

Summary Report on Teton Ranch Proposed Managed Recharge Plan and Groundwater Modeling

Preliminary for Pre-Hearing Conference

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Objective

The purpose of this report is to outline water supply shortage issues that occur on the Teton Ranch and describe a plan that has been developed to address them. The plan involves diverting water from South Leigh Creek and North Leigh Creek to aquifer recharge ponds during high runoff periods when all other water rights are filled. In return, water would be diverted from the aquifer via a series of wells later in the season when additional water supply is needed. The plan has been developed with the following objectives in mind:

- Augment the irrigation water supply on the Teton Ranch during July and August
- Maintain or improve aquifer water levels
- Prevent injury to groundwater pumpers
- Prevent injury to surface water users

This report also describes the development and findings of a groundwater modeling study performed to assess the effects of the recharge and groundwater withdrawal plan on the aquifer and surface water sources in the vicinity of the project.

Teton Ranch Overview

The Teton Ranch is a working ranch located east of Tetonia, Idaho. Approximately 1000 acres of grass pasture are irrigated within the ranch boundaries. Irrigation is accomplished via center pivots and hand line sprinkler systems, and irrigation water supply is currently provided primarily from surface water sources. Water is diverted from South Leigh Creek east of the Idaho-Wyoming border into a short ditch and thence to an 18-inch gravity pipeline. A broad-crested weir is located in the ditch in order to measure the diversion rate from the creek. The 18-inch pipeline serves several center pivots, with booster pumps located at the pivots to increase the pressure as needed. Water is diverted from a North Leigh Creek split channel at a pump station which delivers pressurized water to the irrigation system. Both the north and south systems are hydraulically interconnected, although South Leigh Creek primarily serves the southern portion of the ranch and North Leigh Creek primarily serves the northern portion.

Water Rights on South Leigh and North Leigh Systems

The total water supply from the two surface sources exhibits seasonal patterns typically observed in high mountain streams. In the spring, runoff due to snowmelt usually far

exceeds all irrigation demands or diversion rates under authorized water rights on the creek. As the streamflow recedes, a time is reached where all irrigation demands cannot be filled and cutbacks are necessary according to priority date.

Water rights on South Leigh and North Leigh are shown according to priority in Table 1 along with the cumulative flow rate authorized under each right. With few exceptions, the water rights have been partially decreed in the Snake River Basin Adjudication.

Table 1. Water rights and cumulative authorized flow rate.

Priority	Flow (cfs)	Cum. Flow (cfs)	Period of use		Source
			From	To	
4/1/1889	2.30	2.30	4/15	10/31	South Leigh
6/1/1893	3.20	5.50	4/15	10/31	South Leigh
6/1/1897	3.60	9.10	4/15	10/31	South Leigh
6/10/1897	0.74	9.84	4/15	10/31	South Leigh
6/15/1897	5.28	15.12	4/15	10/31	South Leigh
6/24/1897	3.20	18.32	4/15	10/31	South Leigh
5/25/1898	3.02	21.34	4/15	10/31	South Leigh
6/1/1898	0.26	21.60	4/15	10/31	South Leigh
6/1/1901	1.20	22.80	4/15	10/31	South Leigh
6/1/1902	0.60	23.40	4/15	10/31	South Leigh
6/1/1903	2.34	24.74	4/15	10/31	South Leigh
1/18/1905	13.17	38.91	4/15	10/31	South Leigh
1/22/1916	16.75	55.66	4/15	10/31	South Leigh
6/10/1889	3.20	3.20	4/15	10/31	North Leigh
6/1/1891	2.00	5.20	4/15	10/31	North Leigh
6/1/1892	4.53	9.73	4/15	10/31	North Leigh
6/1/1897	3.64	13.37	4/15	10/31	North Leigh
4/1/1898	0.30	13.67	4/15	10/31	North Leigh
6/1/1898	1.56	15.23	4/15	10/31	North Leigh
9/1/1898	1.35	16.58	4/15	10/31	North Leigh
6/1/1899	2.56	19.14	4/15	10/31	North Leigh
6/1/1900	0.90	20.04	4/15	10/31	North Leigh
6/1/1904	0.30	20.34	4/15	10/31	North Leigh
1/22/1916	16.26	36.60	4/15	10/31	North Leigh

Surface Water Supply

Prior to the last few years, no stream gauge or other systematic record of streamflow in either creek exists. Temporary streamflow gauges have been installed in South Leigh Creek and side channel; additional data is continuing to be collected. Collected data allow a comparison between the water right authorized diversion rates and actual water supply in the two sources. These gauges have been set and monitored by Ryan Colyer of Biota Research and Consulting, Inc. The gauges are set within sections of the channel that can be easily rated by performing multiple current meter measurements of

the flow at various stream stages. The rating curves developed in this manner are then applied to the observed stages to estimate the total streamflow.

The streamflow measurements occurred at numerous locations on surface streams within and near Teton Ranch for 2008 and 2009. Select streamflow locations are shown in Figure 1. Based on maximum snow water content at the NRCS Snotel site at Island Park, these two years reflect near normal conditions and are not indicative of either extreme drought or extreme wet periods.

Streamflow data collected during the 2008 and 2009 irrigation season can be seen from the hydrographs in Figure 2. Technical problems with the upstream station on South Leigh Creek resulted in unreliable data collected during the 2009 season; notice the absence of South Leigh Creek #1 data plotted for 2009. All SRBA recommended water rights from South Leigh Creek total 55.65 cfs. Peak flows recorded in 2008 and 2009 are more than 4 times the allocated flow in South Leigh Creek. This data does not estimate seepage loss.

Water right priority cuts are made by the ditchrider based on available water supply and demands by water right holders. Priority cuts are made in the same manner utilized on most other creeks in southern Idaho. However, a number of unique factors affect the water right cuts on this system include the following. This information was obtained from the ditchrider and from IDWR files:

- The most senior water right holder (priority date 1889) is located near the downstream end of the system. Prior to the spring runoff, no other diversions are allowed until the 1889 right is filled. When runoff occurs, water easily reaches the Teton River.
- When the water supply declines such that the flow does not physically reach the lower users (the usual benchmark is Highway 33), a futile call is declared and the upper users rights may be reinstated.
- If a call is received from senior water right holders on the Teton River in the Rexburg area, South Leigh and North Leigh users may be curtailed; however if the flow does not reach the Teton River, the call is deemed futile and the rights will not be curtailed. Historically, the call has been deemed futile in most instances and the South Leigh and North Leigh rights have not been curtailed for more than 7 days.

Apart from the above special instances, water rights are cut in the typical manner as the water supply decreases.

Teton Ranch Water Rights and Shortage Problem

Water rights on the Teton Ranch range in priority from June 1, 1891 to January 22, 1916. Most of the rights have late priority dates and are not typically available after July 1 during the peak irrigation demand periods. A tabulation of the Teton Ranch water

rights and the history of priority cuts made based on water calls throughout the Teton River from 1991 through 2008 are shown in Table 2.

Table 2: Summary of Teton Ranch water rights and priority cuts based on water calls of the Teton River from 1991 through 2008 based on watermaster data.

Priority Date	Source	Rate (cfs)	% of Years Cut (Cuts/Yr)	Min. Days Avail	Min. Cut Off Date	Avg. Days Avail	Avg. Cut Off Date
6/1/1891	South Leigh	3.20	67% (1.4)	79	July 3	146	Sept 8
6/1/1896	South Leigh	1.80	94% (1.5)	48	June 2	119	Aug 12
1/1/1905	South Leigh	0.63	100% (1.5)	31	May 16	101	July 25
1/18/1905	South Leigh	2.90	100% (1.5)	31	May 16	101	July 25
1/22/1916	South Leigh	12.40	100% (1.8)	17	May 2	73	June 27
6/1/1897	North Leigh	3.72	94% (1.5)	48	June 2	118	Aug 11
6/1/1898	North Leigh	0.30	94% (1.6)	48	June 2	117	Aug 10
6/1/1899	North Leigh	2.08	94% (1.5)	48	June 2	117	Aug 10
6/1/1900	North Leigh	1.30	94% (1.5)	48	June 2	117	Aug 10
6/1/1901	North Leigh	0.60	100% (1.6)	35	May 20	111	Aug 4
6/1/1904	North Leigh	0.30	100% (1.5)	31	May 16	101	July 25
1/20/1908	North Leigh	0.71	100% (1.7)	20	May 5	84	July 8
1/22/1916	North Leigh	3.08	100% (1.8)	17	May 2	73	June 27

Depending on the available water supply each year, the rights on the Teton Ranch are typically out of priority by July 1 with the exception of the 1891 and 1896 rights. In drier years, even the earliest right will be cut sometime in July, leaving the ranch without water. If a futile call is declared due to the streamflow not flowing past Highway 33, the early rights may be reinstated (typically in late July or August) and could continue to be active until the end of the season.

Aquifer Recharge Plan

The water supply shortage on the Teton Ranch, as described above, occurs during the period when the surface water rights are cut but irrigation demand continues to be high. This typically occurs in July and August. The primary objective of the aquifer recharge plan is to provide additional supply from groundwater to make up the shortfall in surface water supply during these months. However, the plan was also designed to ensure that the aquifer is never depleted and no other water right holder is injured, regardless of priority.

Components of the plan are summarized below:

1. Water would be diverted from South Leigh Creek and North Leigh Creek during the high spring runoff period.

2. The diversion to recharge would be authorized under a new permit with a 2006 priority date. This permit would not supersede any other water right and would be curtailed by the ditchrider at any time if any other water right on the system needed to be filled.
3. The water diverted would be directed to unlined ponds which would recharge the water to the aquifer.
4. The maximum diversion rate to recharge from both streams in combination would be 12 cfs.
5. The maximum recharge volume would be 709 acre-feet.
6. The authorized period of diversion to recharge would be May 1 through June 30.
7. The volume of water recharged would be measured and reported to IDWR.
8. Groundwater would be pumped from a series of wells only if the surface water supply is insufficient, typically July-August.
9. The volume of groundwater pumped would be measured and reported to IDWR.
10. The volume of groundwater pumped could not exceed the amount recharged to the aquifer in the same year. This restriction is based on the ultra-conservative assumption that 100% of the pumped water is consumed by the crop. In reality, 10% to 25% of the pumped water will return to the aquifer.
11. The volume of 709 acre-feet was calculated based on a worst-case year. In reality, less than 709 acre-feet would be pumped even though the full amount would be recharged, leaving the aquifer with a surplus in all years. In wet years, little or no groundwater would be pumped. On average, i.e. in an average water year, the pump-out is estimated to be 363 acre-feet.
12. The groundwater pumping would be authorized under a new permit with a 2006 priority date. This permit would not supersede any other groundwater rights or surface water rights, and the watermaster would be empowered to curtail the pumping if any other water right was being injured.

