FRAZIER PARK PUBLIC UTILITY DISTRICT

ENGINEERING REPORT

GROUNDWATER CONDITIONS, WATER QUALITY OF
FRAZIER PARK WELLS, AND GEOPHYSICAL SURVEY
OF THE CUDDY CREEK VALLEY AT FRAZIER PARK

NOVEMBER 2017

DEE JASPAR & ASSOCIATES, INC.
CONSULTING CIVIL ENGINEERS
2730 Unicorn Road, Bldg. A (661) 393-4796
Bakersfield, CA 93308 Fax: (661) 393-4799

FRAZIER PARK PUBLIC UTILITY DISTRICT

ENGINEERING REPORT

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FRAZIER PARK PUBLIC UTILITY DISTRICT

INTRODUCTION

INTRODUCTION

The enclosed suite of three reports includes: Groundwater Conditions in the Frazier Park-Lake of the Woods Area by Kenneth D. Schmidt and Associates; a memorandum report Water Quality Review, Frazier Park Public Utility District Production Wells by Dee Jaspar and Associates, Inc.; a geophysical report Gravity Survey Summary Report – Frazier Park, California by Subsurface Surveys and Associates, Inc. A summary of these reports follows. These studies were sponsored by a grant to Self-Help Enterprises by the State of California Water Resources Control Board.

The purpose of these reports is to review the feasibility of developing groundwater in the Frazier Park Public Utility District (District) to serve the combined service areas of the District and the Lake of the Woods Mutual Water Company.

SUMMARY

Groundwater Conditions in the Frazier Park-Lake of the Woods Area by Kenneth D. Schmidt and Associates

This report is a study of the groundwater conditions in the area that draws on recent well and geophysical information and on past reports authored by Kenneth Schmidt, Ron Barto, the Galli Group, the California Division of Mines and Geology, the California Geological Survey, together with the information from recently-drilled wells combined with information presented in the above-referenced reports by Dee Jaspar and Associates, and Subsurface Surveys and Associates. The purpose of the report is to discuss the future groundwater development that will serve the Frazier Park and Lake of the Woods area.

The report reviews the subsurface geologic conditions in the study area and describes the geologic conditions in the area – defining the rock and alluvium composition of the Cuddy Valley. Of interest is the alluvium that composes the Cuddy Creek Canyon – which is the water source for the wells in the area. An updated subsurface geologic cross section, drawn along the alignment of Cuddy Creek, intersecting wells that have well completion reports, depicts the contact between the alluvium and the hard rock in the canyon. Depth of the alluvium between Frazier Park and Lake of the Woods varies between about 140 feet at Lake of the Woods well No. 4 and 300 feet at Private Well 34H (Figure 3 of the report) to around 200 feet at Frazier Park Wells No. 4 and 6. Of interest is the relative depth of the wells upstream of Frazier Park Well No. 5 compared to the depth of Well No. 5. It is apparent that the Garlock Fault, which is downthrown to the southeast side, is located between Frazier Park Wells 4 and 6 - and Well 5, thus resulting in the deeper deposits in the vicinity of Well No. 5. Additionally, Well No.5 appears to be nearer to the thalweg of Cuddy Creek than Wells 4 and 6. The “thalweg” is the deepest part of the hard rock in the canyon. Figure 3 also depicts the shallowest and deepest well water levels in recent times. The deepest water levels in the Lake of the Woods area reveals that the alluvium was completely dewatered during the times of the deepest water levels, while the alluvium east of Private Well 34M (near the Mobile Home Park) appears to have not experienced complete dewatering. The majority of the storage in the canyon is in the Middle Sub-basin, which is the water supply for Frazier Park. If there is a series of wet years, and there is flow in Cuddy Creek, the water levels will recover in the Lake of the Woods area and the wells there will be productive once again. However if the drought continues, more reliance on the Middle Sub-basin will prevail for the Lake of the Woods area.

Water levels slope in the direction of the fall of the creek – as would be expected. Figure 4 of the report depicts the water levels in the Spring of 2002. This is an average water level slope of 160 feet per mile.

Recharge in the canyon is primarily from seepage from Cuddy Creek streamflow and mountain front recharge. In recent years recharge has been mostly due to mountain front recharge. In the Frazier Park area it is indicated that a major contributor of mountain front recharge is the Cold Springs Canyon drainage, west of Frazier Park, and from the tributary watershed south of Frazier Park.

There are two main constituents in the water in the wells in the area. These two constituents are Uranium and Fluoride. These will be discussed in the following sections of this Summary.

Water Quality Review, Frazier Park Public Utility District Production Wells by Dee Jaspar and Associates, Inc.

Dee Jaspar & Associates reviewed the water quality information for the Frazier Park area for years of record dating back to 1986. Early records are somewhat spotty and incomplete, but there is enough information to draw some preliminary conclusions regarding water quality over time and its relationship to wet and dry rainfall periods.

The two springs that have previously supplied a small amount of water to the District were dry during the drought but have recovered slightly due to the moderate rainfall last year. Uranium and Fluoride activities appear to be well below the MCL in these two springs. The problem is bacteria, likely due to wildlife in the area of the springs. If these springs yielded a substantial amount of water it might be worth the effort to clean them up and run new pipelines to them, but they are in the area governed by the U. S. Forest Service and it would be necessary to obtain a permit to install new pipelines and improve the springs. The springs are in steep country and remote. Vehicular access is not possible. Construction of any improvements would be difficult and time-consuming. The springs are not deemed feasible for re-development at this time.

A detailed review of each well revealed that the uranium activities in the wells has varied over their history of operation and appear to correlate well with the long-term weather trends. That is to say that when a relatively wet cycle of years occurs, the uranium activities drop due to abundant replenishment from streamflow and mountain front recharge. When a relatively dry cycle occurs activities increase. This is evident when one compares the rainfall in the area with the uranium activities in the wells. For example, during the relatively wet period from 1990 to 1999, uranium activities remained relatively low compared to the current activities, wherein after about ten years of drought, they have increased to near the MCL, averaging just below the MCL, but occasionally spiking above the MCL.

A review of fluoride levels revealed that they do not respond to drought in the same fashion as do uranium activities. Fluoride levels have remained relatively constant over the period of record for the wells in Frazier Park. The Monte Vista well has exhibited fluoride levels at or above the MCL over the period of record. The Monte Vista well is inactive. Only one test in one other well, Well 4, has spiked over the MCL and that was a test taken in 1994. On an annual average, fluoride levels in the Frazier Park active wells have remained at or below the fluoride MCL. Mixing might be an option that could reduce both the uranium and fluoride levels in the District's wells.

Gravity Survey Summary Report – Frazier Park, California by Subsurface Surveys and Associates, Inc.

Subsurface Surveys and Associates performed a "gravity" survey in the Cuddy Creek Valley in September of this year. A gravity survey determines the depth of alluvium by measuring variations in the gravitational field at regular intervals along survey traverses. Changes in the depth to hard bedrock, and thus the thickness of the less dense overburden, produces a localized variation or anomaly in the gravity field. The gravity survey determined the depth of the bedrock beneath the alluvium in eleven traverses across the Valley, beginning just east of Frazier Park Well 5 and concluding just west of Lake of the Woods Well 7. The gravity survey focused on the Middle Sub-basin because the purpose of the survey was to determine the best sites for wells for the upcoming test well program. To accomplish this, traverses were separated by about 1,000 feet in the Frazier Park area. In an effort to develop a better understanding of the West Sub-basin, the survey was extended into the Lake of the Woods area. Two additional traverses were performed in this area.

The resulting information is presented in the Subsurface Surveys report, the third report in this suite of three reports. Ken Schmidt and Associates combined the results of the survey with the information that was previously developed by Dr. Schmidt and others, to refine the recommended location of the test wells. One interesting feature that was observed in Traverse 1 (near Frazier Park Well 5) was the discovery of a graben (German for "ditch" or "trench") structure in which Well 5 appears to have been completed. A graben is an elongated block of the earth's crust lying between two faults that is displaced downward relative to the blocks on either side. This would then be the reason that Well 5 is not only the deepest well in the District, but the best producer as well. It is recommended that a test well be drilled into this graben in the vicinity of Well 5. It has also been established that this graben is along the alignment of the Garlock Fault. Two additional test well locations are recommended in the above Groundwater Conditions report by Ken Schmidt and Associates.

CONCLUSION

Given historical climatic conditions, the water supply and quality will be sufficient in the future to supply the combined needs of the Frazier Park and Lake of the Woods areas. However, an unknown factor is the uncertainty of the effects of climate change. As demonstrated in the above reports, and in reports that have been issued in the past, the quantity of runoff has proven to be sufficient for enduring a lengthy and record-setting drought. However, as a long-term strategy, the District should look into the availability of supplemental surface water to enhance its water supply. Anticipating the possible effects of climate change will place the District in favorable position in the long-run.

FRAZIER PARK PUBLIC UTILITY DISTRICT

GROUNDWATER CONDITIONS IN THE FRAZIER PARK – LAKE OF THE WOODS AREA

BY KENNETH D. SCHMIDT AND ASSOCIATES

GROUNDWATER CONDITIONS IN THE FRAZIER PARK-LAKE OF THE WOODS AREA

prepared for
Dee Jaspar & Associates
Bakersfield, California

by
Kenneth D. Schmidt & Associates
Groundwater Quality Consultants
Bakersfield, California

October 2017

KENNETH D. SCHMIDT AND ASSOCIATES
GROUNDWATER QUALITY CONSULTANTS
3701 PEGASUS DRIVE, SUITE 112
BAKERSFIELD, CALIFORNIA 93308
TELEPHONE (661) 392-1630

November 28, 2017

Mr. Dee Jaspar
Dee Jaspar and Associates
2730 Unicorn Rd, Building A
Bakersfield, CA 93308-6843

Re: Groundwater Conditions in the Frazier Park-
Lake of the Woods Area

Dear Dee:

Submitted herewith is our report on the groundwater conditions in the Frazier Park-Lake of the Woods area. We appreciate your assistance in conducting this work.

Sincerely Yours,

Kenneth D. Schmidt
Geologist No. 1578
Certified Hydrogeologist
No. 176

KDS/td

REGISTERED GEOLOGIST
KENNETH D. SCHMIDT
NO. 1578
STATE OF CALIFORNIA

REGISTERED GEOLOGIST
KENNETH D. SCHMIDT
NO. 176
CERTIFIED
HYDROGEOLOGIST
STATE OF CALIFORNIA

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GROUNDWATER CONDITIONS IN THE FRAZIER PARK-LAKE OF THE WOODS AREA

INTRODUCTION

Several hydrogeologic reports have been prepared for the Lebec-Frazier Park-Lake of the Woods area. Barto (1981) and Ron Barto Consulting & Associates (1985 and 1988) reported on groundwater conditions in Cuddy Valley. Kenneth D. Schmidt and Associates (KDSA, 2003) reported on groundwater conditions in the Frazier Park/Lebec Specific Plan area. More recently, the Galli Group (2005 and 2007) focused on groundwater conditions in the lower part of Cuddy Canyon, and estimated the amounts of groundwater in storage in several sub-basins. The purpose of this report is to discuss future groundwater development to serve the Frazier Park PUD and Lake of the Woods area.

SUBSURFACE GEOLOGIC CONDITIONS

Figure 1 shows a generalized geologic map for the study area, modified from California Mines and Geology (1988), and California Geological Survey (2012 a and b). Alluvial deposits are present along Cuddy Creek in an area that average about 600 feet in width upstream of Frazier Park and about 1,200 feet in Frazier Park. Outcrops on the north side of the Cuddy Creek floodplain are primarily granitic rocks. Outcrops on the south side of the floodplain are primarily metamorphic rocks. The San Andreas Rift Zone

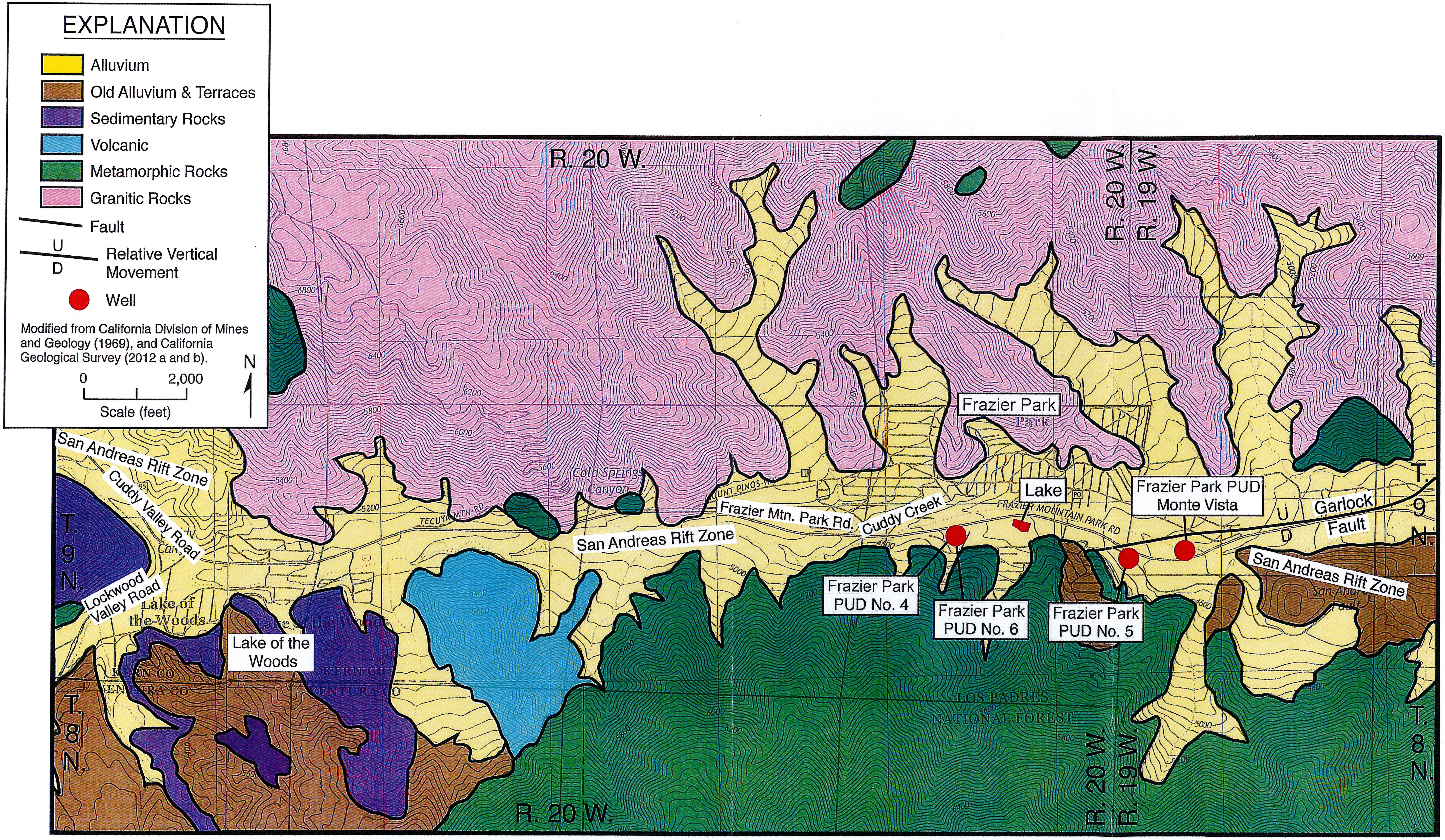

FIGURE 1 - GENERALIZED GEOLOGIC MAP OF STUDY AREA

generally extends along Cuddy Canyon, generally beneath the flood-plain.

KDSA (2003) provided a subsurface geologic cross section extending from about three quarters of a mile upstream of Frazier Park to the east, past Lebec. This section didn't extend upstream to Lake of the Woods. Thus an updated cross section was prepared for this report (Figure 2). Also, since the completion of Well No. 6 for the Frazier Park PUD in Summer 2015, subsurface conditions shown near PUD Wells No. 3 and 4 have been modified from those shown in the previous cross section.

