635	13.3	
	4:00	2466	55	690	13.4	
	5:02	2533	67	757	13.3	
	6:00	2591	58	815	13.3	
	7:00	2651	60	875	13.4	
	8:01	2712	61	936	13.5	
	9:07	2778	66	1002	13.5	

APPENDIX 5
DRAWDOWN DATA FOR BURGETT 'A' WELL
BURGETT 'C', BURGETT 'B', AND AMERICULTURE 1 STATE WELL PUMPING

Date	Time	Minutes	Delta Time	Delta Minutes	Drawdown (ft)	Notes
10/9/2000	9:19	2790	0	0.1	13.50	
	9:24	2795	5	5	18.00	Burgett 'B' on 9:19 (1200 gpm)
	9:40	2811	16	21	20.92	
	9:51	2822	11	32	23.83	
	10:00	2831	9	41	22.75	
	10:10	2841	10	51	23.33	
	10:20	2851	10	61	23.42	Burgett 'C' off 10:18
	10:30	2861	10	71	21.92	
	10:40	2871	10	81	21.75	
	10:50	2881	10	91	22.17	
	11:00	2891	10	101	21.50	
	11:10	2901	10	111	22.00	
	11:20	2911	10	121	22.00	
	11:30	2921	10	131	22.17	
	11:40	2931	10	141	22.08	AmeriCulture well off at 11:33
	11:50	2941	10	151	22.08	Burgett 'B' off at 11:52

APPENDIX 6
DRAWDOWN DATA FOR AMERICULTURE 1 STATE WELL

Date	Time	Minutes	Line (psi)	Casing (psi)	head (ft)	Drawdown (ft)	Notes
10/7/00	11:24	0	75		173.00	0.00	AmeriCulture well on at 11:24
	11:25	1	67		154.56	18.44	
	11:25	1.5	68		156.86	16.14	
	11:26	2	68.5		158.02	14.98	
	11:26	2.5	68.5	0	158.02	14.98	
	11:27	3	69		159.17	13.83	
	11:27	3.5	70		161.48	11.52	
	11:28	4	70		161.48	11.52	
	11:28	4.5	70		161.48	11.52	
	11:29	5	70		161.48	11.52	
	11:29	5.5	70		161.48	11.52	
	11:30	6	70		161.48	11.52	pumping steady at 1000 gpm
	11:30	6.5	70.5	3	162.63	10.37	
	11:31	7	70.5		162.63	10.37	
	11:31	7.5	70.5		162.63	10.37	
	11:32	8	70	3	161.48	11.52	
	11:32	8.5	70.5		162.63	10.37	
	11:33	9	70.5		162.63	10.37	
	11:33	9.5	70	4	161.48	11.52	
	11:34	10	70		161.48	11.52	
	11:35	11	70	4	161.48	11.52	
	11:36	12	70		161.48	11.52	
	11:37	13	69.5	4	160.32	12.68	
	11:38	14	69		159.17	13.83	
	11:39	15	69		159.17	13.83	
	11:40	16	69		159.17	13.83	
	11:41	17	69		159.17	13.83	
	11:42	18	69	4	159.17	13.83	
	11:43	19	69		159.17	13.83	
	11:44	20	69		159.17	13.83	
	11:49	25	69		159.17	13.83	
	11:55	30	68.5		158.02	14.98	
	12:00	35	68		156.86	16.14	
	12:05	40	67.5		155.71	17.29	
	12:10	45	67		154.56	18.44	
	12:15	50	67		154.56	18.44	
	12:20	55	67		154.56	18.44	
	12:25	60	67		154.56	18.44	
	12:40	75	67		154.56	18.44	
	12:55	90	67	4	154.56	18.44	
	13:10	105	67		154.56	18.44	
	13:25	120	67		154.56	18.44	
	13:40	150	67		154.56	18.44	