Groundwater Modeling

A numerical groundwater model of the water table aquifer from the mountains on the east to the Teton River on the west was created (Figure 3). This model was developed according to accepted scientific standards and incorporated all components of the groundwater balance including underflow from the eastern boundary, recharge from irrigation water application and precipitation, and river-aquifer interaction at the Teton River boundary. The GMS 6.5 graphical modeling environment was used, with the underlying code being the MODFLOW code developed by the U.S. Geological Survey. MODFLOW has been used extensively by private firms and government agencies for innumerable groundwater modeling efforts.

Existing data was utilized for the model development, including well drilling records on file with IDWR, precipitation information from NWS weather stations (MesoWest, 2009). Estimates of irrigation recharge based on delineation of irrigated areas were based on evapotranspiration data prepared by Allen & Robison (2007). This data has been formally adopted by IDWR for crop water usage studies. Published reports on groundwater conditions in the Teton Valley and previous groundwater modeling of the regional aquifer were also relied upon.

The model also incorporates aquifer-river interaction for those stream reaches which are not perched. This occurs for South Leigh Creek in the low lying area approximately west of Highway 33, and for the Teton River along the entire western boundary of the model domain.

Significant parameters relating to the steady-state groundwater balance and model development are shown in Table 3.

Table 3: Significant model parameters used to develop the MODFLOW groundwater model for Teton Ranch.

Model Parameter	Value	Units
Underflow from Eastern Mountains	11,221,000	ft ³ /day
Precipitation (MesoWest, 2009)	20.03	in/year
Precipitation Deficiency (P_{def}) (Allen and Robison, 2007)		
Alfalfa	2.04	ft/season
Potatoes	1.19	ft/season
Spring Grain	1.70	ft/season
Winter Grain	1.78	ft/season
Turf (Irrigated)	1.82	ft/season
Evapotranspiration Rate (ET_{act}) (Allen and Robison, 2007)		
Wetlands	2.54	ft/year
Sage Brush	1.53	ft/year
Woodland (Cottonwoods)	2.87	ft/year
Turf (Irrigated)	2.92	ft/year
Bare Soil	1.34	ft/year
Alfalfa	3.37	ft/year
Potatoes	1.68	ft/season
Spring Grain	2.21	ft/season
Winter Grain	3.20	ft/season
Hydraulic Conductivity	80	ft/day
Teton River Conductance	600	ft/day
South Leigh Creek Conductance	20 – 100	ft/day
North/Middle Leigh Creek Conductance	30 – 120	ft/day
No. of Domestic Well Records	373	Wells
No. of Irrigation Well Records	21	Wells
Number of Model Cells	100,965	Cells
Spacing of Model Cells	300x300	ft
Model Layers	1	Layer

The purpose of the report was to evaluate the effect of the proposed managed recharge and groundwater withdrawal project on the timing and magnitude of aquifer response and river response to the project. As such, the model was developed as a transient model with a bi-monthly time step, and seasonal curves for the input parameters were developed.

The model domain is shown in Figure 3. Significant findings of the modeling effort are summarized below. The following findings apply to model runs assuming the worst-case pump-out condition as described above.

1. The mound created by the aquifer recharge represents the storage of recharged water in the aquifer. The water table will be elevated above the natural water table by a maximum of 3.95 feet. This mound is depicted in Figure 4 at the high point of recharge storage in the first year (the recharge mound will continue to increase in magnitude in subsequent years).
2. The recharge mound moves slowly and remains in the vicinity of the Teton Ranch for pump-out by the proposed well field. In other words, the aquifer acts as a suitable storage reservoir for the recharged water.
3. Assuming a maximum pump-out of 709 acre-feet during July and August, the maximum drawdown below the natural water table at a distance of 2300 feet or more from the wells will be 0.01 feet. The projected effect is shown on Figure 5 for various locations around the project.

The following findings pertain to the average scenario, i.e. recharge of 709 acre-feet and groundwater pumping of 363 acre-feet, in order to determine the long-term effect of the plan:

1. Average pumping scenarios result in the estimated groundwater hydrographs and difference between baseline and scenario runs at several points throughout the model domain (Figures 6 through 18). In the direct vicinity of the recharge activity (Point A), the maximum predicted aquifer level increase is 2.43 feet. At every other point the increase is less than 0.5 feet, with minimal increases occurring at points far from the recharge such as Points E and F.
2. Running the model for average operational conditions, the groundwater return to the Teton River from the project will increase and is projected to follow the pattern shown on Figure 19. The time lag from the beginning of recharge to the beginning of groundwater return to the Teton River is significant. Return flow begins appearing about two years after recharge commences.
3. Part of the groundwater return to the Teton River will occur via seepage from the aquifer to the low-lying reaches of South Leigh Creek west of Highway 33. The additional flow from the aquifer to South Leigh Creek west of Highway 33 with the proposed recharge plan in comparison to the existing conditions are shown in Figure 20. The lag time in this case is about 1.25 years.