Cross Section A-A′ extends through three wells and one test hole in Lake of the Woods, to the east through five private domestic wells, thence through three Frazier Park PUD wells (Figure 3). Because the mud rotary method was used to construct many of the wells along the section and geophysical logs were usually not done for these, little information was obtained on groundwater in the hardrock. The air-rotary method is a better method to evaluate groundwater production in the hardrock. In Lake of the Woods, the air rotary method was used for a 400-feet deep test hole and for the lower part of Well No. 5, which was drilled to a depth of 720 feet. In Lake of the Woods, most of the water production has come from gravel and boulders in the alluvial or stream channel deposits. The base of these deposits ranges from

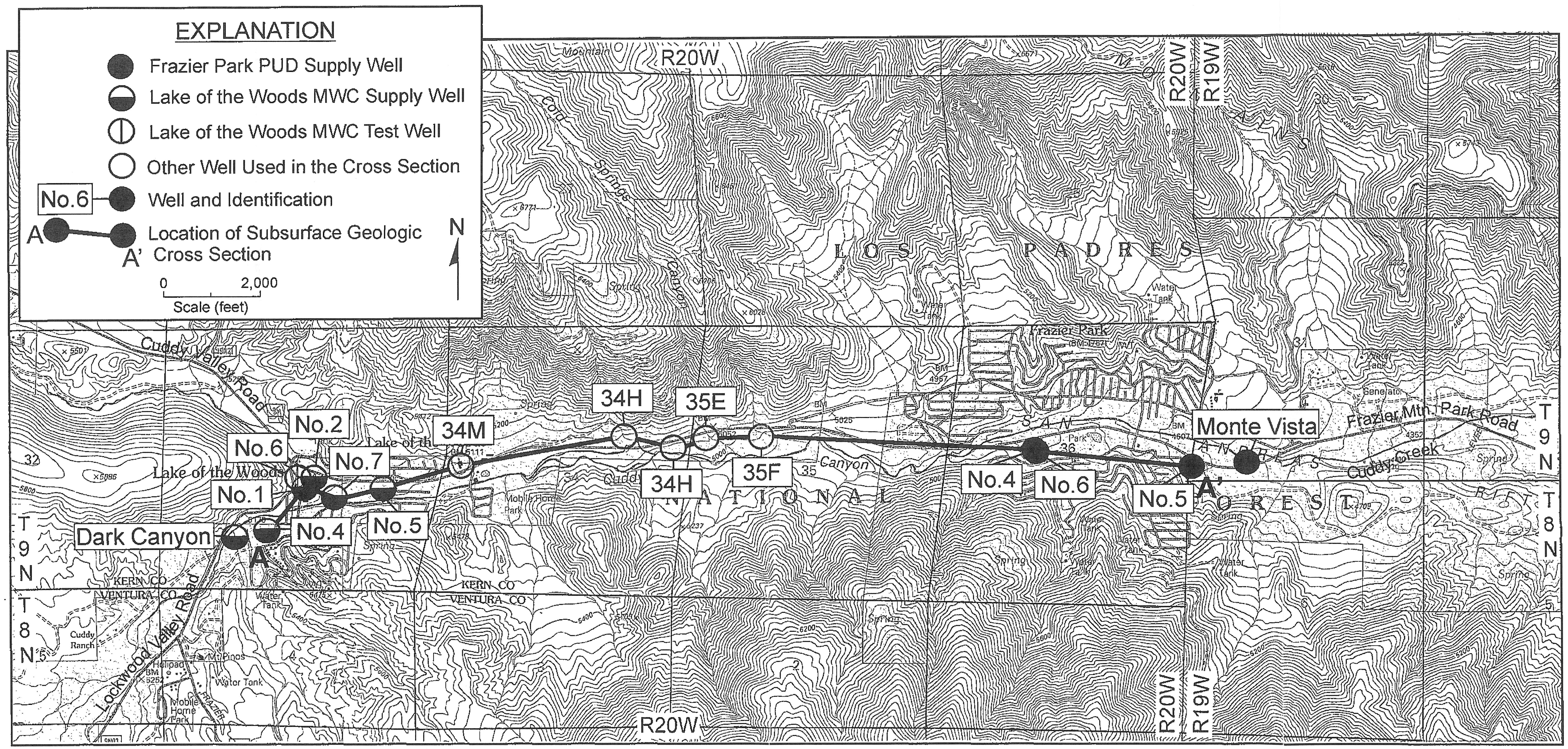

FIGURE 2 - LOCATION OF SELECTED WELLS AND SUBSURFACE GEOLOGIC CROSS SECTION A-A'

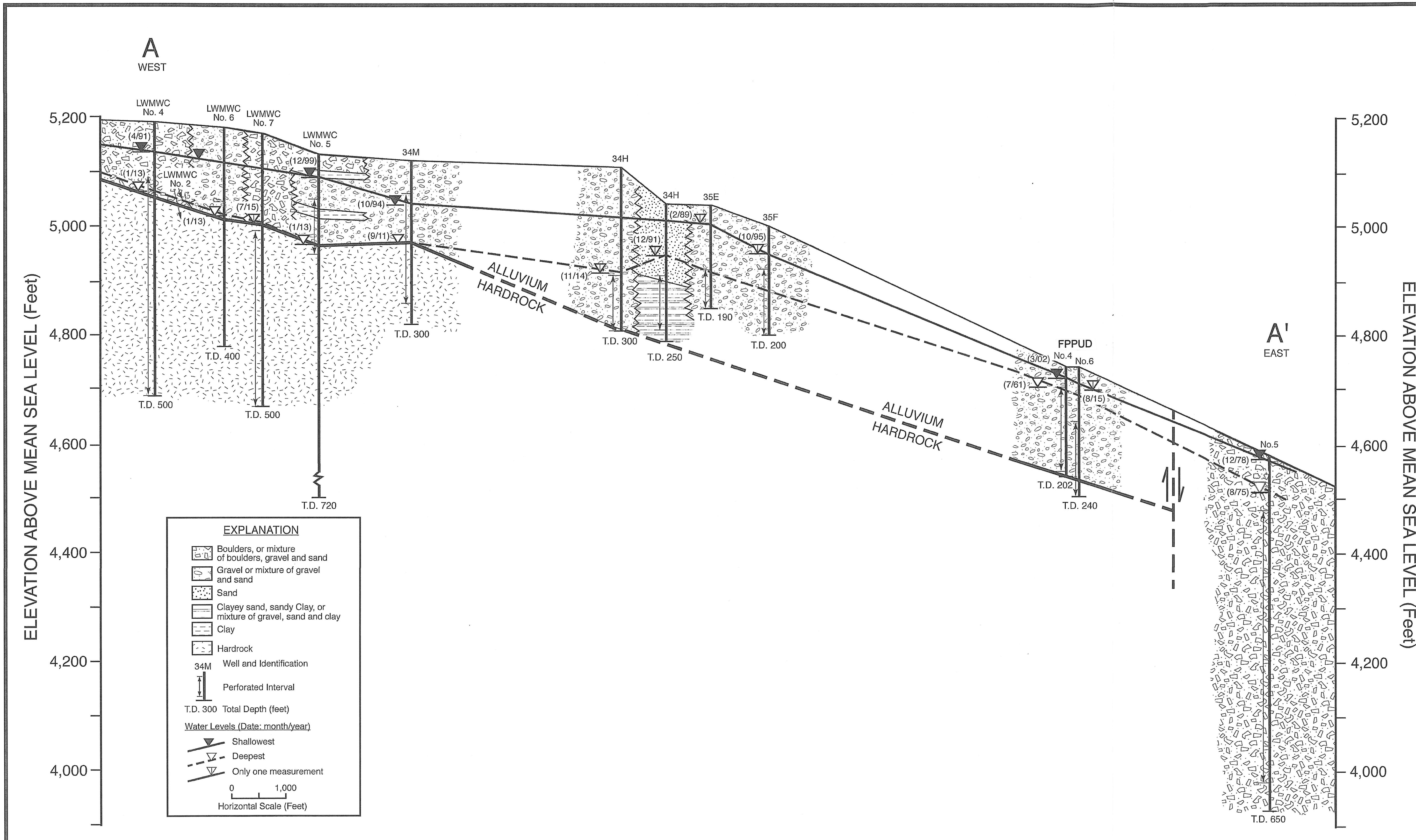

FIGURE 3 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'

about 140 to 170 feet deep along this cross section in Lake of the Woods. The highest and lowest recorded water levels are also shown on the cross section. The deepest water levels in Lake of the Woods (2013-2015) were near the base of the alluvial deposits, explaining the low well yields achievable at that time. The shallowest recorded water levels in Lake of the Woods wells (in 1991 and 1999) ranged from about 40 to 50 feet deep.

Along the reach between Lake of the Woods and the Frazier Park PUD, the alluvial deposits are thicker than in Lake of the Woods. The lowest elevation of the top of the bedrock beneath the floodplain at any cross section is termed the thalweg. The base of the alluvial deposits appears to be about 250 to 300 feet deep along the thalweg in this reach. The lowest water levels in wells in this reach have ranged from about 90 to 170 feet deep. Thus even during drought periods, from about one-third to one-half of the alluvial deposits in this area have apparently still been saturated.

The completion of Well No. 6 for the Frazier Park PUD indicated that the base of the alluvial deposits was only about 200 feet deep at that location. It appears that Wells No. 4 and 6 are well south of the thalweg, and this is at least part of the reason for the shallower depth to the top of the hardrock in this vicinity. Another explanation for the greater depth to the top of the hardrock at Well No. 5 is that the Garlock Fault is projected to extend through Cuddy Canyon upstream of Well No. 5 and downstream of Wells No. 4 and 6. This fault is downthrown on the southeast side, and the top of the hardrock would be expected to be deeper in the area southeast of the fault.

Frazier Park PUD Well No. 5 appeared to encounter alluvial deposits to a depth of 530 feet. This well is thus likely near the thalweg of the stream channel deposits in that area. In contrast to the upstream area, there has been much less variation in water levels between wet periods and droughts in the Frazier Park PUD wells. Water levels in Well No. 5 were frequently measured from 1975-87, and reported by the California Department of Water Resources (Well T9N/R20W-36H1). Depth to water in Well No. 5 ranged from 3 feet in December 1978 to 61 feet in August 1975. Most measured static water levels in Well No. 5 were between about 15 feet and 50 feet deep. At Wells No. 4 and 6, there were still about 140 feet of saturated deposits during drought periods, which is much greater than indicated in the upstream areas.

WELL DATA

Frazier Park PUD

Table 1 provides construction data for Frazier Park PUD water supply wells. Depths of these wells range from 128 to 650 feet. All of these wells are indicated to tap alluvial deposits.

Lake of the Woods

Table 2 provides construction data for Lake of the Woods water supply wells. Depths of these wells ranged from 180 to 700 feet. The base of the stream channel deposits was indicated to be from about 140 feet deep at Well No. 4 to 205 feet deep at Well No. 3. All of the Lake of the Woods wells, except Well No. 5, tapped the hardrock. Wells No. 3 and 7 apparently only tapped the hardrock, whereas the other wells tapped alluvial deposits.

Private Wells between Lake of the Woods and Frazier Park

Completion reports for private wells along Cuddy Creek between Lake of the Woods and Frazier Park indicate well depths ranging from about 120 to 500 feet. Most of these wells are 300 feet deep or shallower and only tap alluvial deposits.

WATER LEVELS

KDSA (2003) prepared a water-level elevation map for the Frazier Park/Lebec Specific Plan area for Spring 2002, and this is provided herein as Figure 4. The measurements corresponded to a wet period. Water-level elevations ranged from 4,990 feet above

TABLE 1 - DATA FOR FRAZIER PARK PUD WATER SUPPLY WELLS

No.	Date Drilled	Total Depth (feet)	Perforated Interval (feet)	Annular Seal (feet)	Casing Diam (inches)
3	10/55	128	42-126	0-6	14
4	7/61	202	39-193	0-39	12
5	1/66	650	100-600	0-50	8
6	7/15	280	60-260	0-55	12
Monte Vista	1960	164	40-164	-	8

Data from well drillers reports and CDOHS Report of November 6, 2000.

TABLE 2 - DATA FOR LAKE OF THE WOODS MWC WATER SUPPLY WELLS

No.	Date Drilled	Total Depth (feet)	Perforated Interval (feet)	Annular Seal (feet)	Casing Diam (inches)
1	5/61	477	121-477	0.22	10
2	9/61	335	Unknown	-	10
3	7/81	490	285-485	0-50	10
4	4/91	500	100-500	0-55	10
5*	11/99	180	80-180	0-55	10
7	4/15	500	180-500	0-165	12

Data from well drillers and completion reports and CDOHS Report of November 6, 2000.

*Well No. 5 was subsequently deepened to a depth of about 700 feet into the hardrock, but little water production was found in the hardrock.

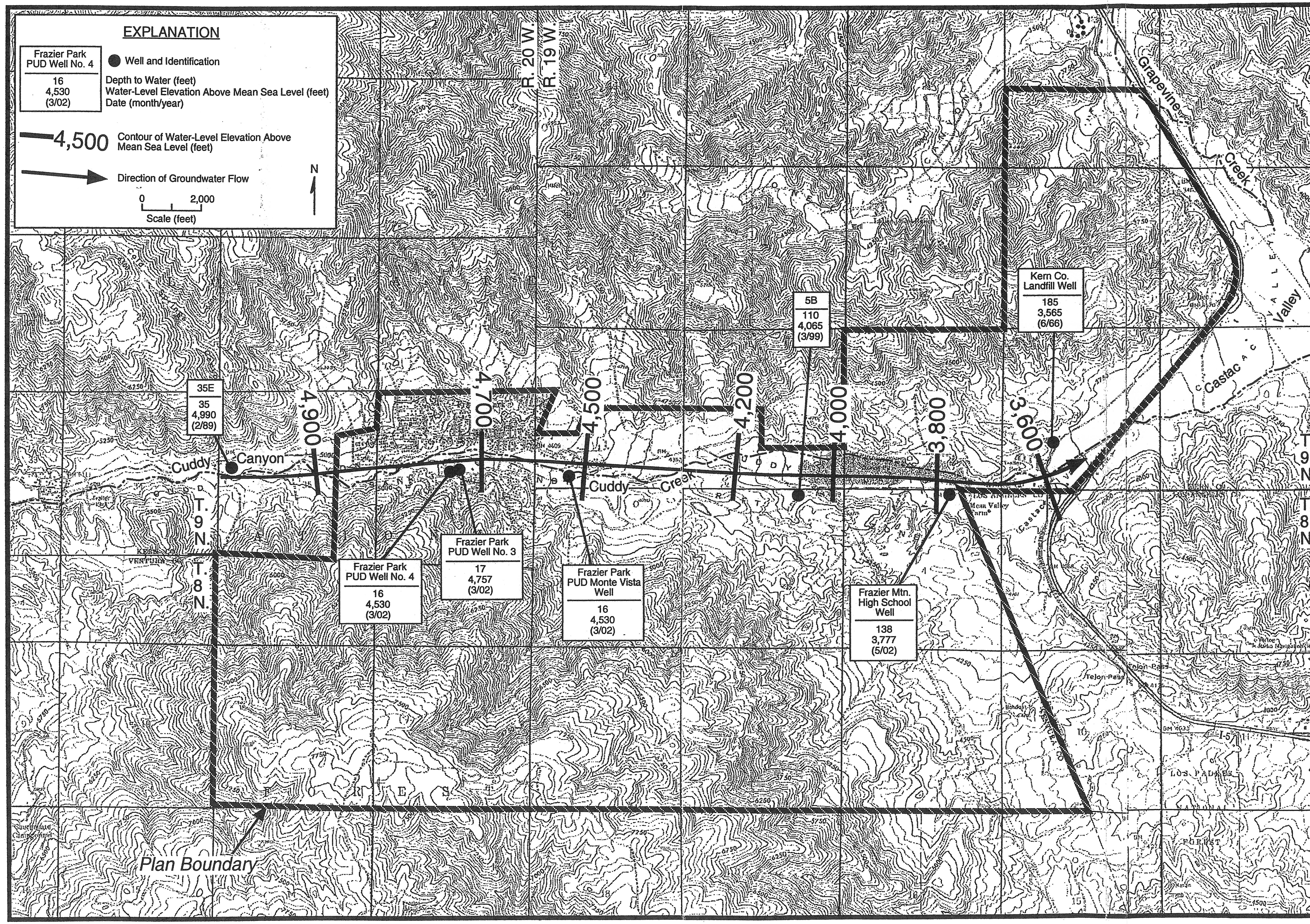

FIGURE 4 - WATER-LEVEL ELEVATIONS AND DIRECTION OF GROUNDWATER FLOW (SPRING 2002)

mean sea level west of the Frazier Park PUD to 4,530 feet at the Monte Vista Well. This indicated an average water-level slope of about 160 feet per mile. Water-level trends for wet and dry periods in the Frazier Park area were discussed previously, under the section on subsurface geologic conditions.

Following is additional information on water levels in Lake of the Woods wells. Static water levels were reported when some of these wells were first constructed and developed. Depth to water in Wells No. 1 and 2 was about 120 feet in 1970. Depth to water in Well No. 3 was 80 feet in July 1981. Depth to water in Well No. 4 was 120 feet in April 1991. Depth to water in Well No. 5 was 40 feet in December 1989. Depth to water in Well No. 7 was 167 feet in July 2015. This variation in depth to water when the wells were developed is highly related to climatic conditions, with the deeper levels being during droughts.