Date	Time	Minutes	Line (psi)	Casing (psi)	head (ft)	Drawdown (ft)	Notes
	14:20	190	67		154.56	18.44	
	14:27	197	67	5	154.56	18.44	recharge bubble line
	15:25	240	67		154.56	18.44	114.4 C
	16:25	300	66		152.25	20.75	
	17:25	360	66	5	152.25	20.75	110.9 C
	18:25	420	65		149.94	23.06	
	19:25	480	64		147.64	25.36	
	20:25	540	65		149.94	23.06	
	21:25	600	65		149.94	23.06	110.9C
	22:25	660	62.5	5	144.18	28.83	recharge bubble line
	23:25	720	62.5		144.18	28.83	110.8 C
10/8/00	0:25	780	62.5		144.18	28.83	111.1 C
	1:25	840	62		143.02	29.98	
	1:25	840	66		152.25	20.75	recharge bubble line
	2:25	900	65.5		151.10	21.90	111.1C
	3:25	960	65.5		151.10	21.90	111.2 C /1800 rpm
	5:25	1080	65.5		151.10	21.90	111.0 C.
	6:25	1140	66		152.25	20.75	recharge bubble line (stays at 66 psi)
	8:25	1260	64		147.64	25.36	
	8:25	1260	63		145.33	27.67	110.9 C
	10:25	1380	62		143.02	29.98	111.3 C
	11:33	1448	64		147.64	25.36	AmeriCulture well off (change oil)
	11:48	1463	72		166.09	6.91	AmeriCulture well on (13.5 psi diff)
	11:48	1463.5	68	5	156.86	16.14	
	11:49	1464.5	67.5		155.71	17.29	
	11:49	1466	67.5		155.71	17.29	
	11:50	1468	67		154.56	18.44	
	11:50	1470.5	67		154.56	18.44	
	11:51	1473.5	67		154.56	18.44	
	11:53	1478.5	67		154.56	18.44	
	11:54	1484.5	67		154.56	18.44	
	11:56	1492.5	66.5		153.40	19.60	
	11:57	1501.5	66.5		153.40	19.60	
	11:58	1511.5	66.5		153.40	19.60	
	12:12	1526.5	66.3		152.94	20.06	
	12:17	1546.5	66.5		153.40	19.60	
	12:22	1571.5	66.5	6	153.40	19.60	
	12:27	1601.5	66.5		153.40	19.60	
	12:48	1622.5	66.5	3.5	153.40	19.60	111.2 C
	13:18	1682.5	66.5		153.40	19.60	
	14:18	1742.5	66.5		153.40	19.60	111.0 C
	15:18	1802.5	66.5		153.40	19.60	110.9 C
	16:18	1862.5	66.5	3.5	153.40	19.60	111.1 C
	17:18	1922.5	66.5		153.40	19.60	110.9 C, Burgett 'C' on 16:30 (650 gpm)
	18:18	1982.5	65		149.94	23.06	110.9 C

Date	Time	Minutes	Line (psi)	Casing (psi)	head (ft)	Drawdown (ft)	Notes
	19:18	2042.5	65		149.94	23.06	110.9 C
	20:18	2102.5	65		149.94	23.06	110.9 C
	21:18	2162.5	65		149.94	23.06	111.2 C
	22:18	2222.5	65		149.94	23.06	111.3 C
	23:18	2282.5	64.5		148.79	24.21	111.6 C
10/9/00	0:18	2342.5	65		149.94	23.06	111.3 C
	1:18	2402.5	65	5	149.94	23.06	111.3 C
	2:18	2462.5	65		149.94	23.06	111.3 C
	3:18	2522.5	65		149.94	23.06	111.3 C
	4:18	2582.5	65		149.94	23.06	111.3 C
	5:18	2642.5	64		147.64	25.36	111.5 C
	6:18	2702.5	64		147.64	25.36	111.5 C
	7:18	2762.5	64.5		148.79	24.21	111.2 C
	8:18	2822.5	64.5		148.79	24.21	111.3 C
	9:18	2882.5	64.5		148.79	24.21	Burgett 'B' on 9:19 (1200 gpm)
	10:00	2924.5	61		140.71	32.29	111.2 C
	10:08	2932.5	61		140.71	32.29	
	10:22	2946.5	61		140.71	32.29	Burgett 'C' off 10:20
	11:09	2960.5	61		140.71	32.29	110.9 C, AmeriCulture well off 11:33
	11:46	1.5	63		145.33	27.67	RECOVERY
	11:58	13	71		163.78	9.22	Burgett 'B' off at 11:52, RECOVERY
	12:03	18	69		159.17	13.83	RECOVERY
	12:04	19	71		163.78	9.22	RECOVERY
	12:06	21	71		163.78	9.22	RECOVERY
	12:10	25	71.5		164.94	8.06	RECOVERY
	12:33	48	67.5		155.71	17.29	RECOVERY