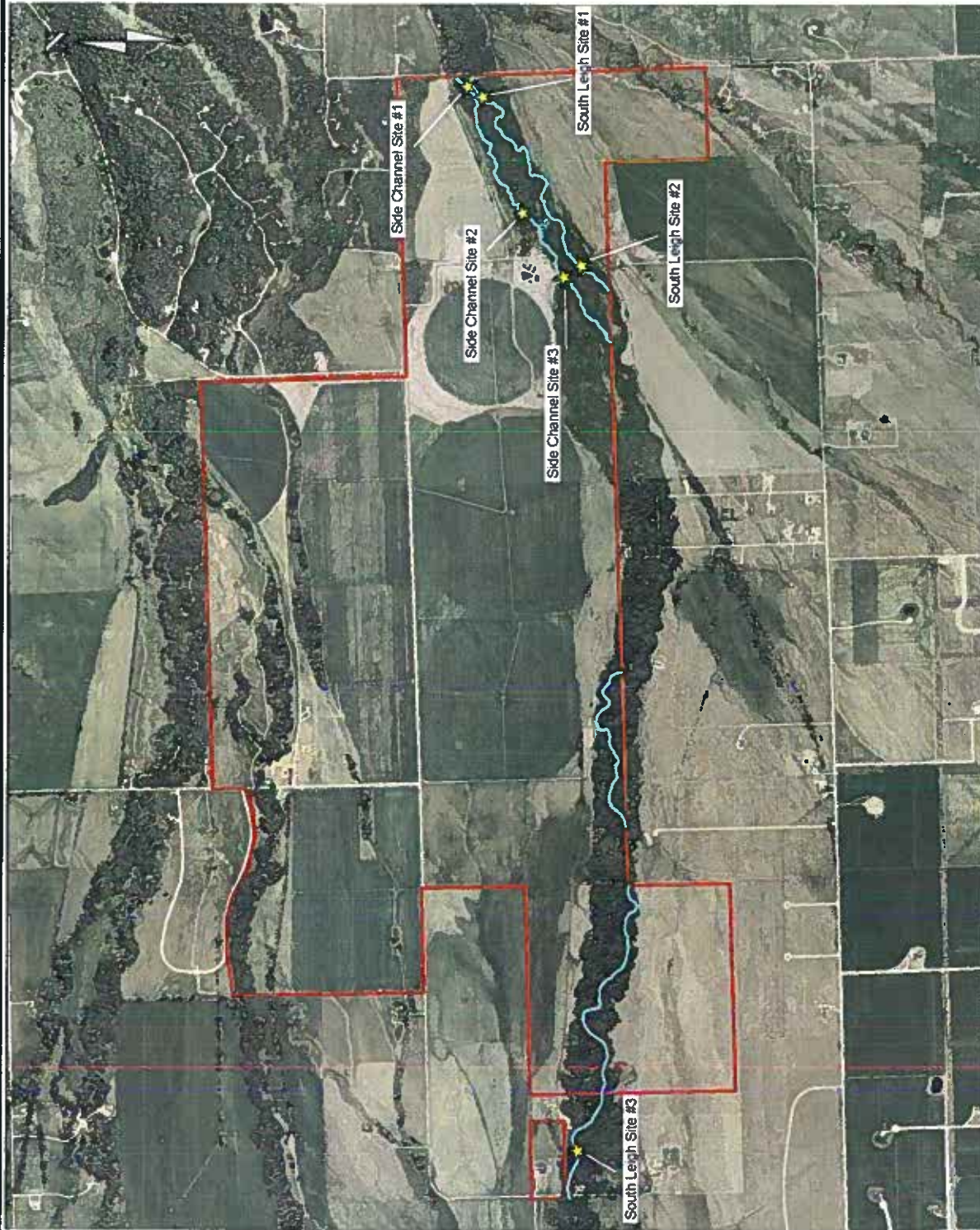


FIGURE 1: TETON RANCH GAGING STATIONS
SOUTH LEIGH AND SIDE CHANNEL STATIONS
 BIOTA RESEARCH AND CONSULTING, INC



**2008 - 2009 Mean Daily Discharge
South Leigh Creek Project Area
Teton Ranch Property, Teton County, Idaho**

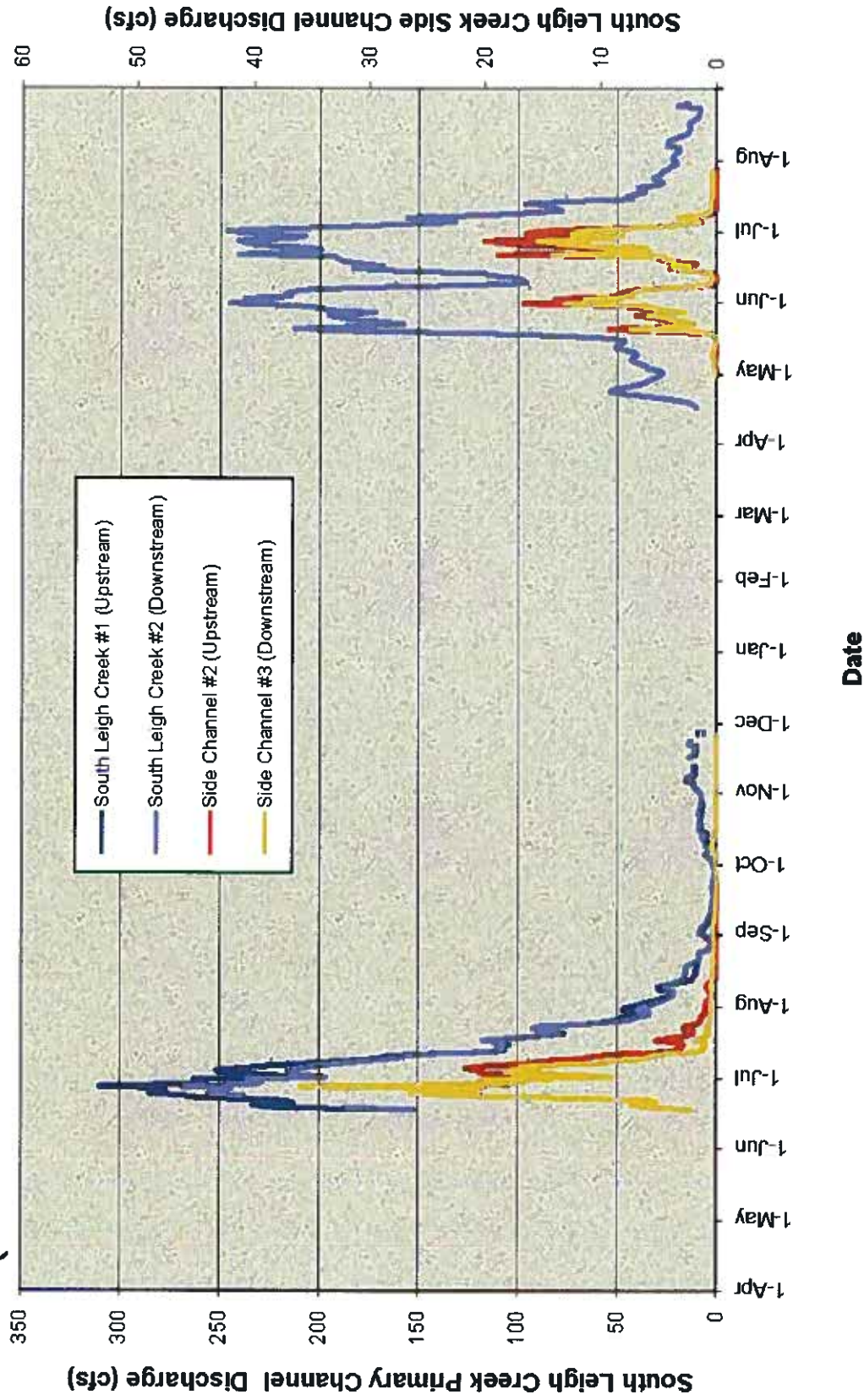


**FIGURE 2: MEASURED HYDROGRAPH NEAR TETON RANCH
SOUTH LEIGH CREEK AND SIDE CHANNEL**
BIOTA RESEARCH AND CONSULTING, INC

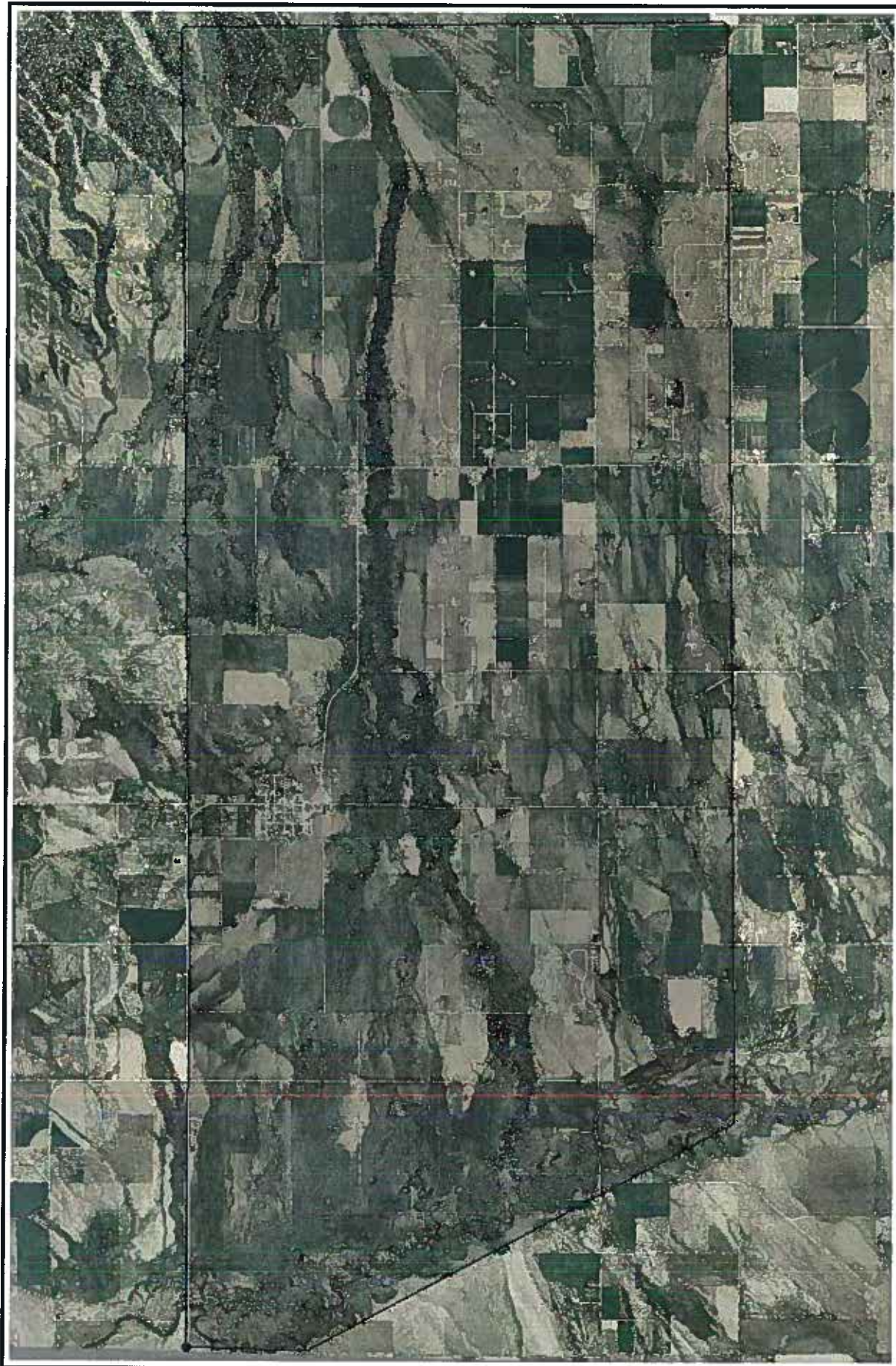


FIGURE 3: TETON RANCH GROUNDWATER MODEL DOMAIN
TETON RANCH
MODFLOW MODEL WITH CELLS AT 300 FT SPACING

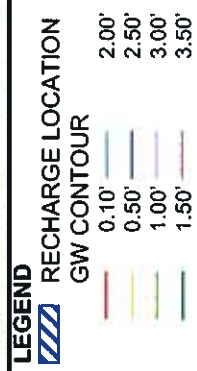
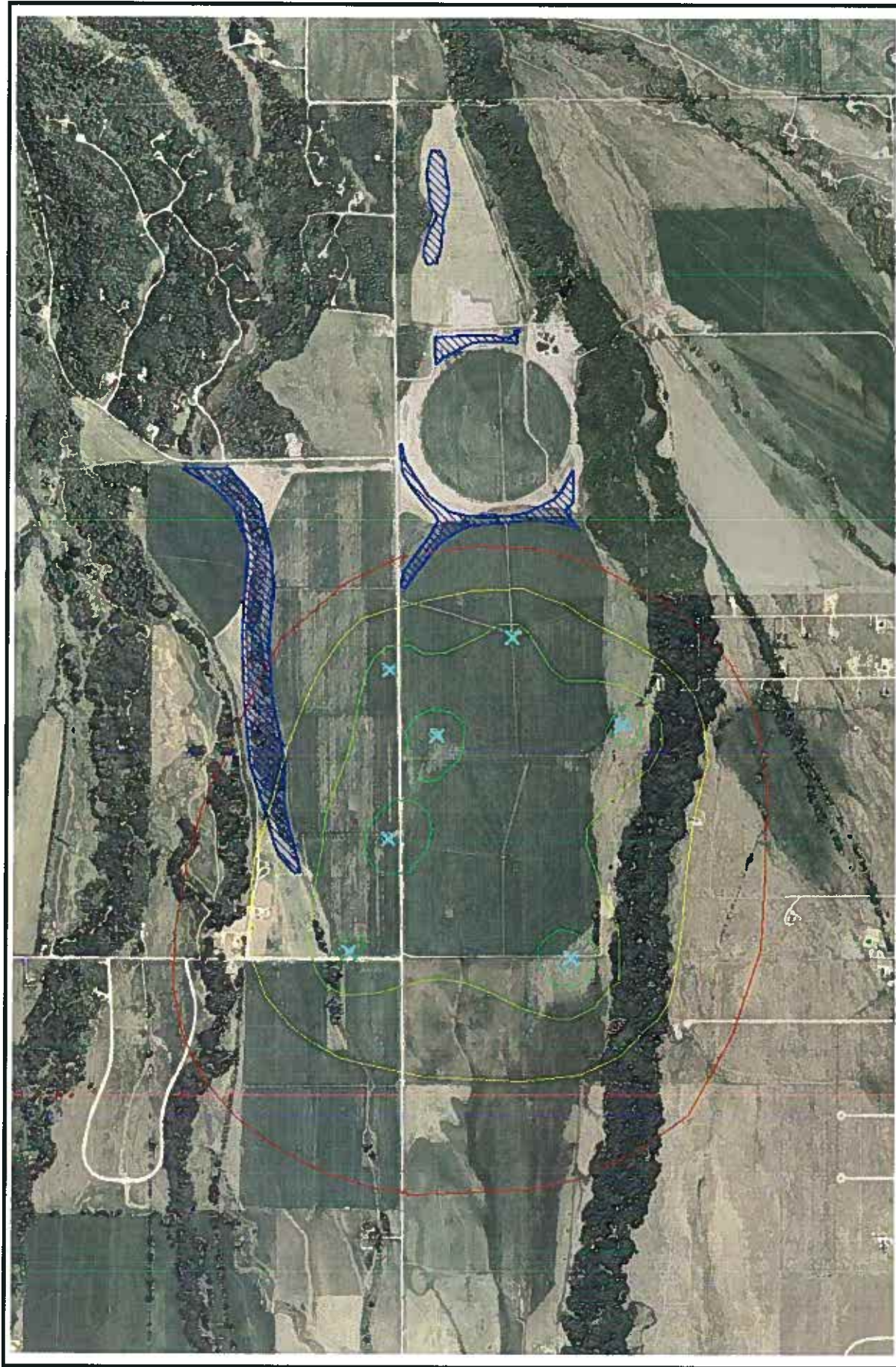