Water-level measurements are available for Lake of the Woods Wells No. 1, 2, 3, 4, and 5 in January 2011, 2012, and 2013, and these are representative of drought conditions. Depth to water in Well No. 1 fell from 146 to 157 feet. Depth to water in Well No. 2 fell from 135 to 160 feet. Depth to water in Well No. 4 fell from 120 to 126 feet. Depth to water in Well No. 5 fell from 156 to 165 feet. Water-level declines in these wells ranged from less than one foot per year at Well No. 4 to 12.5 feet per year at Well No. 2.

WELL PRODUCTION

Frazier Park PUD

KDSA (2003) reported on pump tests for the Frazier Park PUD wells for April 2002. Table 3 also contains information for Well No. 6, which was pump tested in August and October, 2015. Pumping rates for Frazier Park PUD wells ranged from about 200 to 500 gpm. The initial low specific capacity (1.8 gpm per foot) for Well No. 6 compared to the aquifer transmissivity values from the pump test indicated that it was substantially plugged and not fully developed. Subsequently, the well was redeveloped and a specific capacity of 2.7 gpm per foot was obtained, indicating some improvement. The specific capacities for the other wells ranged from 13 to 19 gpm per foot. The highest pumping rates (415 to 515 gpm) were from the two most easterly Frazier Park PUD wells (Well No. 5 and the Monte Vista Well).

Lake of the Woods MWC

DOHS records indicate that Lake of the Woods Well No. 1 had a pump capacity of 197 gpm and Well No. 2 had a capacity of 75 gpm in 1970. When Well No. 3 was constructed, it reportedly produced about 150 gpm in July 1981. When Well No. 4 was constructed, it reportedly produced 40 gpm with a drawdown of 342 feet, or a specific capacity of 0.1 gpm per foot in April 1991. When Well No. 5 was constructed, it reportedly produced 300 gpm

TABLE 3 - PUMP TEST DATA FOR FRAZIER PARK PUD WELLS

Well No.	Date	Pumping Rate (gpm)	Static Level (feet)	Pumping Level (feet)	Specific Capacity (gpm/feet)
3	4/16/02	205	22.5	35.0	16.4
4	4/16/02	370	35.0	44.0	41.1
5	4/16/02	515	46.5	54.0	68.7
6	8/17-18/15	250	40.4	138.5	1.8
	10/27/15	250	40.0	131.3	2.7
Monte Vista	4/16/02	415	16.5	47.5	13.4

Data for Wells No. 3, 4, 5, and the Monte Vista Well from Frazier Park PUD.
Pump test measurements by Farm Pump of Wasco.

in December 1999. Well No. 7 was pump tested on July 16-17, 2015, and produced 18 gpm with a drawdown of 113 feet, and a specific capacity of 0.2 gpm per foot. These variable pumping rates are highly dependent on depth to water. The higher rates are for when substantial groundwater was present in the alluvial deposits.

Private Wells between Lake of the Woods and Frazier Park

Reported short-term yields for most of these wells, which tap alluvial deposits, range from about 10 to 80 gpm.

PUMPAGE

The amount of groundwater delivered for Frazier Park was about 360 acre-feet in 2014. Groundwater pumped in Lake of the Woods was about 120 acre-feet in 2013. After 2013, much less water was able to be pumped in Lake of the Woods, and much of the water used had to be trucked in from Frazier Park and Lebec.

RECHARGE

There are two primary sources of recharge to groundwater in this area. These are seepage from Cuddy Creek streamflow and mountain-front recharge. Available evidence indicates that mountain-front recharge has been more important in the areas downstream of Lake of the Woods. For example, in Frazier Park, mountain-front recharge has sustained the groundwater levels, even in the absence of significant streamflow in Cuddy Creek. Much of the mountain-front recharge is apparently associated with the Cold Springs Canyon drainage (Figure 1), which enters Cuddy Canyon upstream of Frazier Park, and from part of the tributary watershed south of Frazier Park.

AQUIFER CHARACTERISTICS

KDSA (2003) reported on the results of an aquifer test that they conducted in Frazier Park in May 2002. Frazier Park PUD Well No. 4 was pumped continuously for six and a half hours. Well No. 3 located about 80 feet from the pumped well was used as an observation well. The average aquifer transmissivity for the test was 181,000 gpd per foot. The average hydraulic conductivity of the deposits tapped by Well No. 4 was about 1,200 gpd per square foot. These relatively high values are consistent with the coarse-grained nature of the stream channel deposits.

Frazier Park PUD Well No. 6 was pump tested during August 17-18, 2015. A 25.5-hour step drawdown and constant discharge test was conducted. Recovery measurements indicated a transmissivity of 29,000 gpd per foot. This value suggests that a specific capacity of about 20 gpm per foot should have been obtained from a properly constructed and developed well. The low specific capacity for this well (1.8 gpm per foot) indicated that it was substantially plugged, and had not been fully developed. The well was subsequently re-developed and the specific capacity for a 12-hour pump test in October 27, 2015 was 2.7 gpm per foot. This indicated that the redevelopment was only partially successful.

GROUNDWATER IN STORAGE

The Galli Group (2008) provided tables on the amount of groundwater in storage in the West and Middle Sub-basins of Cuddy Canyon. The West Sub-basin extends along an 8,500-foot long reach between Lake of the Woods and just upstream of Frazier Park. The Middle Sub-basin extends along a reach between the east edge of the West Sub-basin and just east of Frazier Park. The amounts of groundwater in storage in the West Sub-basin were:

Depth to Groundwater (ft)	Total Thickness Saturated Deposits (ft)	Average Width for Saturated Deposits (ft)	Groundwater in Storage (acre-ft)
30	170	327	1,300
45	155	309	1,100
60	140	291	950
70	130	279	850
80	120	267	750
90	110	255	650

It is apparent that considering the deep water levels as of June 2015 in Lake of the Woods, there was little groundwater in storage in the alluvial deposits. Thus most of the limited well production at that time was from the hardrock. The amounts of groundwater in storage in the Middle Sub-basin were:

Depth to *Groundwater* (ft)	Total Thickness Saturated Deposits (ft)	Average Width for Saturated Deposits (ft)	Groundwater in Storage (acre-ft)
15	385	629	7,000
20	380	622	6,800
30	370	609	6,500
40	360	595	6,200
50	350	581	5,900
60	340	568	5,700

This indicates that even during droughts, there is a sub-stantial amount of groundwater in storage beneath the Frazier Park area.

GROUNDWATER QUALITY

KDSA (2003) sampled a number of wells in the Frazier Park/ Lebec Specific Plan area in May 2002. That report indicated that exceedances of the Maximum Contaminant Level (MCL) for ei-ther fluoride (2.0 mg/l) or alpha activity (15 picocuries per liter) were common. Alpha activity is an indicator of uranium activity in the groundwater. The lowest fluoride concentrations (less than 1.5 mg/l) were found in a well between Lake of the Woods and Frazier Park, and in water from the Frazier Park PUD Pine Canyon and San Young springs. The lowest alpha activities (less than 6 picocuries per liter) were found in water from the two springs. Figure 5 shows concentrations of selected constituents in groundwater in or near the Frazier Park/Lebec Specific Plan area as of 2002.

Dee Jaspar and Associates (DJA) has provided a report on the water quality for the Frazier Park PUD supply wells (DJA, 2017). The two most important chemical constituents in terms of the Title 22 standards for public water supply in the Frazier Park PUD are uranium and fluoride. The SWRCB, Division of Drinking Water, has indicated that if possible, groundwater in the Cuddy Creek area should be tapped that meets the MCL for uranium (20 picocuries per liter).

DJA (2017) plotted fluoride concentrations and uranium activities in water from Frazier Park PUD wells No. 4, 5, and the Monte Vista Well for the period of record. The fluoride concentrations in water from Well No. 4 have usually ranged from 1.5 to 1.8 mg/l, below the MCL of 2.0 mg/l. The fluoride concentrations in water from Well No. 5 have usually ranged from 1.4 to 1.7 mg/l, also below the MCL. The fluoride concentration in water from the Monte Vista Well have normally ranged from 2.0 to 2.3 mg/l, at or above the MCL. The fluoride concentrations in

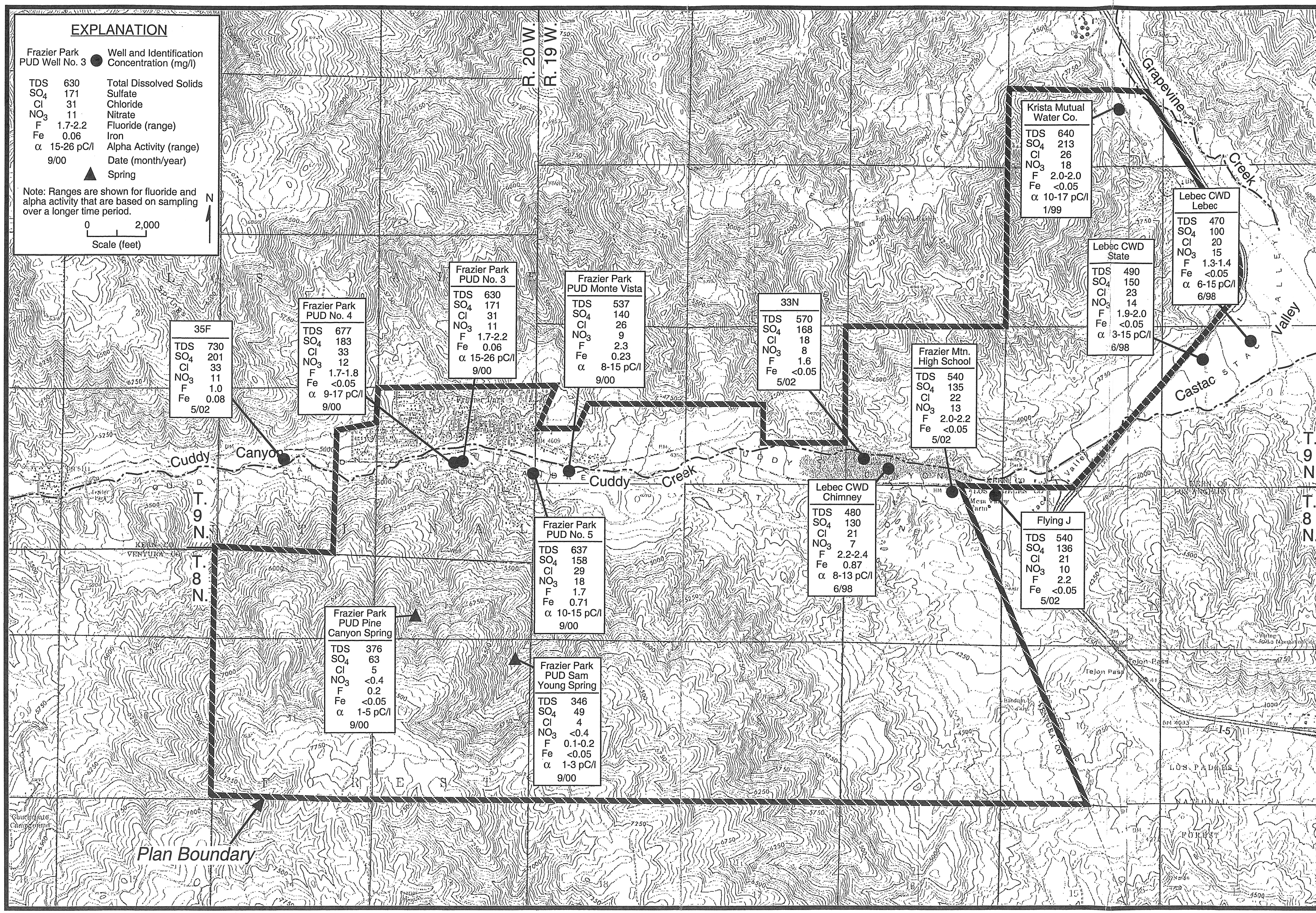

FIGURE 5 - CONCENTRATIONS OF SELECTED CONSTITUENTS IN WELL WATER

water from new Well No. 6 have ranged from 1.7 to 2.0 mg/l. Long-term trends for fluoride concentrations in water from the Frazier park PUD wells have been relatively stable.

Uranium activities in water from Well No. 4 have generally increased since 1994, when they ranged from 10.3 to 13.5 picocuries per liter, to a range of 17 to 20 picocuries per liter during 2011-17. Only two samples from this well have had an activity of 20 picocuries per liter (the MCL) or greater. The uranium activities in water from Well No. 5 have also increased since 1994, when they ranged from 6.7 to 16.7 picocuries per liter, to a range of 15 to 18 picocuries per liter during 2012-17. All test results for Well No. 5 have been below the MCL. Uranium activities in water from the Monte Vista Well have apparently increased from 9.4 to 12.1 picocuries per liter in 1994 to 16 picocuries per liter in 2017. Only one sample from this well (4/20/91) was at the MCL, and no samples exceeded the MCL. Water from Well No. 6 has had uranium activities ranging from 18 to 21 picocuries per liter, close to the MCL.

A review of runoff records for Cuddy Creek and precipitation records at Lebec indicates that lower uranium activities in the Frazier Park PUD well water have been present during wet periods, and high activities during droughts. This trend suggests that streamflow in Cuddy Creek has had low uranium activities, and recharge from creek seepage has reduced the uranium activities in the groundwater. It should be noted that although 2016-17 was indicated to be a wet period from precipitation records, Cuddy Creek did not flow significantly. Thus uranium activities in water from the Frazier Park PUD wells stayed relatively high.

Figure 6 shows concentrations of nitrate and fluoride and uranium activities in water from wells in the Lake of the Woods-Frazier Park area. Nitrate concentrations in water from wells down stream of the Lake of the Woods have ranged from 9 to 21 mg/l, less than the MCL of 45 mg/l. Nitrate concentrations have been elevated (49 to 66 mg/l) in the new Lake of the Woods MWC Well No. 7, exceeding the MCL, and in water from Well No. 1 (23 to 49 mg/l). Because of the relatively small lot size, these higher nitrate concentration may be due to recharge from septic tank effluent. Except for Well No. 2, fluoride concentrations in water from Lake for the Woods MWC wells have been 1.3 mg/l or less, below the MCL. Alpha activities in water from Lake of the Woods MWC Wells No. 4 and 7 ranged from 17 to 21 picocuries per liter, exceeding the MCL of 15 picocuries per liter. The uranium activities in water from Lake of the Woods MWC Well No. 2 ranged from 14 to 18 picocuries per liter, less than the MCL.