APPENDIX 7
DRAWDOWN DATA FOR AMERICULTURE FEDERAL WELL

Date	Time	Minutes	Drawdown (ft)	Notes
10/7/00	11:30	6	0.0	AmeriCulture well on 11:24
	12:00	36	0.0	(1000 gpm)
	12:30	66	0.0	
	13:30	126	0.0	
	14:30	186	0.0	
	15:30	246	0.0	
	16:30	306	0.0	
	18:08	404	0.0	
	19:06	462	0.0	
	22:08	644	0.1	
	23:03	699	0.2	
10/8/00	0:02	758	0.2	
	2:37	913	0.3	
	4:05	1001	0.5	
	6:45	1161	1.0	
	8:05	1241	0.9	
	9:00	1296	0.8	
	10:00	1356	0.8	
	11:00	1416	0.8	AmeriCulture well off at 11:33
	12:00	1476	0.8	change oil in prime drive
	13:00	1536	0.8	Americuture well on a 11:48
	14:00	1596	0.9	(1000 gpm)
	15:00	1656	0.8	
	16:00	1716	0.7	
	17:00	1776	0.8	Burgett 'C' on 16:30 (650 gpm)
	18:00	1836	0.8	
	19:00	1896	0.8	
	20:00	1956	0.8	
	21:00	2016	0.8	
	22:08	2084	1.0	
	23:04	2140	1.1	
10/9/00	0:05	2201	1.1	
	1:04	2260	1.1	
	2:04	2320	1.1	
	3:05	2381	1.0	
	4:10	2446	1.1	
	5:07	2503	1.1	
	6:03	2559	1.1	
	7:04	2620	1.1	
	8:05	2681	1.1	
	10:14	2810	1.2	Burgett 'B' on 9:19 (1200 gpm)
	10:47	2843	1.7	Burgett 'C' off 10:20
	11:30	2886	1.7	AmeriCulture well of at 11:33

Date	Time	Minutes	Drawdown (ft)	Notes
	13:00	2976	0.8	Burgett 'B' off at 11:52
	14:00	3036	0.8	
	15:00	3096	0.8	
	16:00	3156	0.8	
	17:00	3216	0.8	
	18:00	3276	0.8	
	21:00	3456	0.8	
10/10/00	8:00	4116	0.8	

APPENDIX 8
DRAWDOWN DATA FOR STEAM RESERVE 55-7 WELL

date	time	Water level (ft)	Drawdown (ft)	Notes
10/9/00	8:30	54.08	0.00	Begin drawdown measurment
	9:55	54.79	0.71	(water level 54.08 ft)
	11:20	55.00	0.21	Burgett 'C' off at 10:20
	11:45	54.67	-0.33	AmeriCulture well off at 11:30
	11:48	54.58	-0.08	
	11:50	54.58	0.00	
	11:55	54.58	0.00	Burgett 'B' off at 11:52
	12:00	54.58	0.00	
	12:05	54.55	-0.03	
	12:15	54.54	-0.01	
	12:20	54.53	-0.01	
	12:30	54.51	-0.02	
	12:40	54.49	-0.02	
	12:50	54.48	-0.01	
	13:30	54.38	-0.10	