FIGURE 4: AQUIFER MOUND CREATED BY RECHARGE
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER



LEGEND

- RECHARGE LOCATION
- WELL LOCATION
- GW CONTOUR
- 0.10'
- 0.50'
- 1.00'
- 1.50'
- 2.00'

FIGURE 5: DRAWDOWN FROM MAX WELL EXTRACTION
MODFLOW GROUNDWATER MODEL
 TETON RANCH AQUIFER

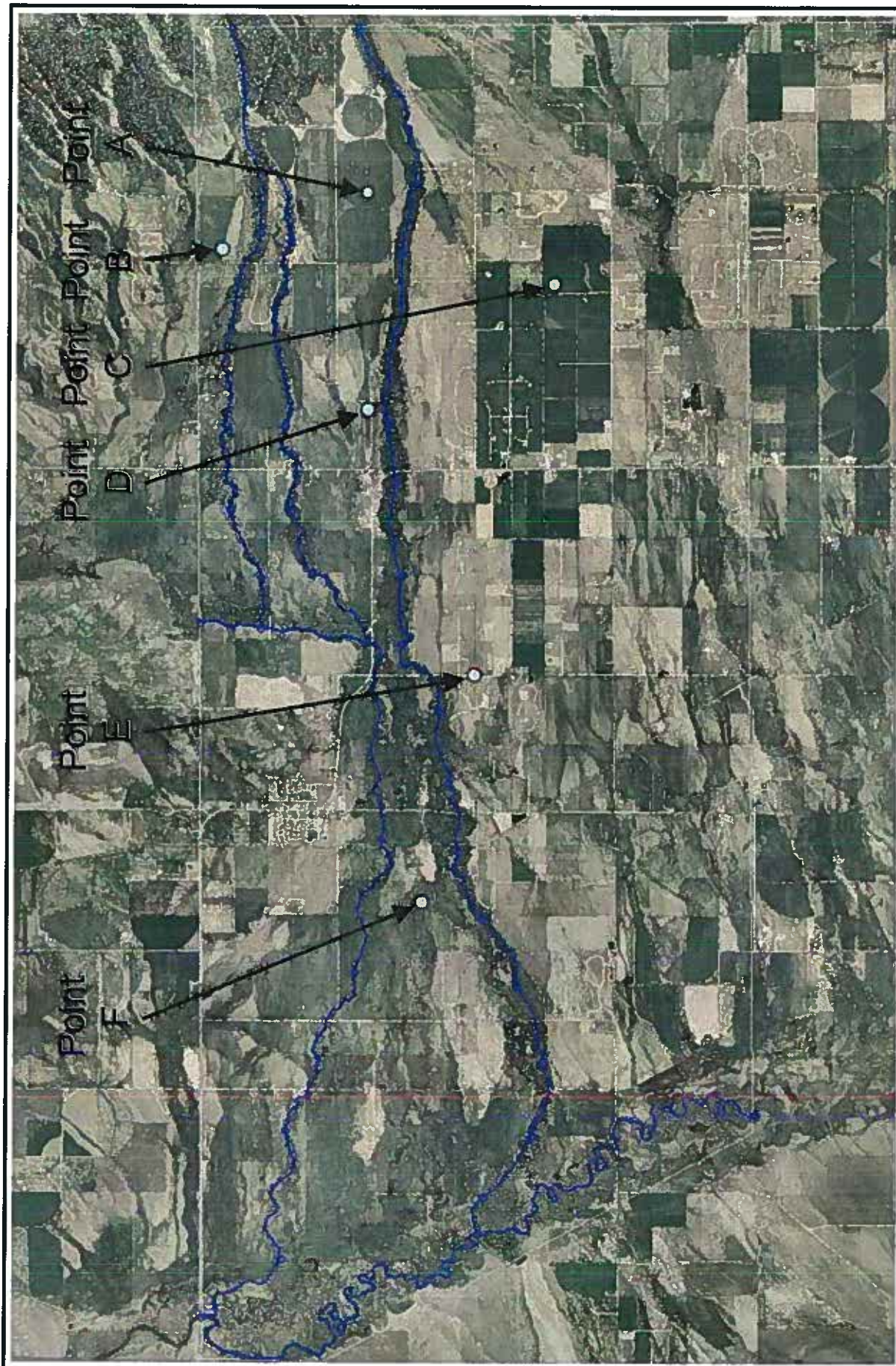


FIGURE 6: TETON RANCH OBSERVATION POINTS
MODFLOW GROUNDWATER MODEL
 TETON RANCH AQUIFER

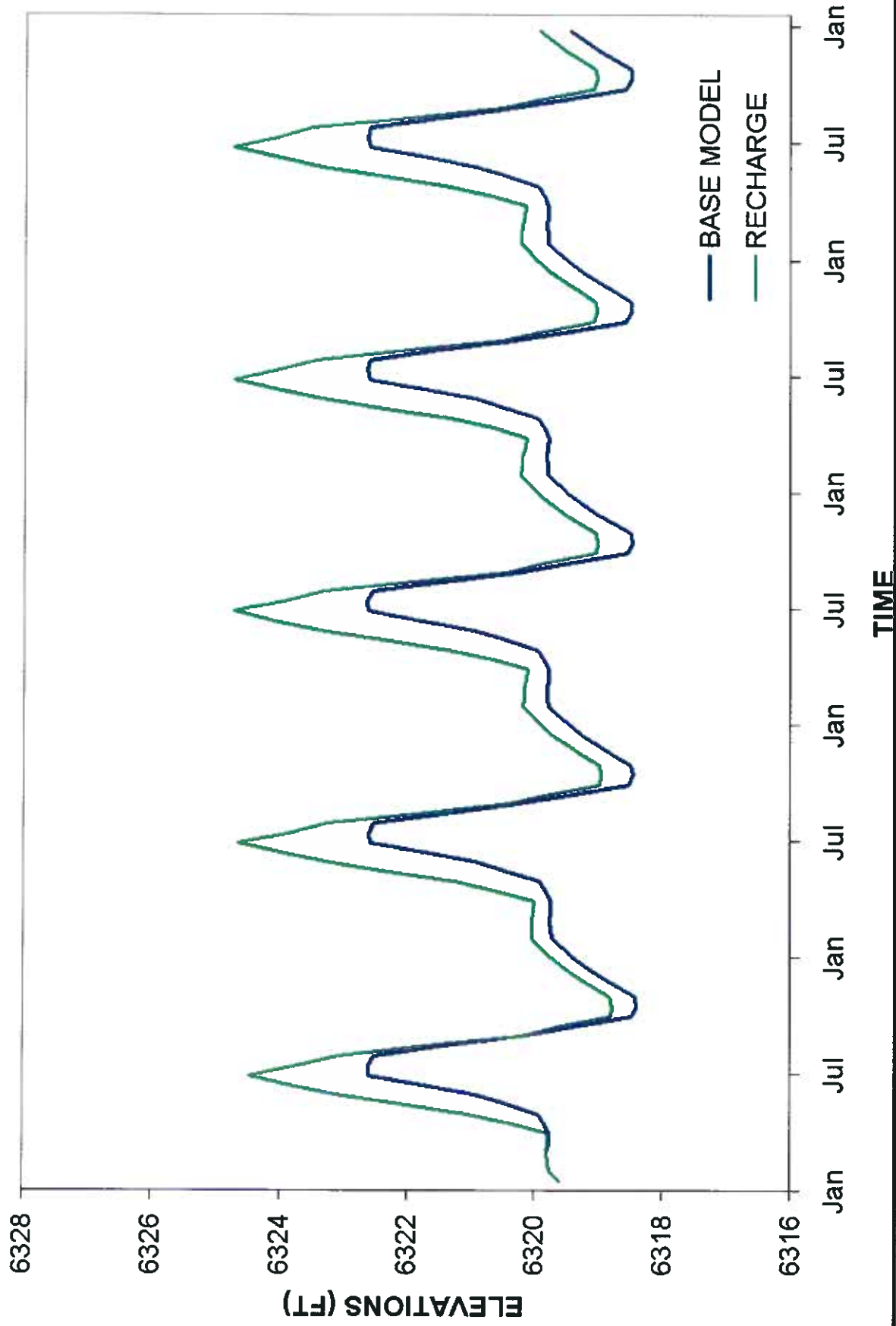