RESULTS OF GRAVITY SURVEY

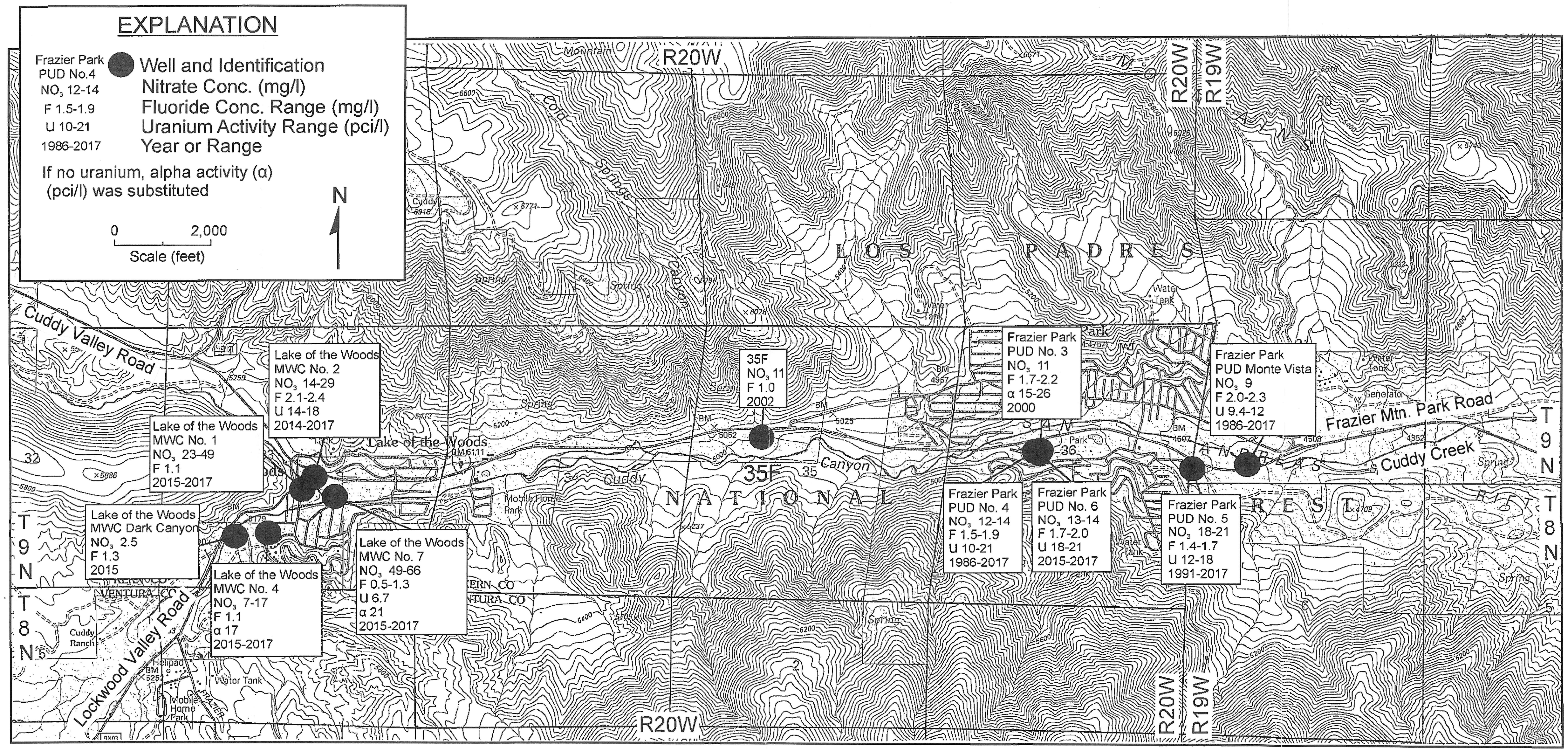

FIGURE 6 - CONCENTRATIONS OF NITRATE, FLUORIDE AND URANIUM ACTIVITIES IN WELL WATER

During September 4-15, 2017, Subsurface Surveys & Associates of Carlsbad conducted a gravity survey along eleven traverses between Lake of the Woods and the east part of Frazier Park (Figure 7). The purpose of the survey was to determine the thickness of alluvial deposits along each traverse. The results of these surveys were generally similar in terms of the approximate depth to the top of the bedrock (hardrock), except for Traverse 1, which passed through Frazier PUD Well No. 5. Four of the surveys were intentionally run through wells where either geologic logs or drillers logs were available, so that the survey could be calibrated. The maximum depths to the top of the hardrock for each of the ten traverses (except 1) ranged from 159 to 230 feet, whereas the maximum depth at Traverse 1 was 830 feet. The deep area along Traverse 1 was interpreted to coincide with a graben (downthrown) structure between two bounding faults.

The shallowest depth to the hardrock (about 170 feet or less) was along Traverses 2, 7, and 9. Traverses 7 and 9 were between Frazier Park and Lake of the Woods. Traverse 2 is near a suspected shallow bedrock area below the lake. Except for Traverse 1, the greatest depths to the top of the hardrock (exceeding 200 feet) were at Traverses 0, 3, 4, 5, and 8.

RECOMMENDATIONS

Figure 7 also shows the locations recommended for test holes.

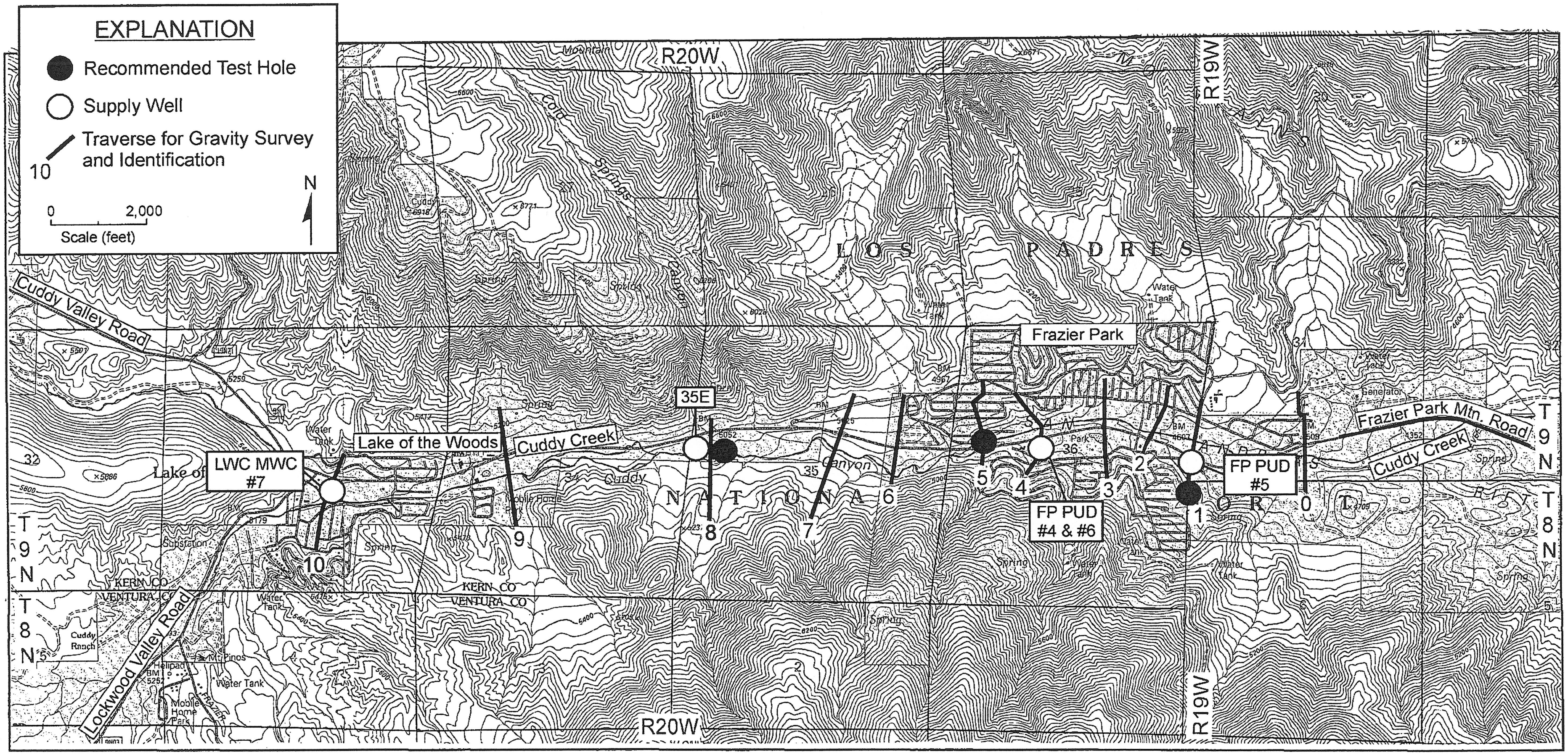

FIGURE 7 - LOCATION OF GRAVITY TRAVERSES AND RECOMMENDED TEST HOLES

The preferred site would be near Traverse 1, south of PUD Well No. 5. The other two test holes would be near Traverses 5 and 8. The test holes would be done by the mud rotary method and electric logged, or drilled by the casing hammer method, which would allow water samples to be collected and airtest yields to be determined at various depths.

REFERENCES

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APPENDIX A

RESULTS OF GRAVITY SURVEY

FRAZIER PARK PUBLIC UTILITY DISTRICT

WATER QUALITY REVIEW, FRAZIER PARK PUBLIC UTILITY DISTRICT PRODUCTION WELLS

BY DEE JASPAR & ASSOCIATES, INC.

DEE JASPAR & ASSOCIATES, INC.
CONSULTING CIVIL ENGINEERS
2730 UNICORN ROAD, BUILDING A
BAKERSFIELD, CA 93308
PHONE (661) 393-4796
FAX (661) 393-4799

October 31, 2017

Tehachapi District, State Waterboards, Division of Drinking Water
4925 Commerce Drive, Suite 120
Bakersfield, CA 93309
Attn: Jesse Dhaliwal, P.E., District Engineer

Re: Water Quality Review, Frazier Park Public Utility District Production Wells

Ladies and Gentlemen:
The subject of this Memorandum is the suitability of the water quality in the Frazier Park P.U.D. wells (“FPPUD”) for provision of temporary water service to the Lake of the Woods area via trucking from Frazier Park to Lake of the Woods. Data reviewed were the “Drinking Water Analyses Results Reports” for the FPPUD for the District’s water production facilities dating back to 1986, together with recent water quality test results from May 25, 2017. Each source will be considered individually, beginning with the two springs, the Sam Young Spring and the Pine Canyon Spring. The springs were not used during the drought. There are contamination issues with the spring boxes and problems with the connective piping. Flow from the springs is minimal (less than 25 gpm each). The springs need to be retested to update their water quality record. Reconnection of these springs is problematic and consideration should be given to the benefit of these springs compared to the cost of operating them. At this time it is not recommended that these springs be reconnected to the District System.

Please refer to the accompanying charts showing the fluoride and uranium concentrations in the FPPUD wells. The springs are not charted – but are discussed in the following paragraphs.

Sam Young Spring
For the period of record (Fluoride = November 1989 – March 2016; Uranium = one test in March 1999) there have been no exceedances in the reported constituents.

<u>Uranium</u>
The only Uranium test of record (Uranium March 10, 1999 = 1.2 pci/l) was well below the MCL of 20.0.
<u>Fluoride</u>
Fluoride concentrations have remained steady at around 0.2 mg/l for the period of record.

Pine Canyon Spring
For the period of record (Fluoride = April 1986 – March 2016; Uranium & Gross Alpha = 1994 & 1999) there have been no reported exceedances in either uranium or fluoride.

Uranium
The last test for uranium was March 10, 1999. Therefore record for uranium is not complete, however, the Gross Alpha and Radium 228 (Radium 228 September 30, 2014 and March 21, 2016) activities were below the DLR of 3.0 and 1.0 pci/l, respectively. Radium 226 was not reported.
Fluoride
Fluoride concentrations have remained steady at around 0.2 mg/l for the period of record.

Monte Vista Well
The Monte Vista well is a standby well that has not provided water to the District's system for a number of years. It is on Standby because Fluoride concentrations in the water exceed the MCL. Iron concentrations have also frequently been above the mcl – however, this is likely due to corrosion of the casing because of the inactivity of the well.

This well is a candidate for blending with other wells in the District due to its relatively lower uranium activity (only one uranium test has been conducted on this well since 2000, however, the recent test indicates that the uranium concentrations in this well, if subsequent tests confirm recent results, are near 16 pci/l).

Uranium
Uranium activity in 1991 was at the MCL of 20.0 pci/l. However, testing between 1994 and 2000 (six tests) revealed uranium activities in the range of 7 to 12 pci/l. No tests between 2000 and 2017 are of record, but the recent sampling of May 25, 2017 revealed a uranium activity of 16 pci/l. This was the lowest of the uranium activity reported in recent samplings of the FPPUD wells.

Fluoride
The Monte Vista well has been inactive for a number of years due to the presence of fluoride near and above the MCL of 2.0 mg/l. The chart shows the concentrations for the period 1986 – 2017. The highest concentration was 2.3 mg/l in 1997, 1998 and 2000. Except for one test in 2000 (1.7 mg/l) all fluoride concentrations were 2.0 – 2.3 mg/l, equal to or exceeding the MCL.

This well should be evaluated over a period of time to determine range of uranium activities and fluoride concentrations, and therefore its candidacy as a well that can blend down uranium activities while at the same time be blended by other wells so that the fluoride concentrations and uranium activities remain below their respective MCLs.

Well 4

Uranium

This well had a uranium activity (20.7 pci/l), above the MCL in 1991. However from 1994 – 1999 the activities were reported to be in the range of 10 to 14 pci/l (six tests). However in 2000 and through the present, uranium activities have been in the 17 – 20 pci/l range, the most recent activity (May 25, 2017) being 20.0 pci/l (at the MCL). Uranium activities appear to be influenced by periods of abundant rainfall and by periods of drought. They are now near the MCL. The reason for the increase is not known, but Cuddy Creek has not had significant flow in it for the past decade. The streamflow is believed to dilute the uranium activities in the groundwater.

Fluoride

Fluoride concentrations in Well 4 have only been above the MCL one time since 1986, and this was in 1994 (2.2 mg/l). Tests in 1986, 89 and 92 all reveal fluoride concentrations less than 2.0 mg/l, as did sampling after 1994. A total of nine samples since 1994 all show fluoride concentrations below 2.0, the most recent being 1.5 mg/l on May 25, 2017. The trend in this well for fluoride concentrations is relatively constant at about 1.5 to 1.8 mg/l.

Well 5

Uranium

Five tests were taken in 1994 (January 16.7 pci/l; April 11.6 pci/l; June 6.7 & 9.9 pci/l, and November 15.3 pci/l – averaging 12.0 pci/l).Tests taken in 2012 – 2017 had uranium activities in the range of 15.0 – 18.0 pci/l, with 18.0 pci/l. The trend for uranium activities in water from Well 5 is upward, as it is for the Monte Vista Well and Well 4.

Fluoride

Fluoride concentrations in the water from Well 5 have remained relatively consistent over the period of record (1986 – 2017). Fluoride concentrations have varied between 1.4 and 1.7 mg/l over the period. There was a slight downward trend for the higher concentrations. The average fluoride concentration was about 1.6 mg/l.

Well 6

Uranium

Well 6 was placed in production in July 2016. Therefore there is a short history of operation for the well. Well 6 is about 200 feet away from Well 4. It was drilled to a depth slightly deeper than Well 4, however, it produces from the same strata as Well 4. There have been four tests for uranium in Well 6: August 2016 (21.0 pci/l), November 2016 (18.0 pci/l), February 2017 (18.0 pci/l), and May 2017 (21.0 pci/l). The activities average 19.5 pci/l, just below the MCL.

Fluoride

Fluoride concentrations in Well 6 (four samples) have ranged from 1.7 to 2.0 mg/l, averaging 1.8 mg/l, which is below the MCL.

Discussion

When averaged, uranium activities in Wells 4, 5, 6, and Monte Vista are just under the MCL of 20.0 pci/l. However there are spikes at or above 20.0 pci/l in Wells 4 and 6. Generally uranium activities are below the MCL at around 18 pci/l in Wells 4, 5 and 6. Well 6 was placed on line in July 2016 and has a very short period of record. It is expected that Well 6 will follow the trends of Wells 4 and 5, which is to remain, on average, just below the MCL.

Uranium activities in the groundwater have been higher during periods of drought, probably due to the absence of recharge due to little or no streamflow in Cuddy Creek. A review of the rainfall records at Lebec and Sandberg (just south of Lebec, east of I-5) reveals the trends in precipitation over the year from 1980 to 2015. The higher uranium activities appear to correspond to a pattern of lower precipitation (1980-1990 and 2006-2015). The lower uranium activities (1994–1999) appear to respond to a period of higher precipitation (1992–1998).

Fluoride concentrations appear to remain relatively constant, not changing in response to Cuddy Creek streamflow.

Conclusion

Uranium

Water quality test records indicate uranium activities fluctuate with periods of drought. For example, during the relatively wet period from 1990 – 1999, uranium activities remained relatively low, compared to today, where, after roughly 10 years of low precipitation and drought, uranium activities have increased in all wells compared to 2000- 2001. It also appears that there is a lag in the influence of wet and dry periods on uranium activities, and thus the effect of the recent wet year may not be apparent for several months to a year, and further, these levels of uranium activity will be affected by the rainfall that the year 2017-18 produces. The Monte Vista Well and Well 5 exhibit lower uranium activities (15.0 – 18.0 Pci/L) than Wells 4 and 6 (17.0 – 21.0 Pci/L). All wells still meet uranium activity standards based on annual averages. Further testing is necessary in order to reach definitive conclusions regarding uranium activities. It appears that a combination of the wells in a mixing scenario would be helpful in controlling uranium activity levels in the system. Additionally it appears that wells drilled very near the thalweg of Cuddy Creek (ref. "Groundwater Conditions in the Frazier Park – Lake of the Woods Area", October, 2017, Kenneth D. Schmidt and Associates) would be most effective in maintaining acceptable uranium activity levels in the system.