APPENDIX 9
COOPER AND JACOB METHOD TRANSMISSIVITY AND STORATIVITY CALCULATIONS FOR THE AMERICULTURE 1 STATE WELL

WELL AMERICULTURE 1 STATE WELL
ANALYSIS All drawndown data

DATA			
h	30 ft	pump rate	1000 gpm
h(o)	13.8 ft	radial distance	0 ft
t	240.0 min		
t(o)	25.0 min		
log cycle	E2		
LOG CYCLE CALCULATIONS			
interval drawdown	16.492 ft		
lower log cycle intercept	20.745 ft		
upper log cycle intercept	30.292		
log cycle drawdown	9.548		
drawdown 'O' intercept	0.25783 min		
corr drawdown 'O' intercept	2.58E+00 min	manually change to proper log cycle	

COOPER AND JACOB METHOD CALCULATIONS

Transmissivity	27,650 gpd/ft

APPENDIX 10
COOPER AND JACOB METHOD TRANSMISSIVITY AND STORATIVITY CALCULATIONS FOR THE BURGETT 'A' WELL

WELL BURGETT 'A'
ANALYSIS EARLY drawdown data

DATA

h	4.29 ft	pump rate	1000 gpm
h(o)	2.88 ft	radial distance	825 ft
t/r2	8.228 min/ft2		
t/r2(o)	3.820 min/ft2		
log cycle	E-5		

LOG CYCLE CALCULATIONS

log cycle drawdown	4.2313 ft	
log cycle intercept	0.417 ft	
drawdown 'O' intercept	0.9014215 min/ft2	
corr drawdown 'O' intercept	9.01E-06 min/ft2	manually change to proper log cycle

COOPER AND JACOB METHOD CALCULATIONS

Transmissivity	62,392 gpd/ft
Storativity	1.17E-04

APPENDIX 11
THEIS METHOD RESERVOIR DRAWDOWN PREDICTION THROUGH TIME WITH PUMPING OF THE AMERICULTURE 1 STATE WELL
27,650 gpd/ft TRANSMISSIVITY

SHORT TERM DRAWDOWN PREDICTION AT BURGETT 'A' WELL WITH THEIS MODEL

Storativity	1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity	27,650 gpd/ft
radial distance	825 ft
pump rate	1000 gpm

0.5 day		1 day		1.5 day		2 day	
u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table
1.0771E-02	3.9719	5.3857E-03	4.6532	3.5905E-03	5.056	2.6928E-03	5.3438

drawdown	time (days)
16.5	0.5
19.3	1
21.0	1.5
22.1	2

APPENDIX 12
THEIS METHOD RESERVOIR DRAWDOWN PREDICTION THROUGH TIME WITH PUMPING OF THE AMERICULTURE 1 STATE WELL
62,392 gpd/ft TRANSMISSIVITY

SHORT TERM DRAWDOWN PREDICTION AT BURGETT 'A' WELL WITH THEIS MODEL

Storativity	1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity	62,392 gpd/ft
radial distance	825 ft
pump rate	1000 gpm

0.5 day		1 day		1.5 day		2 day	
u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table
4.7735E-03	4.7722	2.3867E-03	5.463	1.5912E-03	5.8679	1.1934E-03	6.1555

drawdown	time (days)
8.8	0.5
10.0	1
10.8	1.5
11.3	2

LONGTERM DRAWDOWN 50 FEET RADIAL DISTANCE FROM AMERICULTURE WELL

Storativity	1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity	62,392 gpd/ft
radial distance	50 ft
pump rate	1000 gpm

1 yr = 365 days		5 yr = 1825 days		10 yr = 3650 days		15 yr = 5475 days		20 yr = 7300 days	
u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table
2.4018E-08	16.9672	4.8037E-09	18.5766	2.4018E-09	19.2698	1.6012E-09	19.6754	1.2009E-09	19.9629

drawdown	time (days)
31.2	365
34.1	1825
35.4	3650
36.1	5475
36.7	7300

LONGTERM DRAWDOWN 100 FEET RADIAL DISTANCE FROM AMERICULTURE WELL

Storativity 1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity 62,392 gpd/ft
radial distance 100 ft
pump rate 1000 gpm