FIGURE 7: POINT A GROUNDWATER OBSERVATION POINT HYDROGRAPH
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

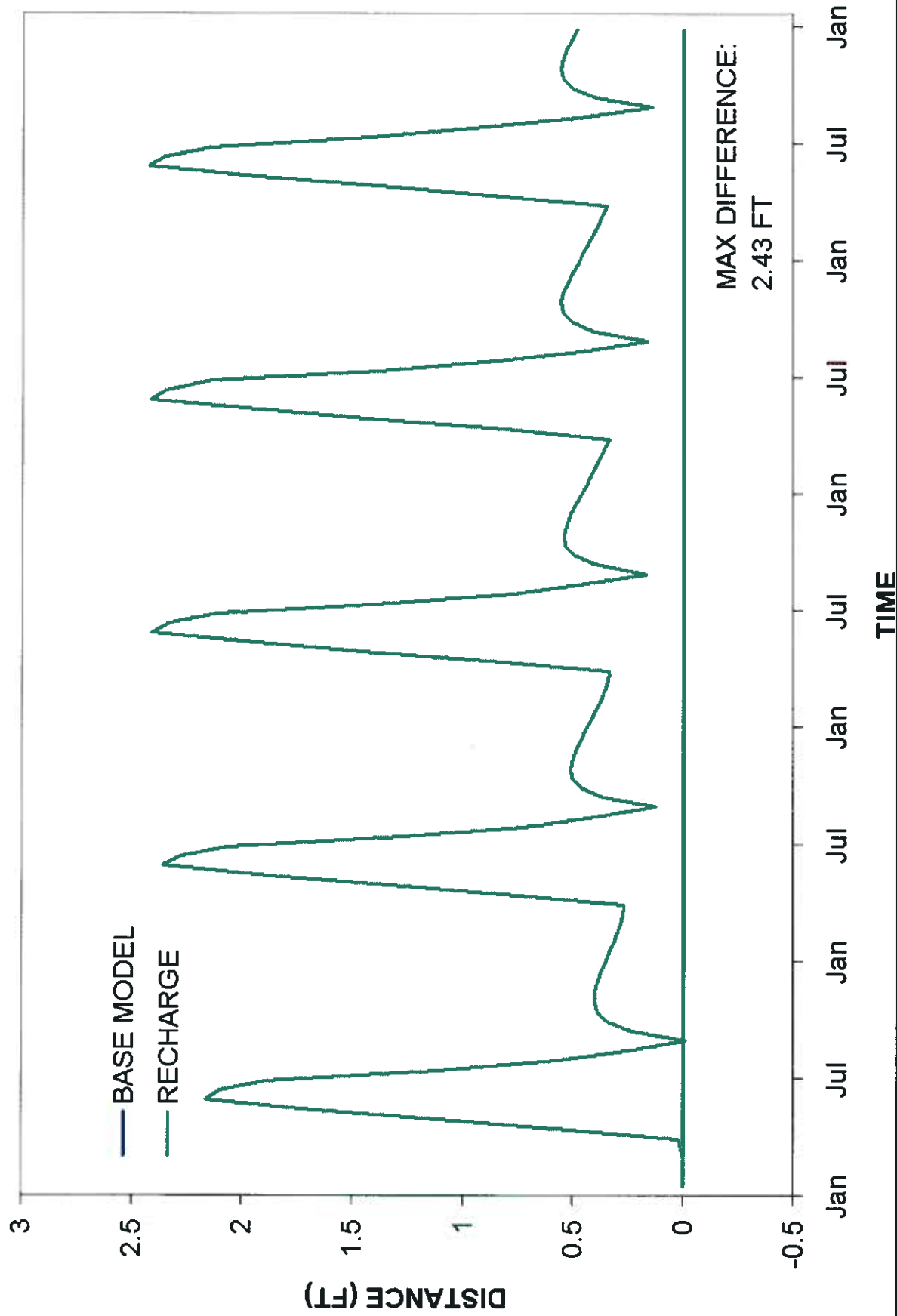


FIGURE 8: POINT A DIFFERENCES BETWEEN BASE MODEL AND RECHARGE
MODFLOW GROUNDWATER MODEL
 TETON RANCH AQUIFER

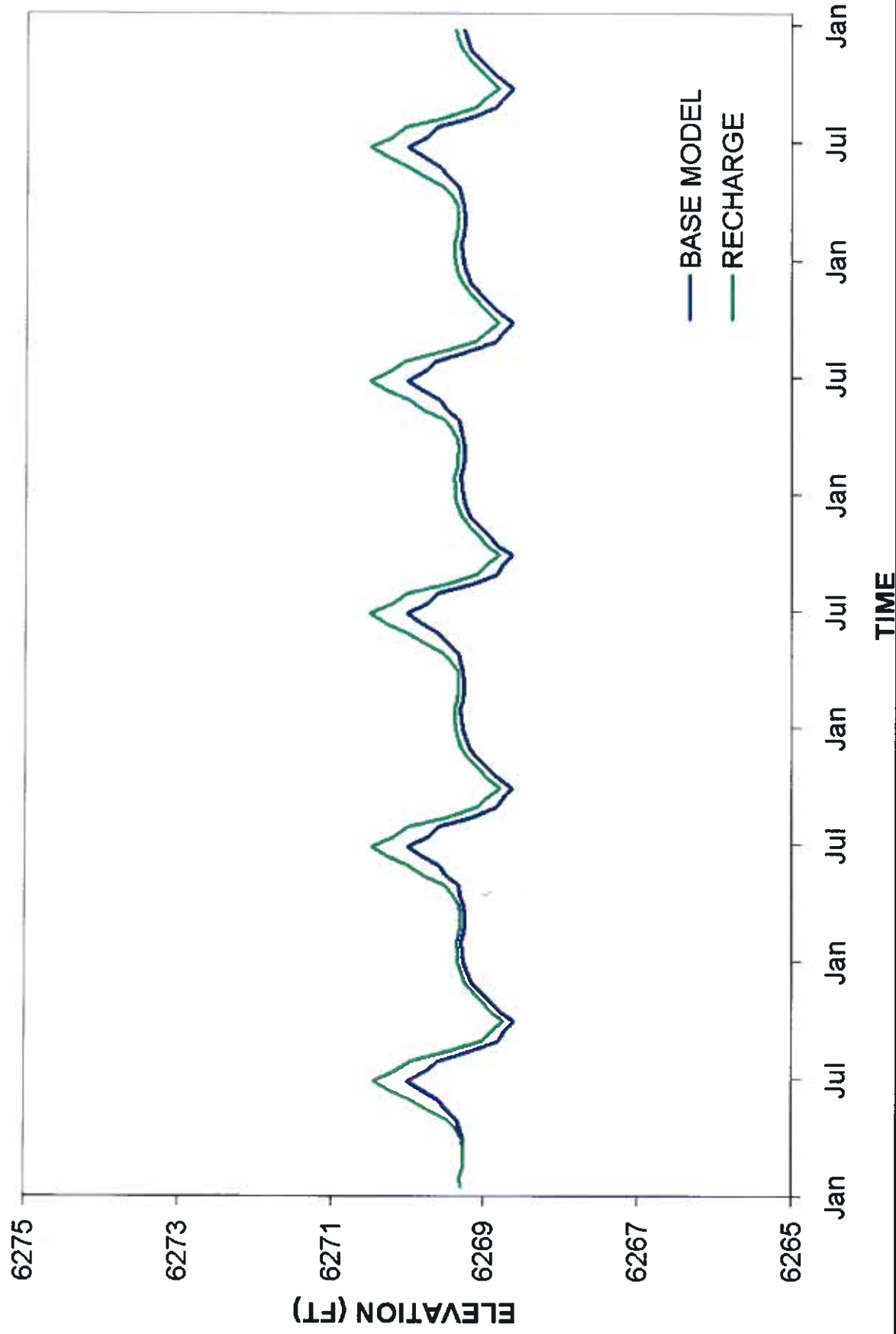


FIGURE 9: POINT B GROUNDWATER OBSERVATION POINT HYDROGRAPH
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

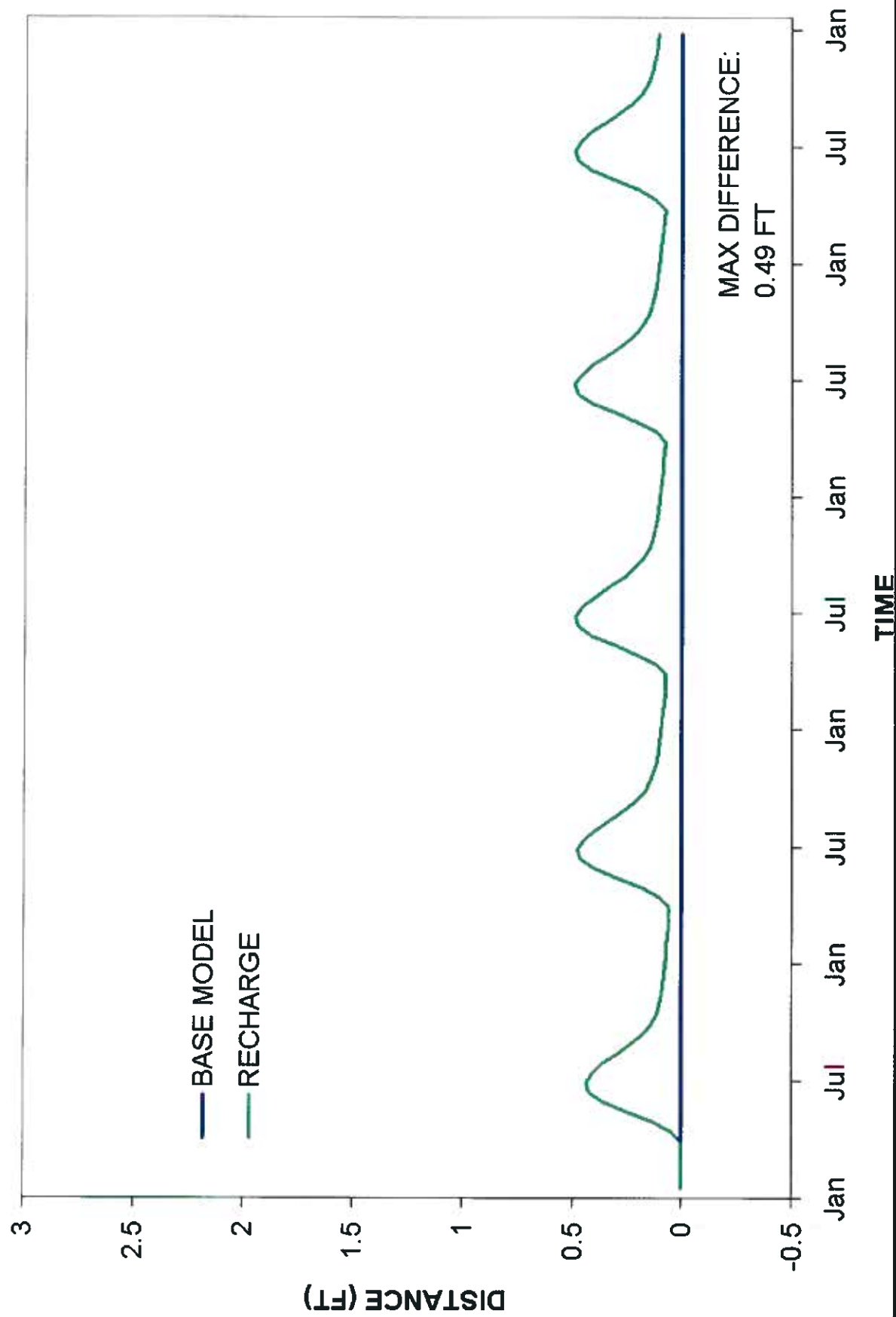