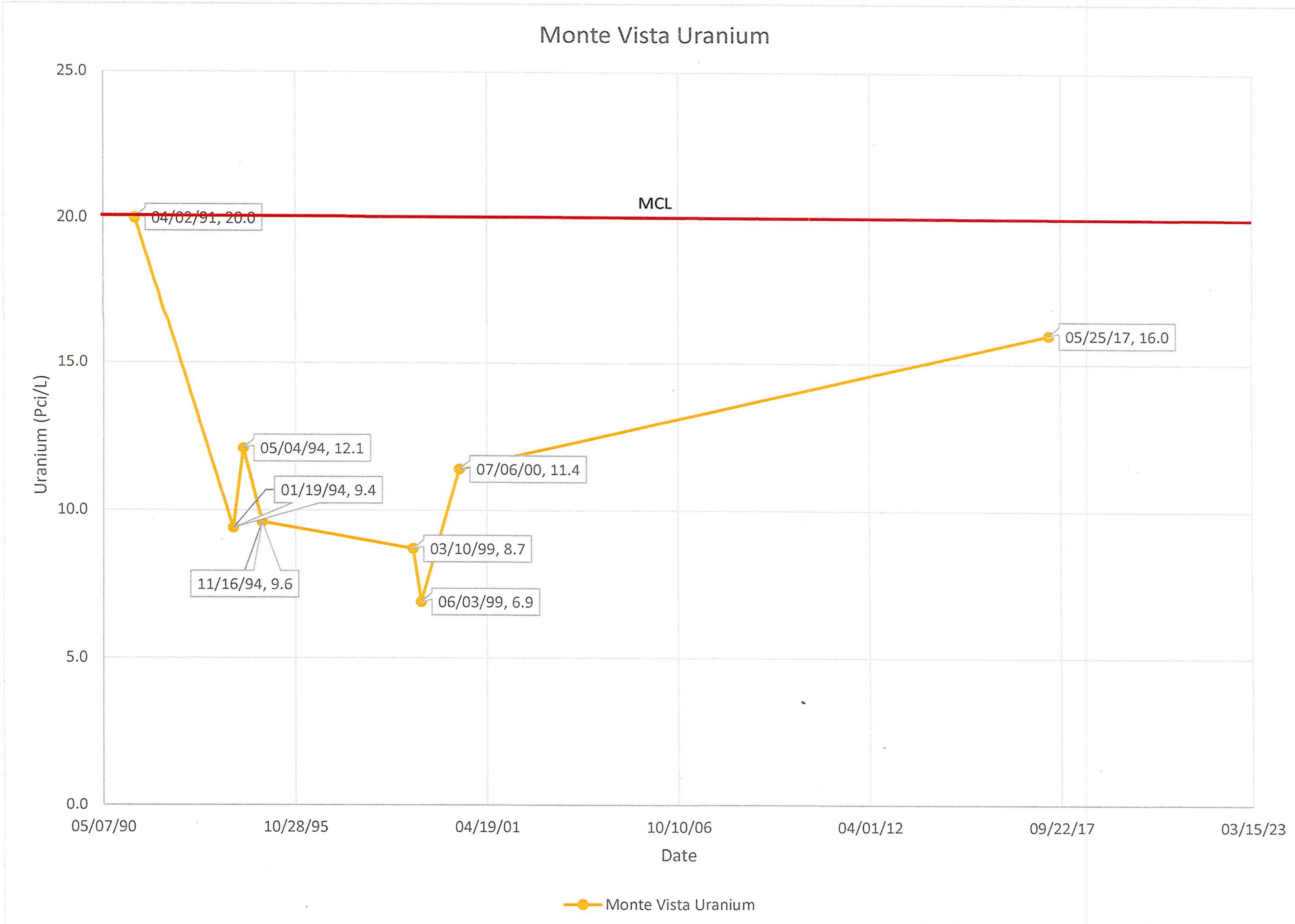
Fluoride

Fluoride levels have remained relatively constant over the period of record and appear to be less affected by wet and dry years. The Monte Vista well is the most affected by fluoride levels at or above the MCL. All remaining wells have been at or just under the MCL with the exception of a 1994 test in Well 4 (2.2 mg/l), which was not characteristic of the fluoride concentrations in that well before or after that date. On an annual average, fluoride appears in all active Frazier Park wells at levels near or below the MCL.

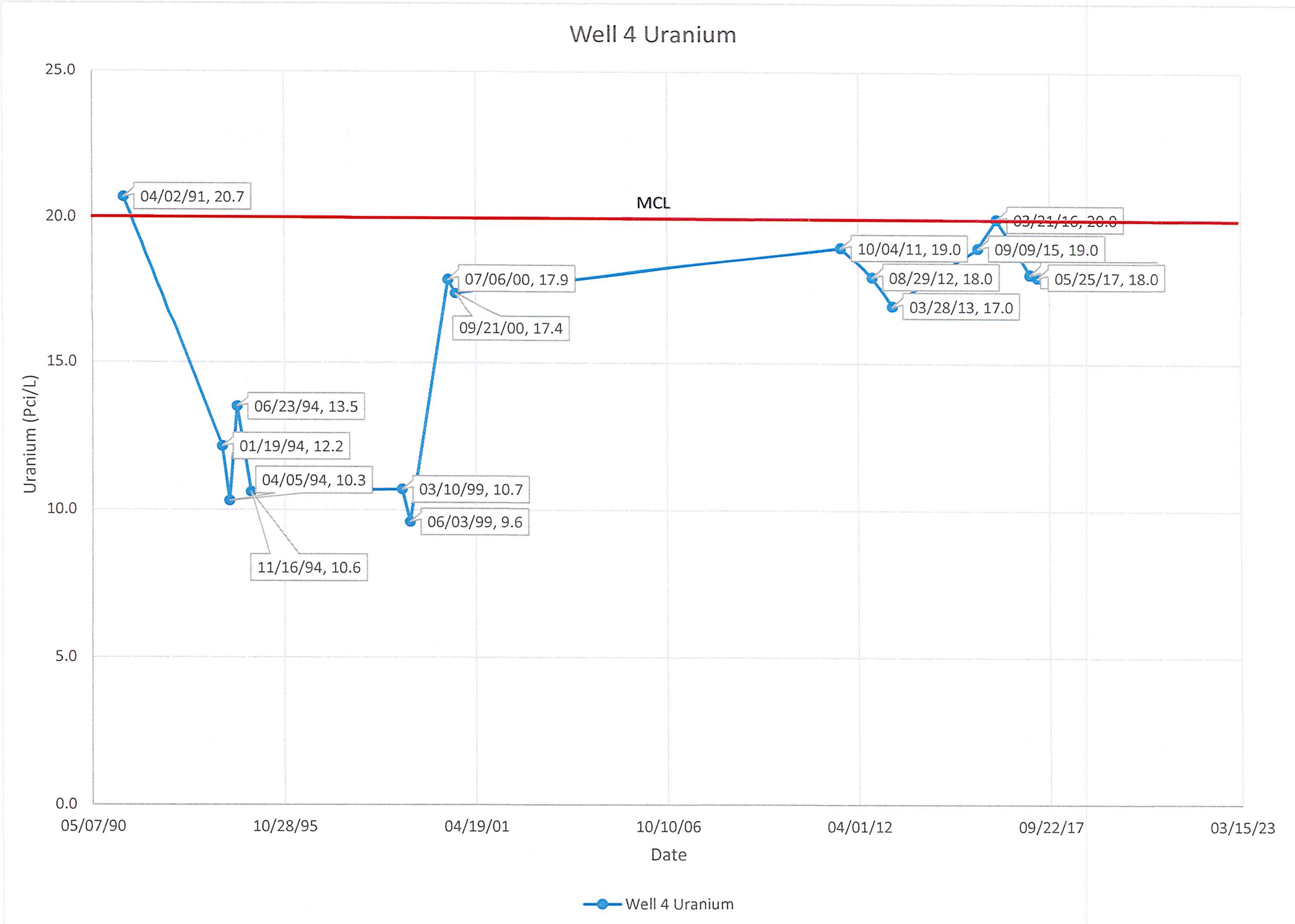
General Observation

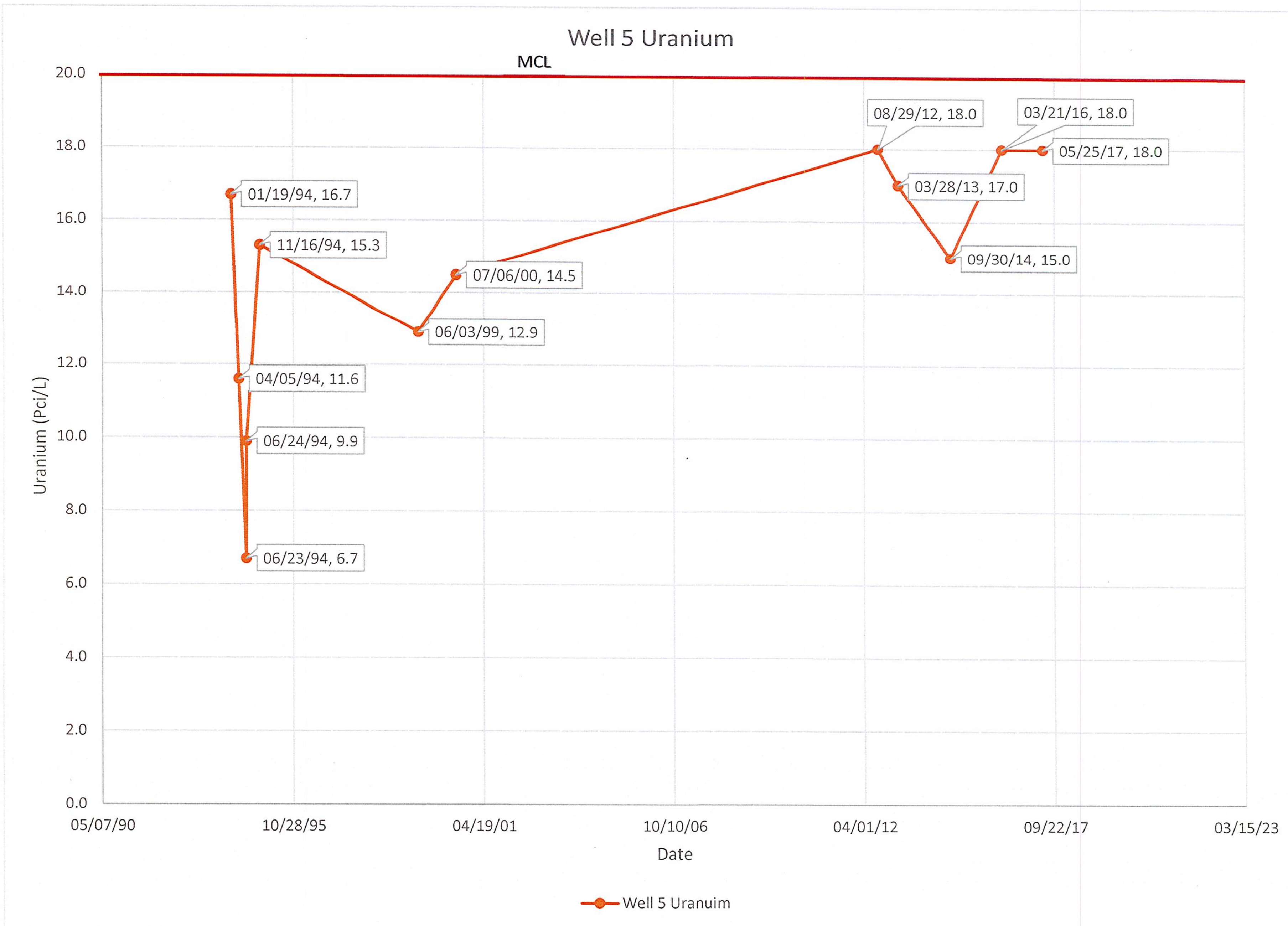
In the absence of a surface water supply, groundwater in the Frazier Park area is the best water source for the Frazier Park–Lake of the Woods area. Active wells, on an annual average, currently meet water quality standards, and the water supply is most reliable in the Frazier Park area. Mixing well production at a central location would appear to be effective in reducing both uranium and fluoride levels in the distribution system. Water quality in the area is affected by long periods of drought or abundance, which consequently affects groundwater recharge in the Cuddy Creek Canyon. The effect of the recent multi-year drought remains an influence on water quality in the Cuddy Creek Canyon, and it is not anticipated to abate until there are several years of normal or above-normal precipitation in the basin.