1 yr = 365 days		5 yr = 1825 days		10 yr = 3650 days		15 yr = 5475 days		20 yr = 7300 days	
u	W(u)	u	W(u)	u	W(u)	u	W(u)	u	W(u)
calculated	table	calculated	table	calculated	table	calculated	table	calculated	table
9.6074E-08	15.5809	1.9215E-08	17.1903	9.6074E-09	17.8836	6.4049E-09	18.289	4.8037E-09	18.768

drawdown	time (days)
28.6	365
31.6	1825
32.8	3650
33.6	5475
34.5	7300

LONGTERM DRAWDOWN 500 FEET RADIAL DISTANCE FROM AMERICULTURE WELL

Storativity 1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity 62,392 gpd/ft
radial distance 500 ft
pump rate 1000 gpm

1 yr = 365 days		5 yr = 1825 days		10 yr = 3650 days		15 yr = 5475 days		20 yr = 7300 days	
u	W(u)	u	W(u)	u	W(u)	u	W(u)	u	W(u)
calculated	table	calculated	table	calculated	table	calculated	table	calculated	table
2.4018E-06	12.362	4.8037E-07	13.9715	2.4018E-07	14.6646	1.6012E-07	15.0703	1.2009E-07	15.3578

drawdown	time (days)
22.7	365
25.7	1825
26.9	3650
27.7	5475
28.2	7300

LONGTERM DRAWDOWN 1000 FEET RADIAL DISTANCE FROM AMERICULTURE WELL

Storativity	1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity	62,392 gpd/ft
radial distance	1000 ft
pump rate	1000 gpm

1 yr = 365 days		5 yr = 1825 days		10 yr = 3650 days		15 yr = 5475 days		20 yr = 7300 days	
u	W(u)	u	W(u)	u	W(u)	u	W(u)	u	W(u)
calculated	table	calculated	table	calculated	table	calculated	table	calculated	table
9.6074E-06	10.9757	1.9215E-06	12.5851	9.6074E-07	13.2784	6.4049E-07	13.6838	4.8037E-07	13.9714

drawdown	time (days)
20.2	365
23.1	1825
24.4	3650
25.1	5475
25.7	7300

LONGTERM DRAWDOWN 2000 FEET RADIAL DISTANCE FROM AMERICULTURE WELL

Storativity	1.17E-04 (ASSUMED from early drawdown Burgett 'A')
Transmissivity	62,392 gpd/ft
radial distance	2000 ft
pump rate	1000 gpm

1 yr = 365 days		5 yr = 1825 days		10 yr = 3650 days		15 yr = 5475 days		20 yr = 7300 days	
u	W(u)	u	W(u)	u	W(u)	u	W(u)	u	W(u)
calculated	table	calculated	table	calculated	table	calculated	table	calculated	table
3.8430E-05	9.5896	7.6859E-06	11.1989	3.8430E-06	11.8921	2.5620E-06	12.2977	1.9215E-06	12.5851

drawdown	time (days)
17.6	365
20.6	1825
21.8	3650
22.6	5475
23.1	7300

LONGTERM DRAWDOWN 1 FEET RADIAL DISTANCE FROM AmeriCulture WELL WITH A 20 YEAR PRODUCTION OF 1,200 GPM

Storativity	1.17E-04
Transmissivity	62,392 gpd/ft
radial distance	1 ft
pump rate	1200 gpm

1 yr = 365 days		5 yr = 1825 days		10 yr = 3650 days		15 yr = 5475 days		20 yr = 7300 days	
u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table	u calculated	W(u) table
9.6074E-12	24.792	1.9215E-12	26.4119	9.6074E-13	27.0946	6.4049E-13	27.5001	4.8037E-13	27.7878

drawdown	time (days)
54.6	365
58.2	1825
59.7	3650
60.61	5475
61.2	7300