FIGURE 10: POINT B DIFFERENCES BETWEEN BASE MODEL AND RECHARGE
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

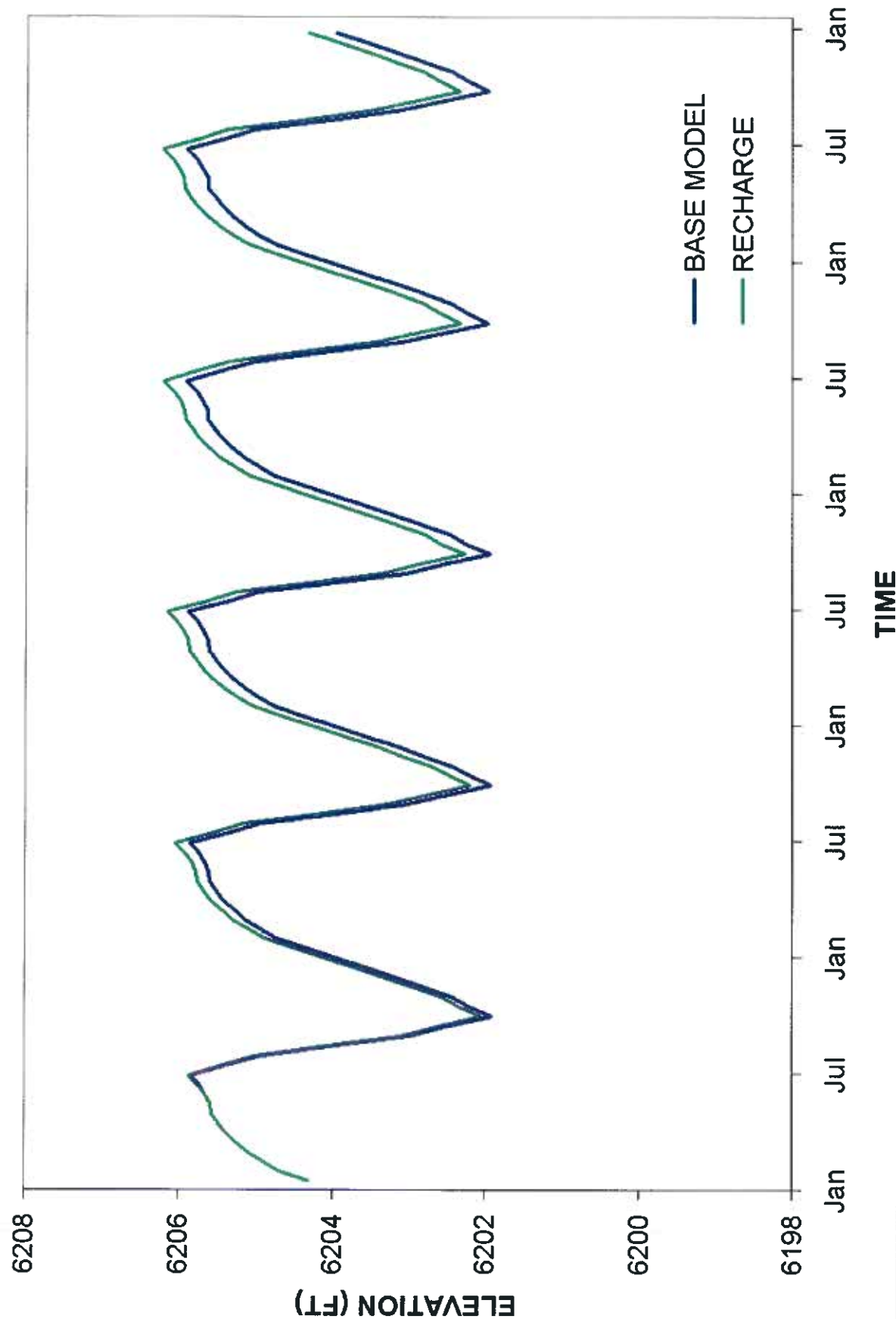


FIGURE 11: POINT C GROUNDWATER OBSERVATION POINT HYDROGRAPH
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

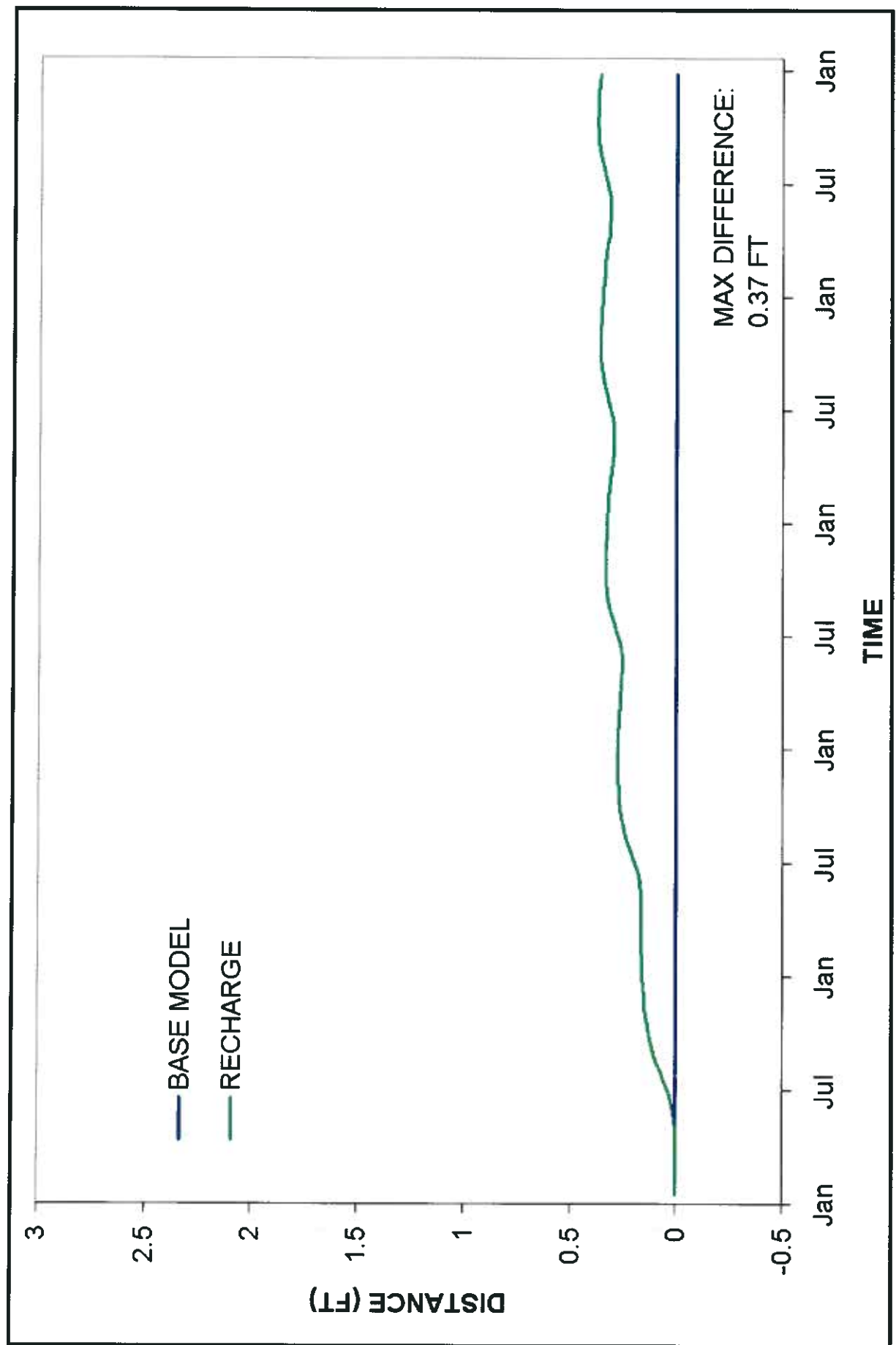


FIGURE 12: POINT C DIFFERENCES BETWEEN BASE MODEL AND RECHARGE
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

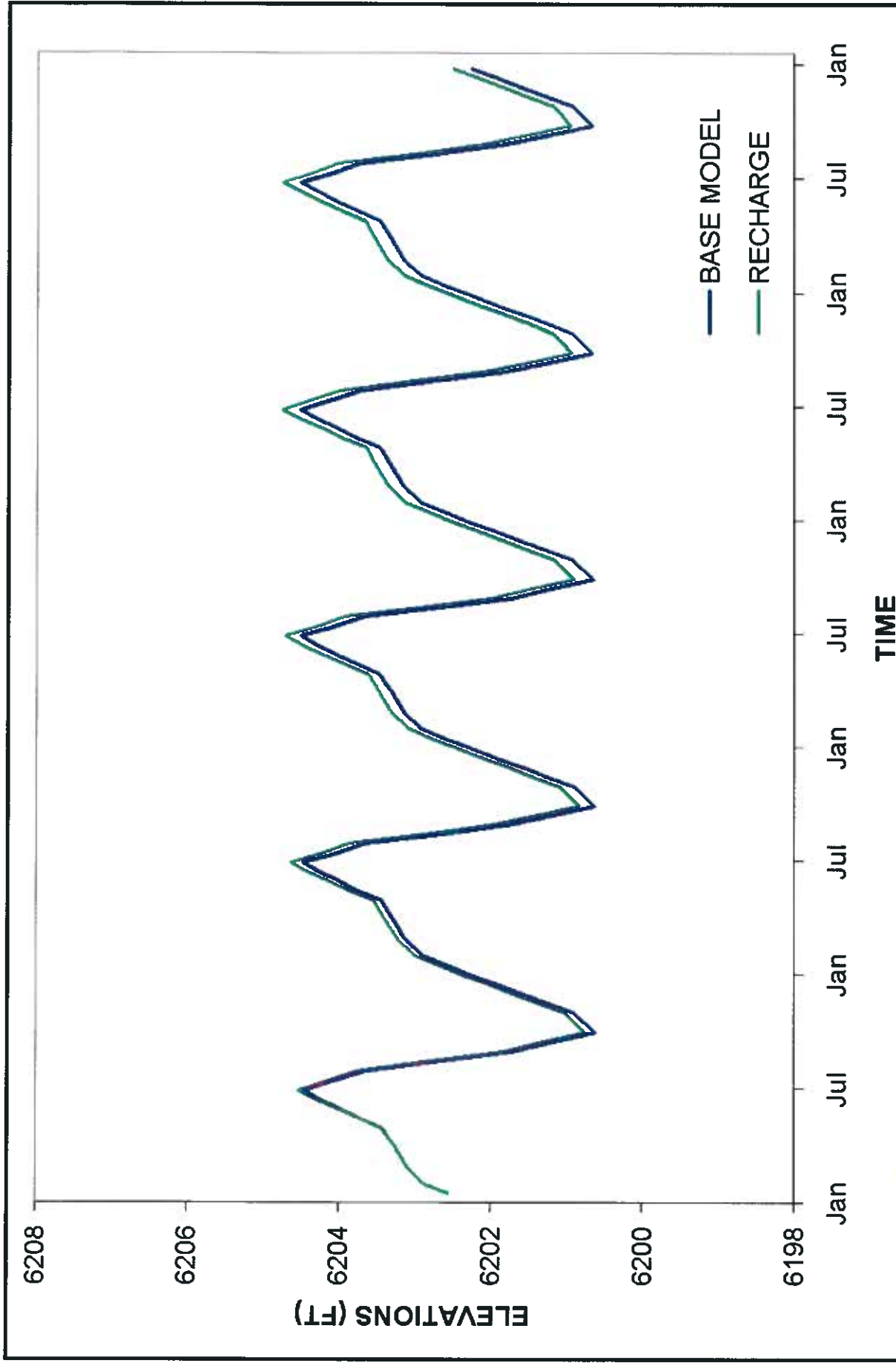