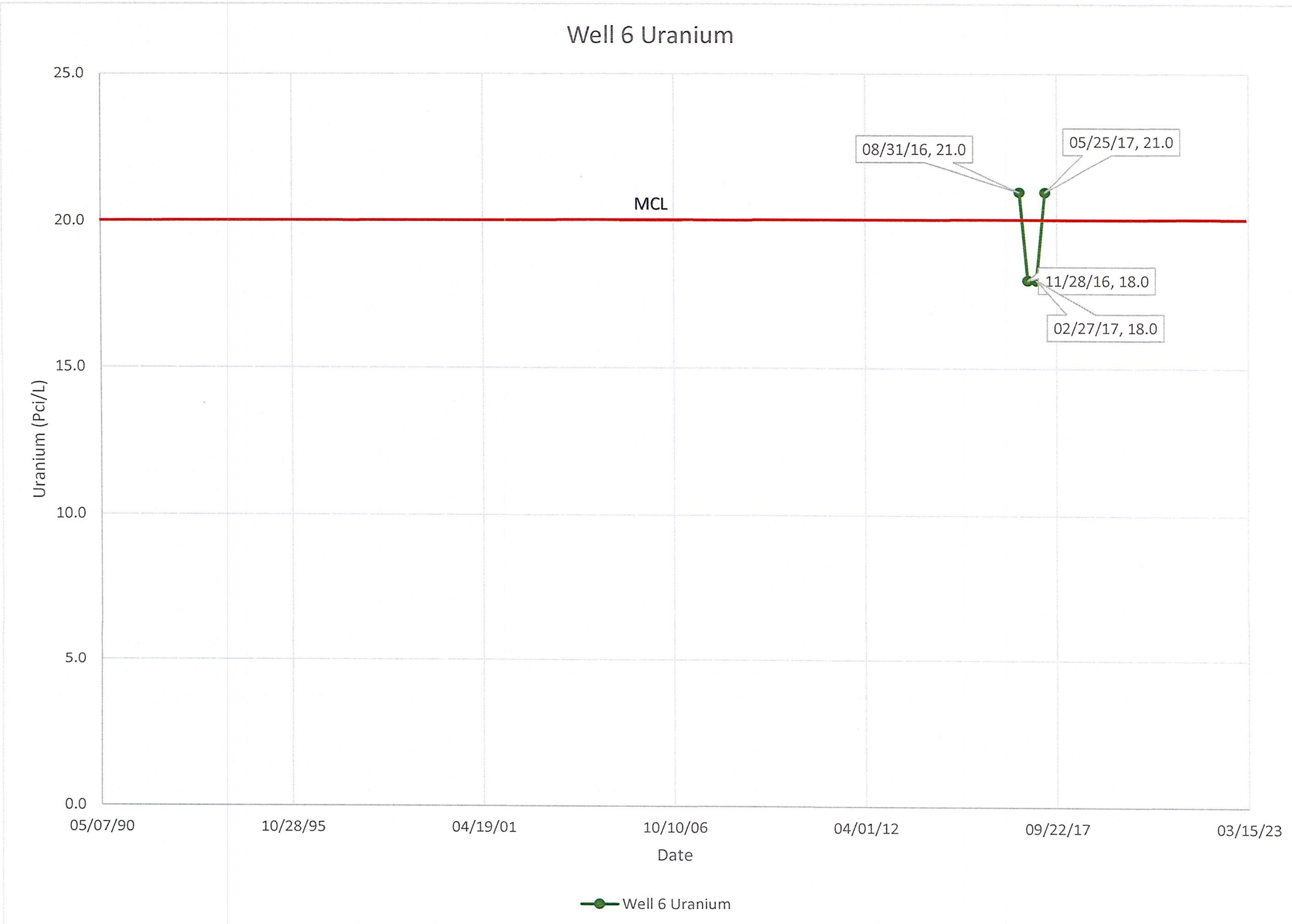
URANIUM ACTIVITIY GRAPHS



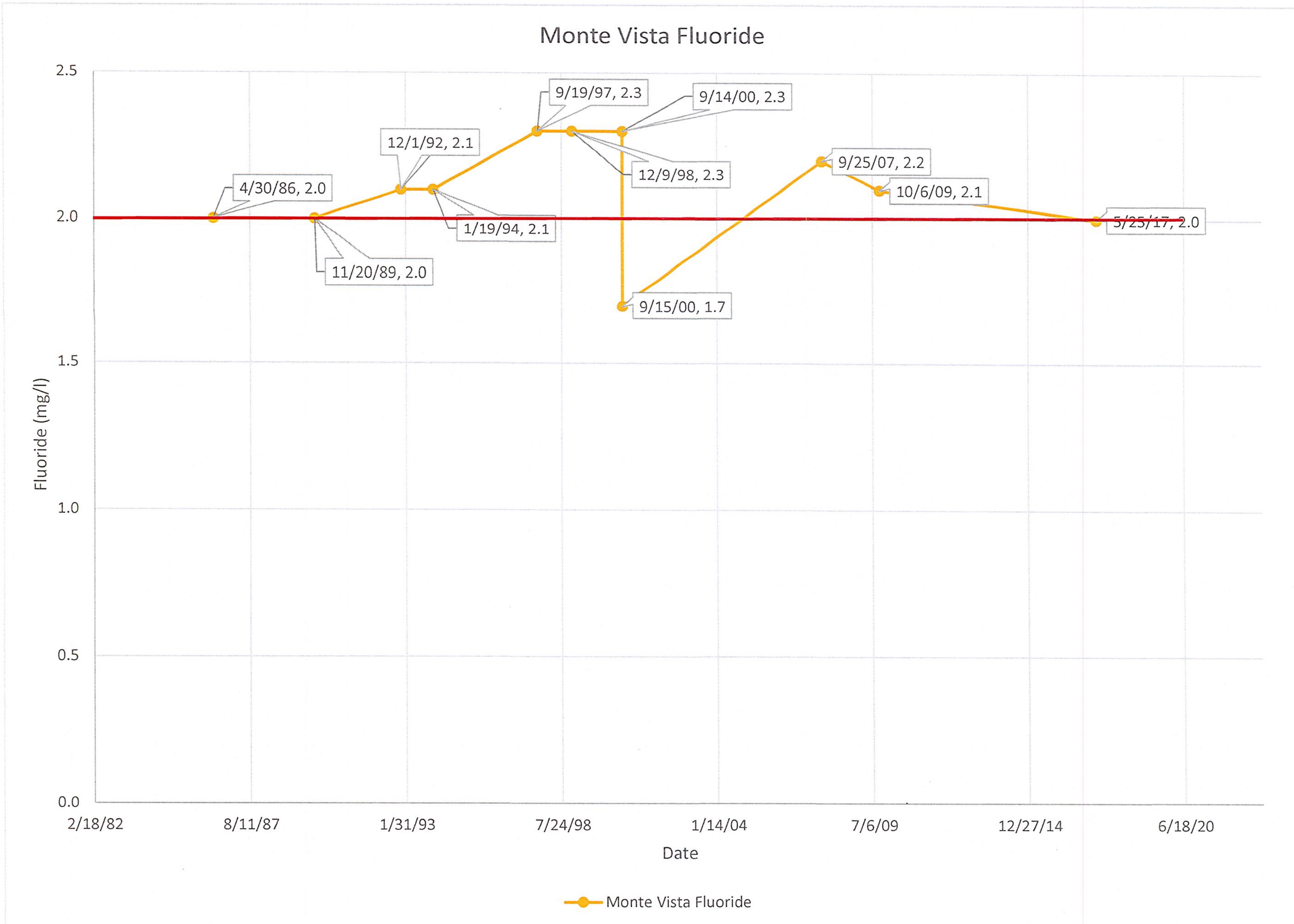
Monte Vista Uranium
Uranium (Pci/L)
25.0
20.0
15.0
10.0
5.0
0.0
MCL
04/02/91, 20.0
05/04/94, 12.1
01/19/94, 9.4
11/16/94, 9.6
07/06/00, 11.4
03/10/99, 8.7
06/03/99, 6.9
05/25/17, 16.0
05/07/90
10/28/95
04/19/01
10/10/06
04/01/12
09/22/17
03/15/23
Date
Monte Vista Uranium

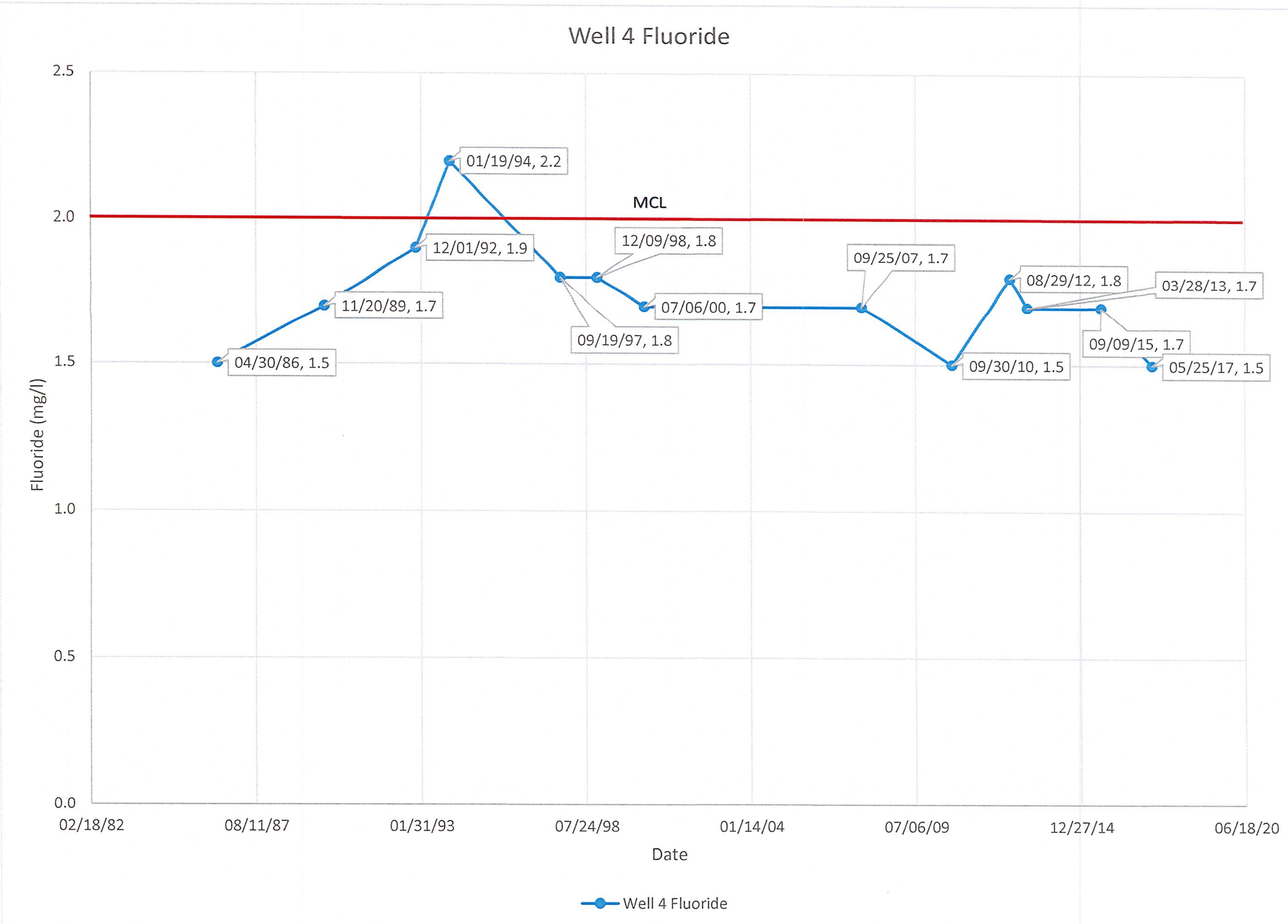

Well 4 Uranium
Uranium (Pci/L)
25.0
20.0
15.0
10.0
5.0
0.0
MCL
04/02/91, 20.7
06/23/94, 13.5
01/19/94, 12.2
04/05/94, 10.3
11/16/94, 10.6
03/10/99, 10.7
06/03/99, 9.6
07/06/00, 17.9
09/21/00, 17.4
10/04/11, 19.0
08/29/12, 18.0
03/28/13, 17.0
09/09/15, 19.0
05/25/17, 18.0
05/07/90
10/28/95
04/19/01
10/10/06
04/01/12
09/22/17
03/15/23
Date
Well 4 Uranium


Well 5 Uranium
MCL
Uranium (Pci/L)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
01/19/94, 16.7
11/16/94, 15.3
04/05/94, 11.6
06/24/94, 9.9
06/23/94, 6.7
06/03/99, 12.9
07/06/00, 14.5
08/29/12, 18.0
03/28/13, 17.0
09/30/14, 15.0
03/21/16, 18.0
05/25/17, 18.0
05/07/90
10/28/95
04/19/01
10/10/06
04/01/12
09/22/17
03/15/23
Date
Well 5 Uranuim

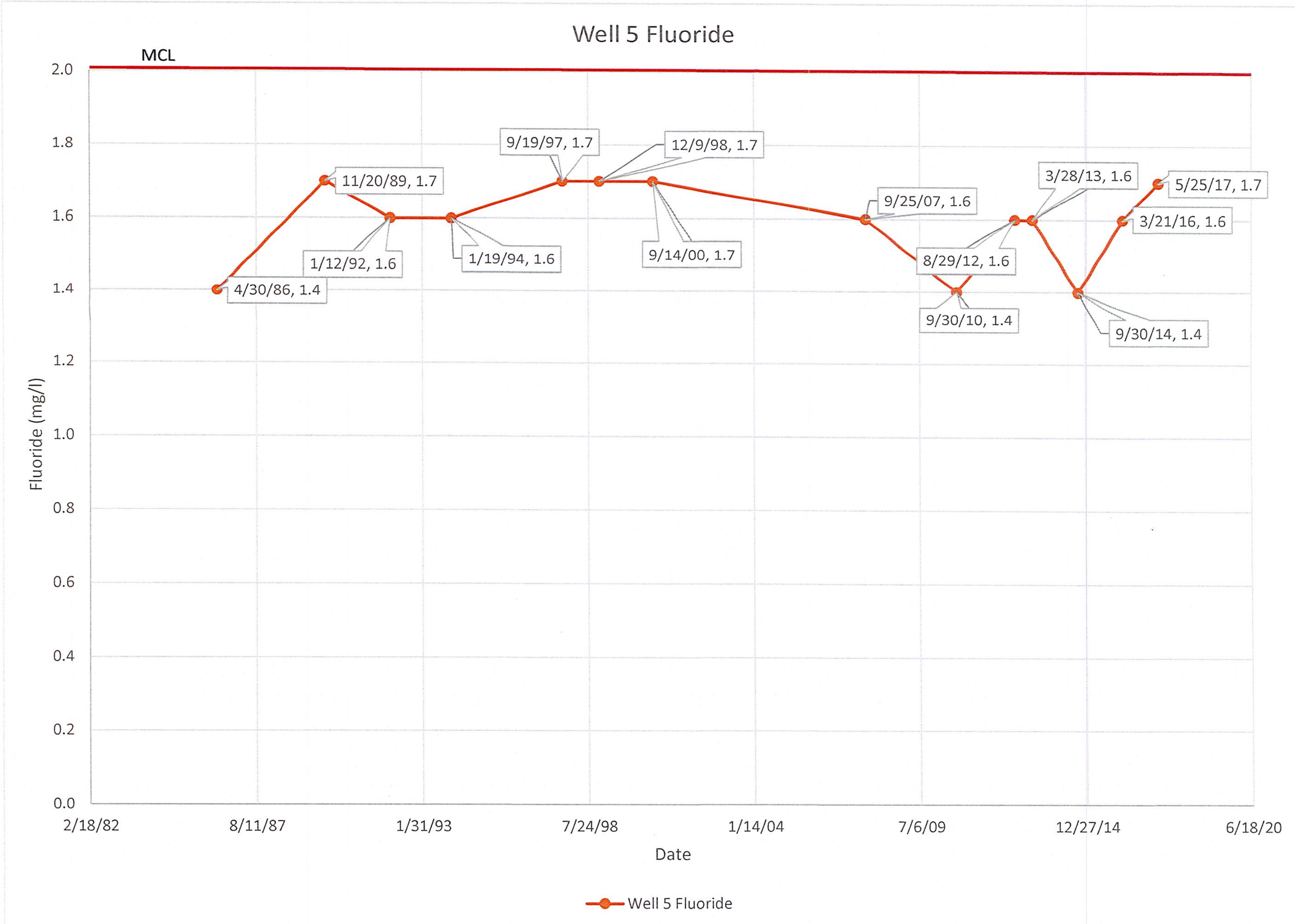

Well 6 Uranium
25.0
20.0
15.0
10.0
5.0
0.0
Uranium (Pci/L)
MCL
08/31/16, 21.0
05/25/17, 21.0
11/28/16, 18.0
02/27/17, 18.0
05/07/90
10/28/95
04/19/01
10/10/06
04/01/12
09/22/17
03/15/23
Date
Well 6 Uranium

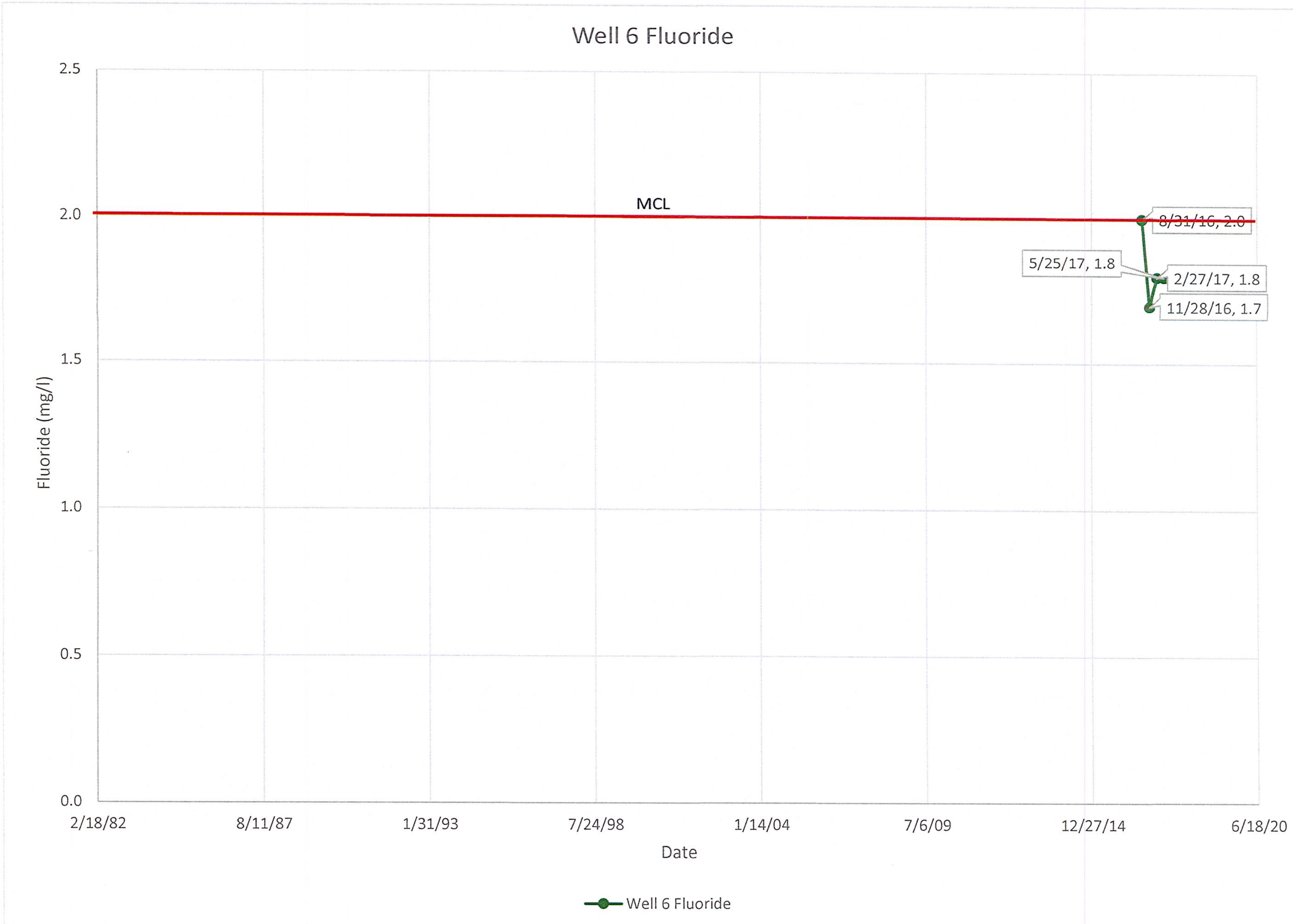
FLUORIDE CONCENTRATION GRAPHS


Monte Vista Fluoride
Fluoride (mg/l)
2.5
2.0
1.5
1.0
0.5
0.0
4/30/86, 2.0
11/20/89, 2.0
12/1/92, 2.1
1/19/94, 2.1
9/19/97, 2.3
12/9/98, 2.3
9/14/00, 2.3
9/15/00, 1.7
9/25/07, 2.2
10/6/09, 2.1
5/25/17, 2.0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
7/6/09
12/27/14
6/18/20
Date
Monte Vista Fluoride