FIGURE 13: POINT D GROUNDWATER OBSERVATION POINT HYDROGRAPH
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

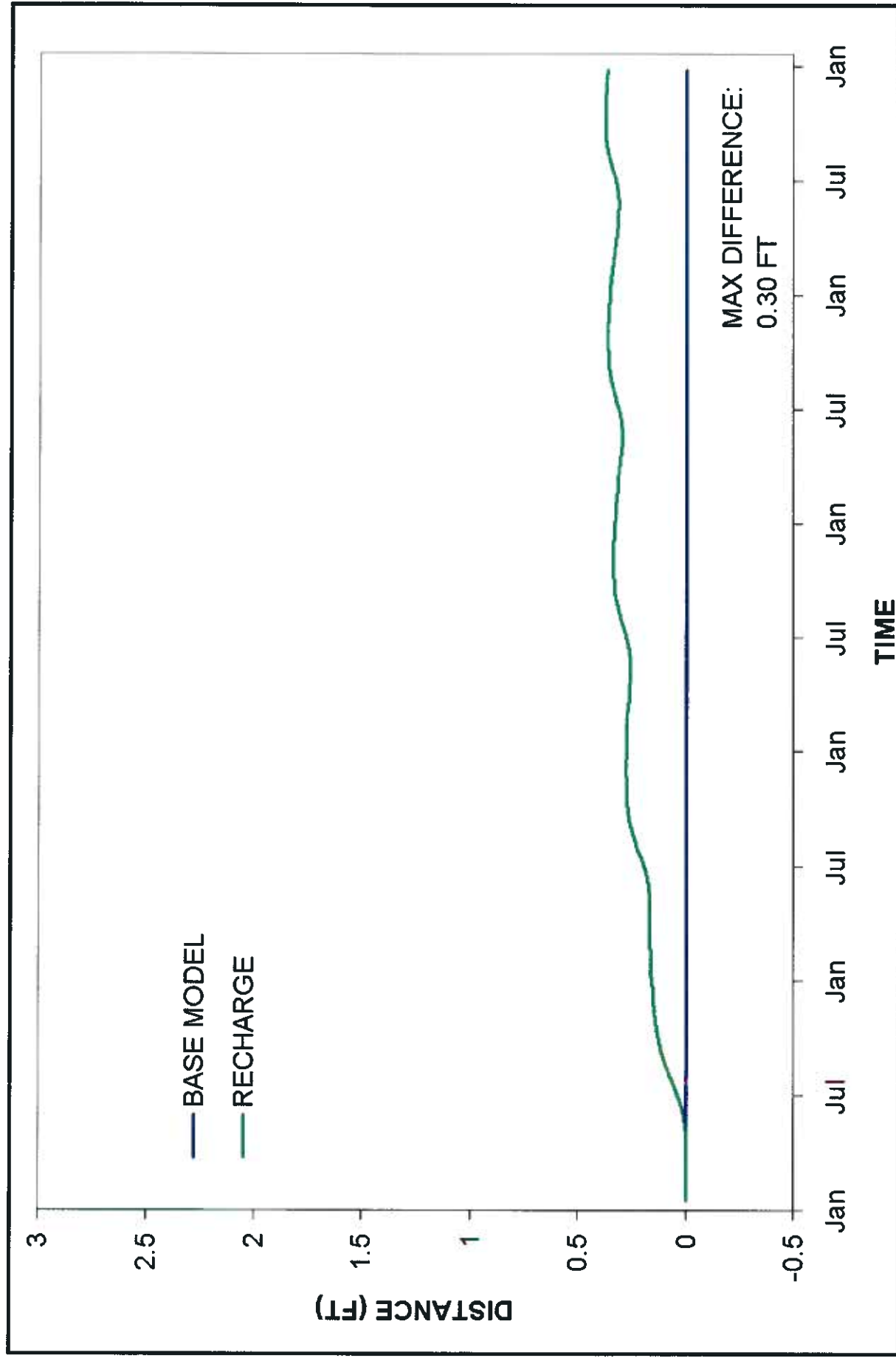


FIGURE 14: POINT D DIFFERENCES BETWEEN BASE MODEL AND RECHARGE
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER

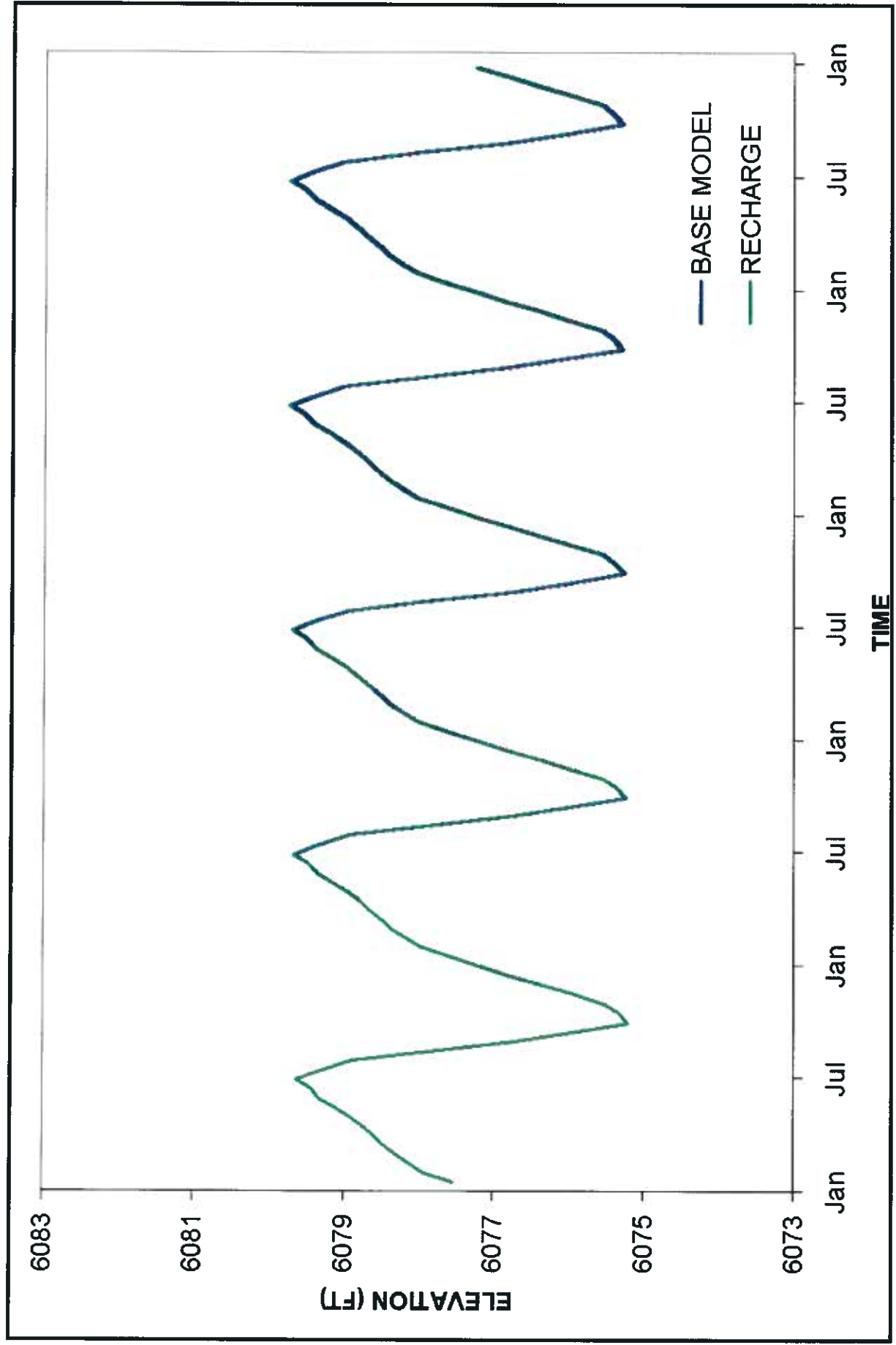


FIGURE 15: POINT E GROUNDWATER OBSERVATION POINT HYDROGRAPH
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER



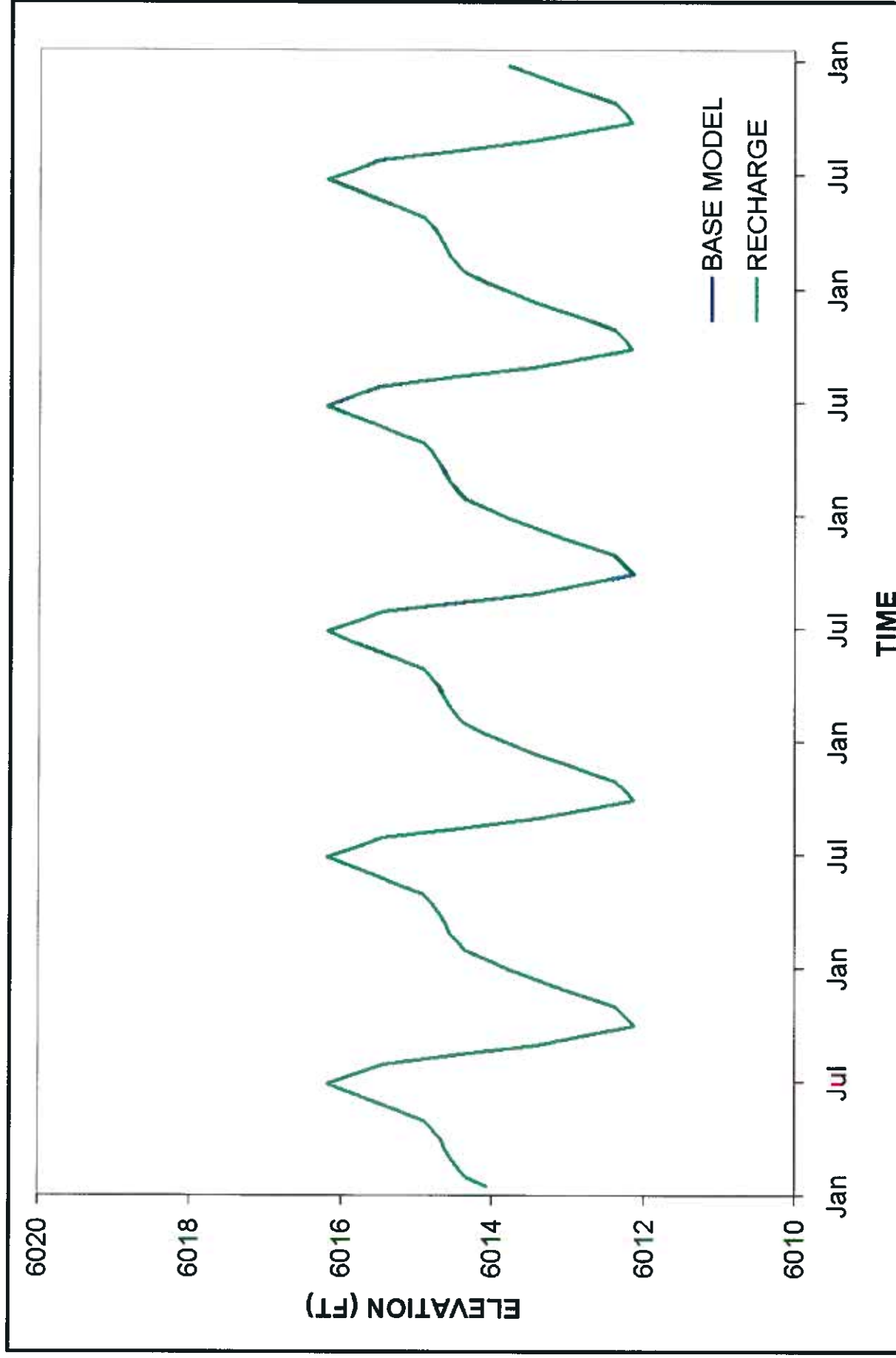


FIGURE 17: POINT F GROUNDWATER OBSERVATION POINT HYDROGRAPH
MODFLOW GROUNDWATER MODEL
TETON RANCH AQUIFER



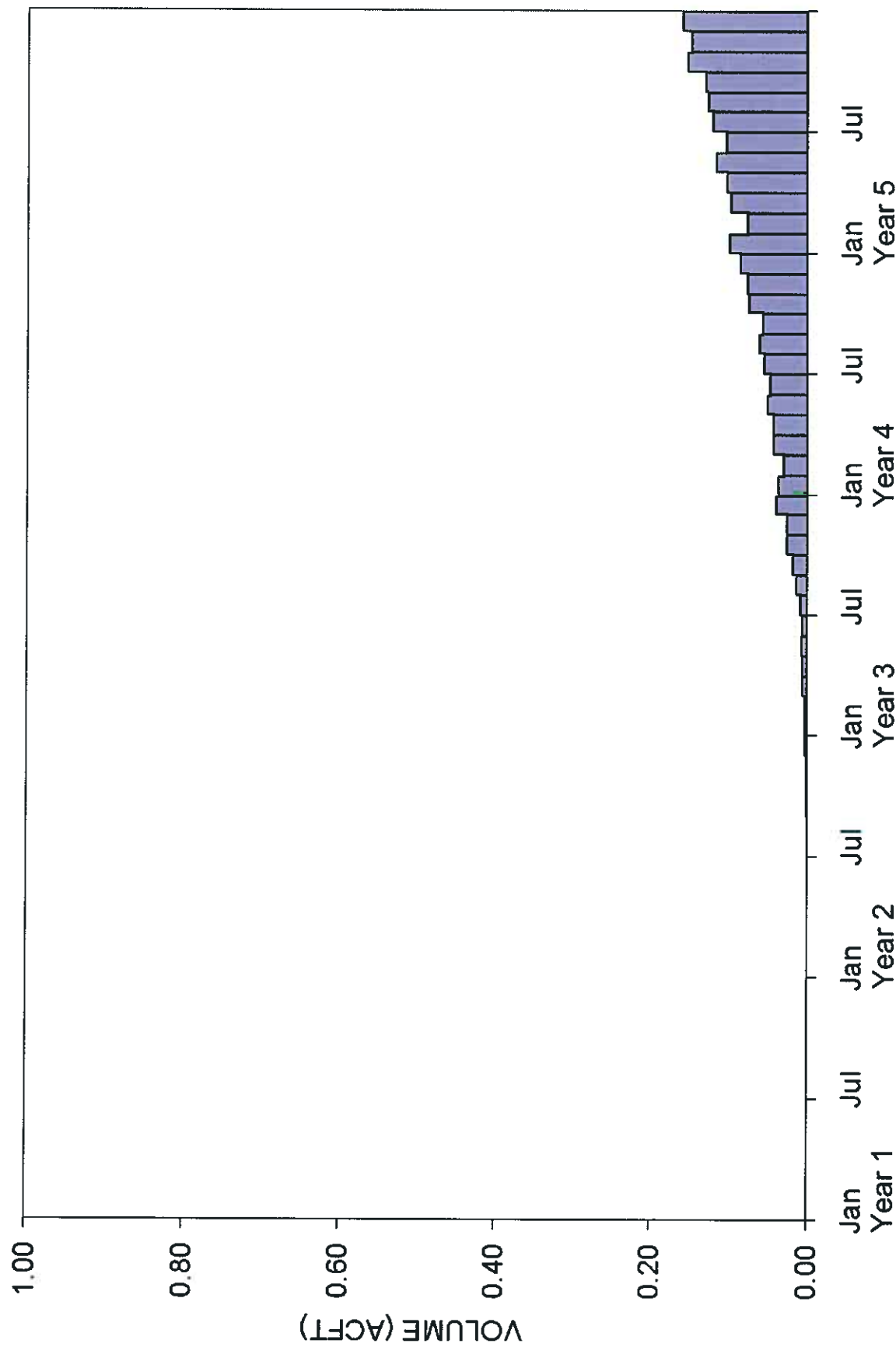


FIGURE 19: TETON RIVER FLOW DIFFERENCE: BASE MODEL AND AVG RECHARGE SCENARIO
 MODFLOW GROUNDWATER MODEL
 TETON RANCH AQUIFER

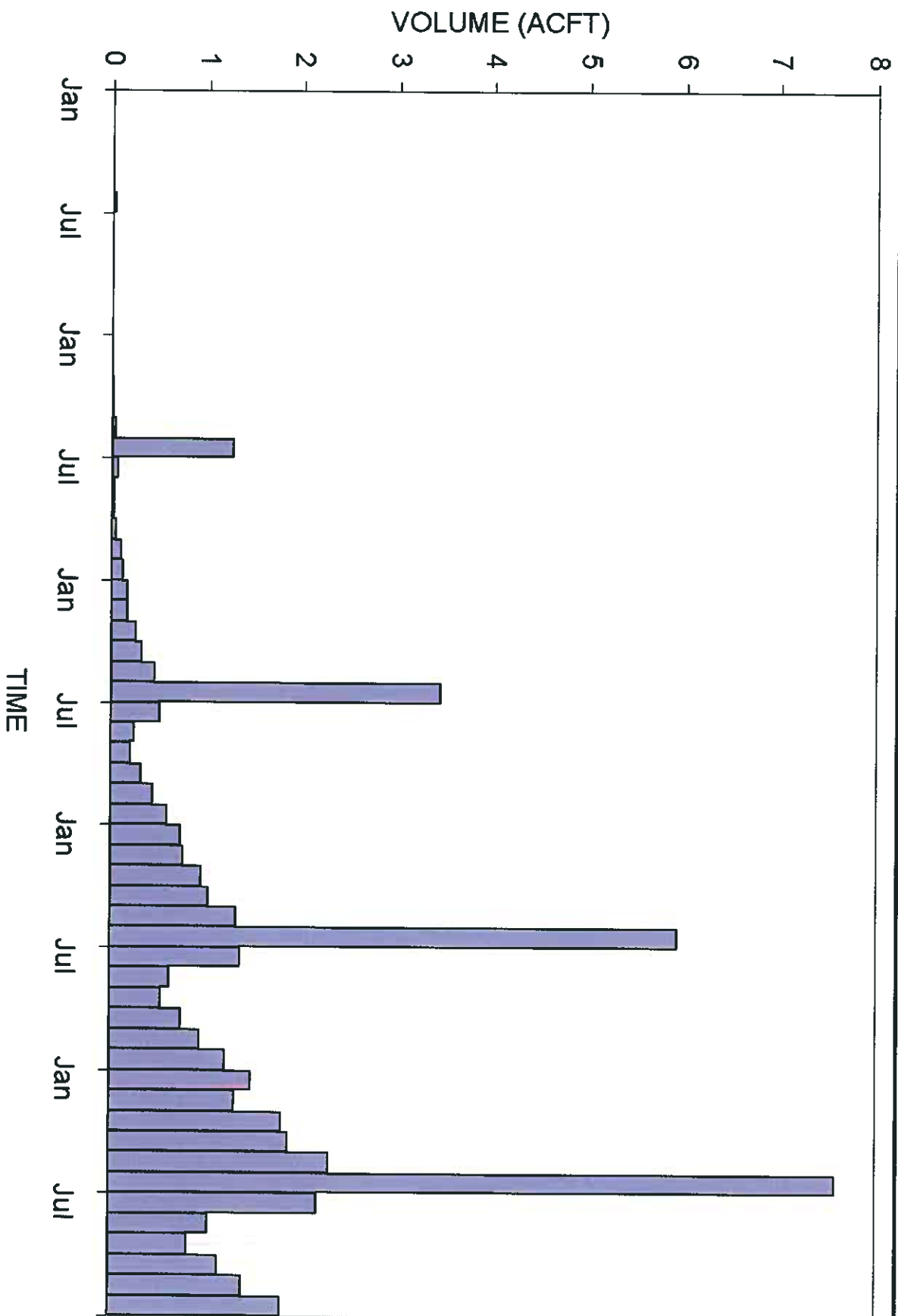


FIGURE 20: SOUTH LEIGH CREEK FLOW DIFFERENCE DOWNSTREAM OF HIGHWAY 33
 MODFLOW GROUNDWATER MODEL
 TETON RANCH AQUIFER