Well 4 Fluoride
2.5
2.0
1.5
1.0
0.5
0.0
Fluoride (mg/l)
MCL
01/19/94, 2.2
12/01/92, 1.9
11/20/89, 1.7
04/30/86, 1.5
12/09/98, 1.8
09/19/97, 1.8
07/06/00, 1.7
09/25/07, 1.7
09/30/10, 1.5
08/29/12, 1.8
03/28/13, 1.7
09/09/15, 1.7
05/25/17, 1.5
02/18/82
08/11/87
01/31/93
07/24/98
01/14/04
07/06/09
12/27/14
06/18/20
Date
Well 4 Fluoride


Well 5 Fluoride
MCL
Fluoride (mg/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
4/30/86, 1.4
11/20/89, 1.7
1/12/92, 1.6
1/19/94, 1.6
9/19/97, 1.7
12/9/98, 1.7
9/14/00, 1.7
9/25/07, 1.6
8/29/12, 1.6
9/30/10, 1.4
3/28/13, 1.6
9/30/14, 1.4
3/21/16, 1.6
5/25/17, 1.7
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
7/6/09
12/27/14
6/18/20
Date
Well 5 Fluoride



Well 6 Fluoride
2.5
2.0
1.5
1.0
0.5
0.0
Fluoride (mg/l)
MCL
8/31/16, 2.0
5/25/17, 1.8
2/27/17, 1.8
11/28/16, 1.7
2/18/82
8/11/87
1/31/93
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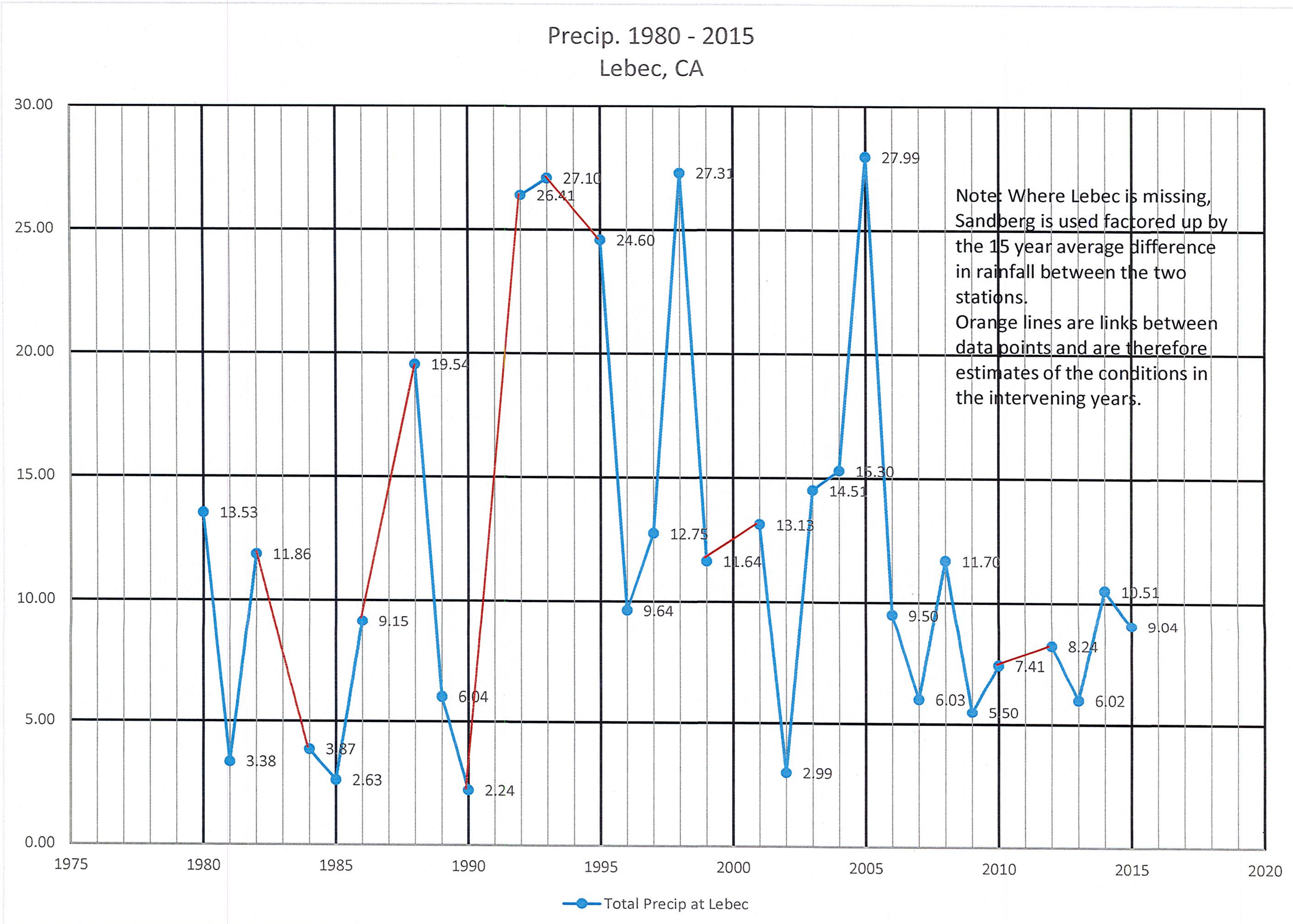
1/14/04
7/6/09
12/27/14
6/18/20
Date
Well 6 Fluoride

RECORDED PRECIPITATION



Precip. 1980 - 2015
Lebec, CA
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
13.53
3.38
11.86
3.87
2.63
9.15
19.54
6.04
2.24
26.41
27.10
24.60
9.64
12.75
27.31
11.64
13.13
2.99
14.51
15.30
27.99
9.50
6.03
11.70
5.50
7.41
8.24
6.02
10.51
9.04
Note: Where Lebec is missing, Sandberg is used factored up by the 15 year average difference in rainfall between the two stations.
Orange lines are links between data points and are therefore estimates of the conditions in the intervening years.
Total Precip at Lebec

FRAZIER PARK PUBLIC UTILITY DISTRICT

GRAVITY SURVEY SUMMARY REPORT – FRAZIER PARK, CA

BY SUBSURFACE SURVEYS AND ASSOCIATES, INC.

Subsurface Surveys & Associates, Inc.
2075 Corte Del Nogal, Suite W Carlsbad, CA 92011
Phone: (760) 476-0492 Fax: (760) 476-0493

Dee Jaspar and Associates
2730 Unicorn Road
Bakersfield, CA 93308

November 4, 2017

Attn: Dee Jaspar

Re: Final - Gravity Survey Summary Report
Frazier Park, California

This report covers the results of a gravity survey performed across the Cuddy Creek Valley in Frazier Park, California. The main objective was to map the depth and configuration of bedrock and provide cross sections showing the thickness of the overlying sediments. This information should be useful for selecting sites for future water wells.

The field work was conducted during September 4 - 15, 2017 and was carried out according to the scope of work outlined in Subsurface Surveys proposal dated August 20, 2017. On September 5, three additional traverses were added to the original eight bringing the total to eleven. The location and length of the traverses were provided by Ken Schmidt and Associates, the hydrogeology consultants for this project. During the fieldwork many of the lines were lengthened and extended to bedrock outcrop for modeling and depth calculation purposes. Survey location maps are provided on Figures 1-5.

GEOLOGIC SETTING

A review of the "Preliminary Geologic Map of the Frazier Mountain 7.5' Quadrangle" Version 1.0", (California Geological Survey, 2016) indicates the local area is underlain by Lebec granodiorite (Kle) of Cretaceous age on the north side of Cuddy Creek. To the south, the mountain slopes are mapped as Paleo-proterozoic quartzo-feldspathic gneiss (Xgn). Sediments along the valley floor are Holocene alluvium and alluvial fan deposits.

GRAVITY METHOD

The gravity method as applied to this project involves using a portable gravimeter to measure changes in the earths gravitational field at regular intervals along survey traverses. Changes in depth to hard bedrock, and thus the thickness of the less dense overburden, will produce a localized variation or "anomaly" in the gravity field. Using known depths to bedrock from well data as calibration points, the density contrast between bedrock and the overlying sediments can be derived and used to calculate depths along the profile. This method assumes there is not a significant lateral variation in the density of the sediments and that the density of bedrock is fairly consistent across the site.

DATA ACQUISITION AND FIELD METHODS

Gravity observations were made with a La Coste and Romberg Model G gravimeter. Measurements made with this instrument can be recorded to the nearest 0.001 milliGal, however the overall repeatability is about 0.01 milliGal. Profile stations were laid out in advance of the survey using 100-foot spacing. The stations were marked by a feathered nail and in some cases additional ribbon flagging.

The survey is referenced to U.S.G.S. gravity base station PB2N03A located north of I-5 in the nearby town of Gorman. The observed gravity value for PB2N03A is 979,408.223 mGal and is tied to the International Gravity Standardization Net established in 1971 (IGSN 71). Because the survey area is located many miles away, a field base (M6Base) was established to provide easy access at all hours during the day. It is located in the northeast corner of the Flying J Truck Center and was established by performing two complete survey loops between the two bases. This makes the Frazier Park gravity data set compatible with other regional gravity data collected in this region. The observed gravity at M6Base is 979,412.992 mGal. Photographs of both base stations are provided in Appendix C.

Station locations and elevations were determined by a precision GPS (Global Positioning System) land survey that used a Trimble GeoExplorer 6000 XH receiver. This instrument used differential corrections to achieve sub-foot accuracy, mostly in the range of 4-8 inches. Latitude and longitude positions are based on the WGS 1984 North American Datum.

DATA PROCESSING

Gravity readings were reduced to complete (i.e. terrain corrected) Bouguer anomalies by computer using a system of software programs developed by P. Walen (OBSG2, 1988). The readings are first converted to milliGals by applying a dial conversion constant. The data is then corrected for the combined effect of ridig earth solar and lunar tides and linear meter drift, to produce an observed gravity value. Finally, latitude, free air, Bouguer slab, and terrain corrections are applied to produce a complete Bouguer anomaly. The following equation was used for this process:

$$CBA = Gobs - (theoG - fa + S - T)$$

Where

- Gobs = observed gravity
- TheoG = theoretical gravity for station latitude
- fa = free air correction
- S = Bouguer slab correction using an assumed crustal density of 2.67 grams/cm3
- T = terrain correction which modifies the slab value for actual topography surrounding the observation point.

Gravity readings were corrected for terrain effects out to a distance of 2000 meters around each station. This was accomplished with the InnerTC program developed by Geopotential Software, Inc. The program uses Digital Elevation Model (DEM) data made available by the U.S.G.S. and sold through commercial map stores. The gravity data from this survey was corrected using DEM files with 10 meter spacing.

DISCUSSION AND INTERPRETATION OF RESULTS

Survey results are displayed on two dimensional cross sections showing bedrock depth and configuration and the thickness of overlying alluvial sediments (see Figures 6-16). Appendix A provides a complete listing of the gravity *Principal Facts,* which includes latitude and longitude, elevation, terrain corrections, and complete Bouguer anomalies. Appendix B has listings of the GPS data and Appendix C provides photographs of the base stations.

After corrections and reductions are applied to the gravity data, the resultant Complete Bouguer Anomalies reflect changes in density between basement rocks (assumed to be 2.67 g/cm3) and the alluvial sediments. To use the CBA values for modeling the thickness of alluvium, an effective density contrast has to be determined. This was accomplished by using points of known bedrock depth from water wells PUD 5, PUD 6, 35E, and MWC-7. Well 34E was not used because its location relative to Traverse 9 was not known. Also, many of the gravity traverses ended with stations directly on outcrop which provides anchor points of zero depth.

Using inverse calculations, a density contrast was derived that produced the best fit with the well data. The overall range was 0.46-0.56 g/cm3. Traverses without well logs were processed with the density contrast derived from the nearest well site. The maximum bedrock depth along each traverse is listed in the table below:

Traverse	Maximum Depth (feet)	Station
0	220	0-5
1	830	1-8
2	171	2-7
3	218	3-0
4	200	4-4
5	230	5-4
6	195	6-6
7	159	7-5
8	222	8-2
9	167	9-12
10	188	10-8

As shown above, bedrock depth varied from 159 - 230 feet with the exception of Line 1 where the depth is projected to be approximately 830 feet. The south half of Traverse 1 crosses over a suspected graben structure with north and south bounding faults. The high angle bedrock interface, on the north side of this feature, correlates with an inferred fault trace shown on the geologic map described in the Geologic Setting. The mapped fault trend is southeast.

To further explore the extent and lateral boundaries of this structure, Traverse 0 could be extended from Station 0 southward to the base of the range front. Also, please note that the dip of the suspected fault traces are expected to be at a higher angle than shown on the cross section. This is because gravity is a potential field measurement and processing tends to flatten high angle structures.

The gravity work, in combination with the GPS land survey and the sophisticated terrain corrections using 10 meter DEMs, was successful in accomplishing the main objectives of the project.

All data acquired during this survey is considered confidential and is available for review by your staff at any time. Please call if there are any questions.

PAWalen

Phillip A. Walen
Senior Geophysicist
CA Registration No. GP917

Gravity Survey Location Map -- Traverse 0-10

Figure 1

Gravity Survey Location Map -- Traverse 0 and 1

N

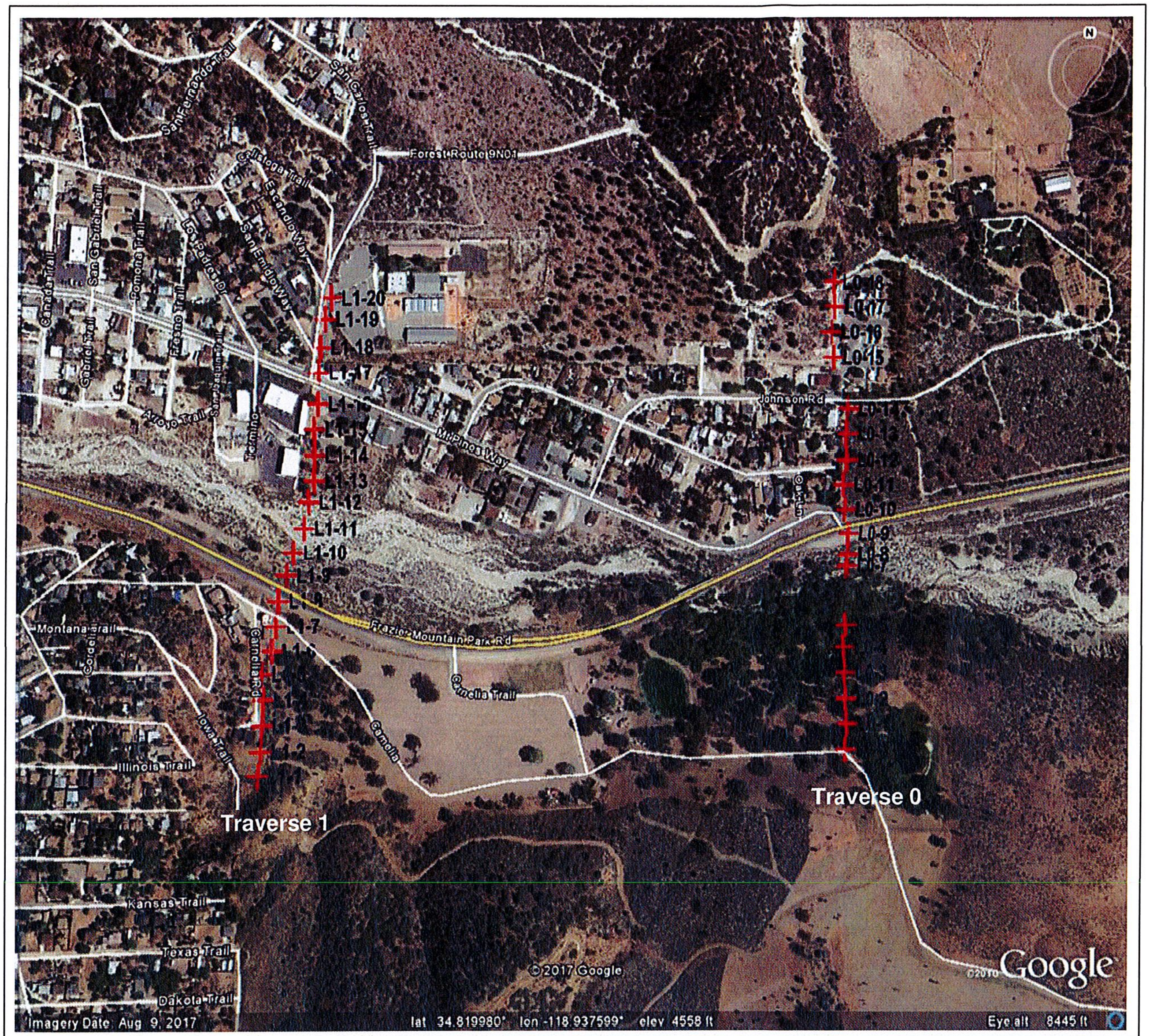


Figure 2

Gravity Survey Location Map -- Traverse 2 - 5

N

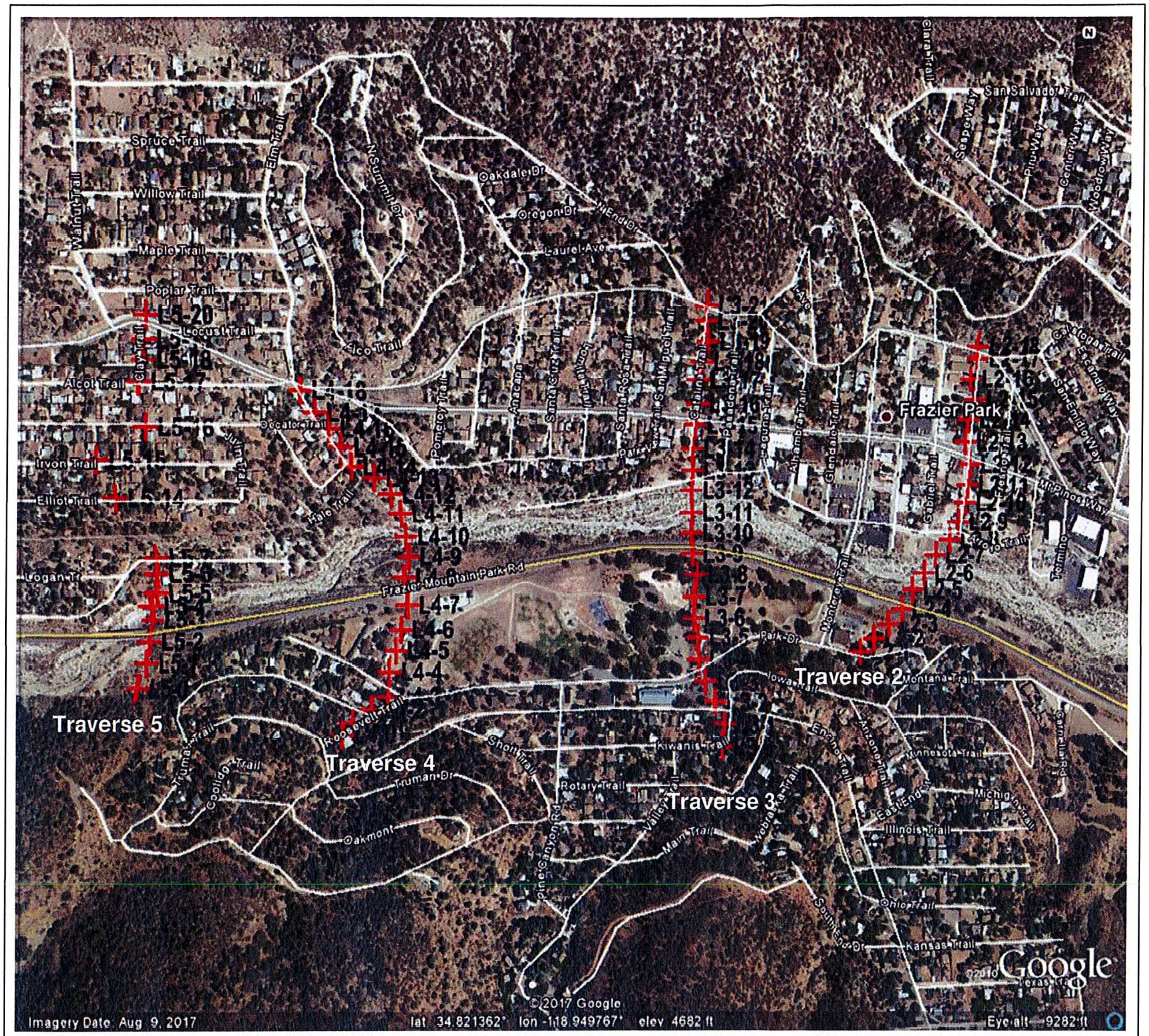


Figure 3

Gravity Survey Location Map -- Traverse 6 - 8

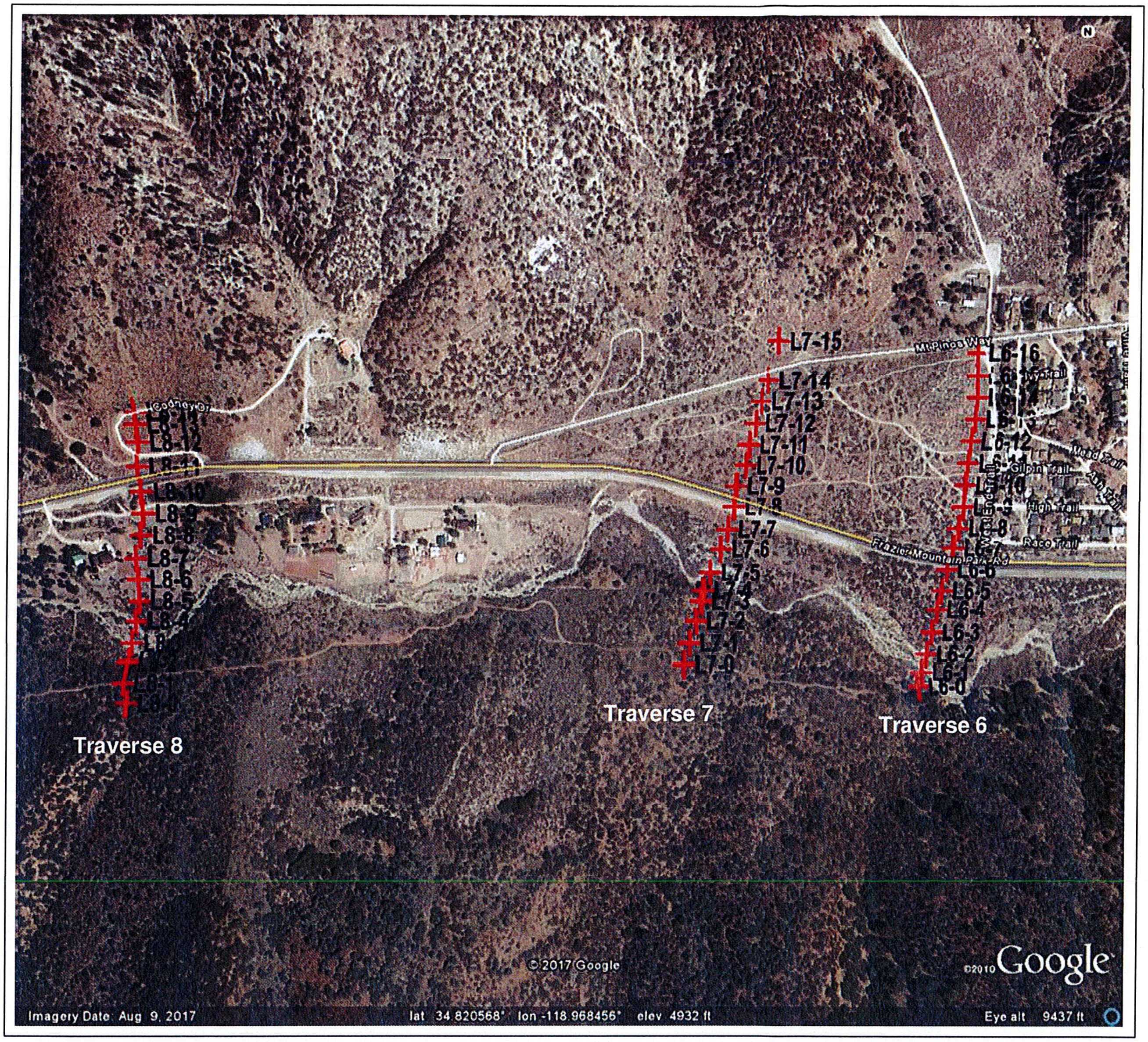


Figure 4

Gravity Survey Location Map -- Traverse 9 and 10

Figure 5

Bedrock Profile - Line 0

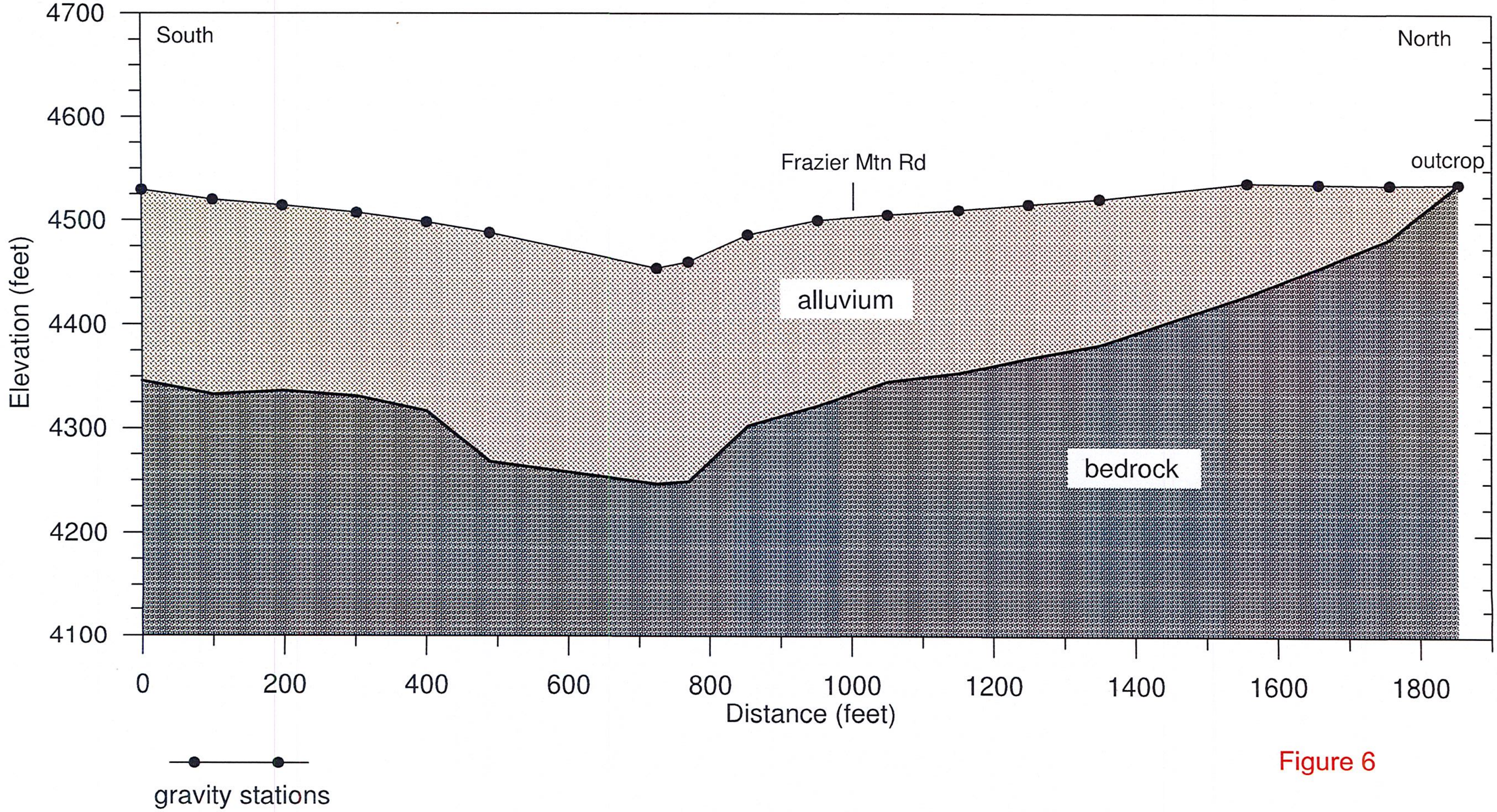


Figure 6

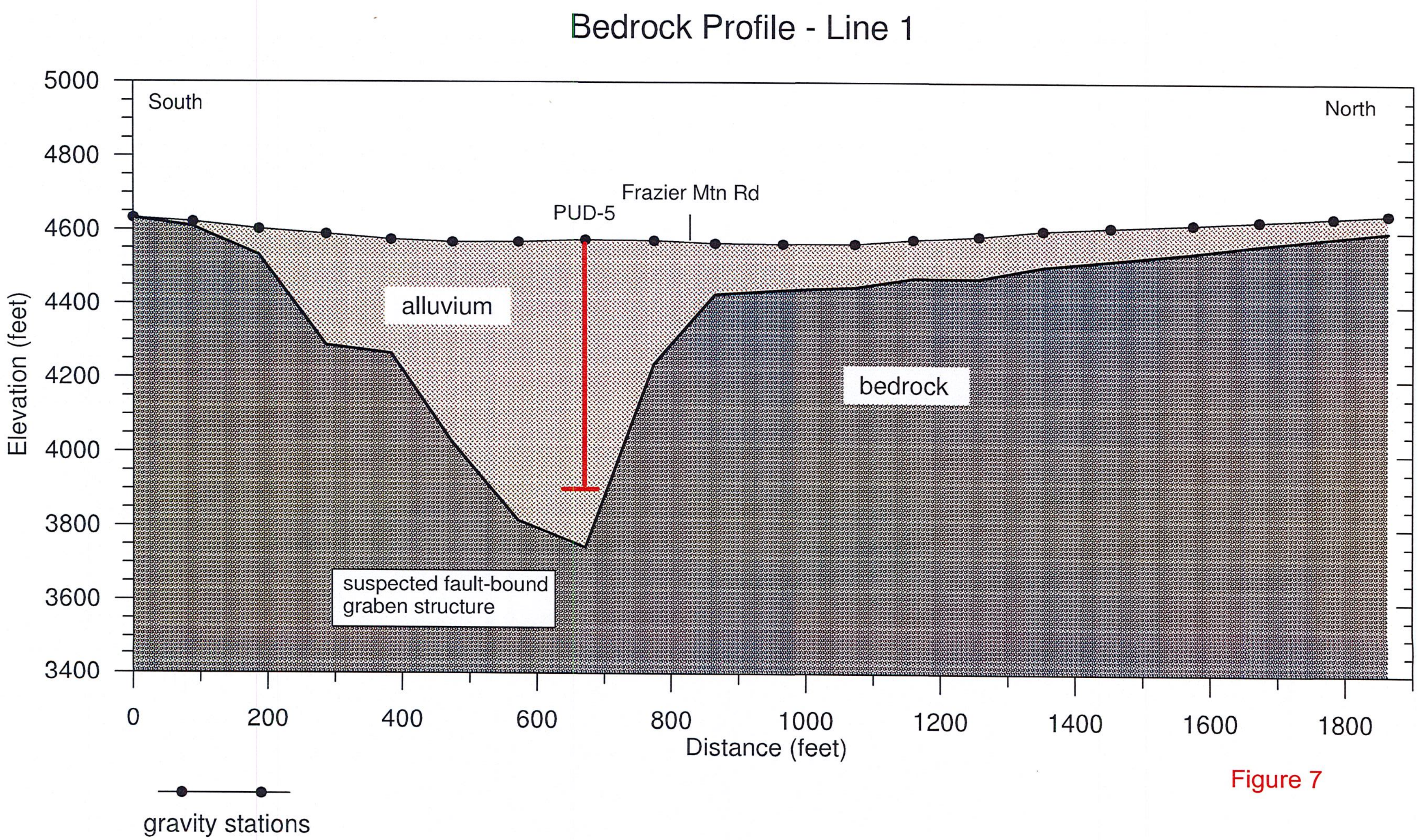

Bedrock Profile - Line 1
South
North
Frazier Mtn Rd
PUD-5
alluvium
bedrock
suspected fault-bound
graben structure
Elevation (feet)
5000
4800
4600
4400
4200
4000
3800
3600
3400
0
200
400
600
800
1000
1200
1400
1600
1800
Distance (feet)
gravity stations

Figure 7

Bedrock Profile - Line 2

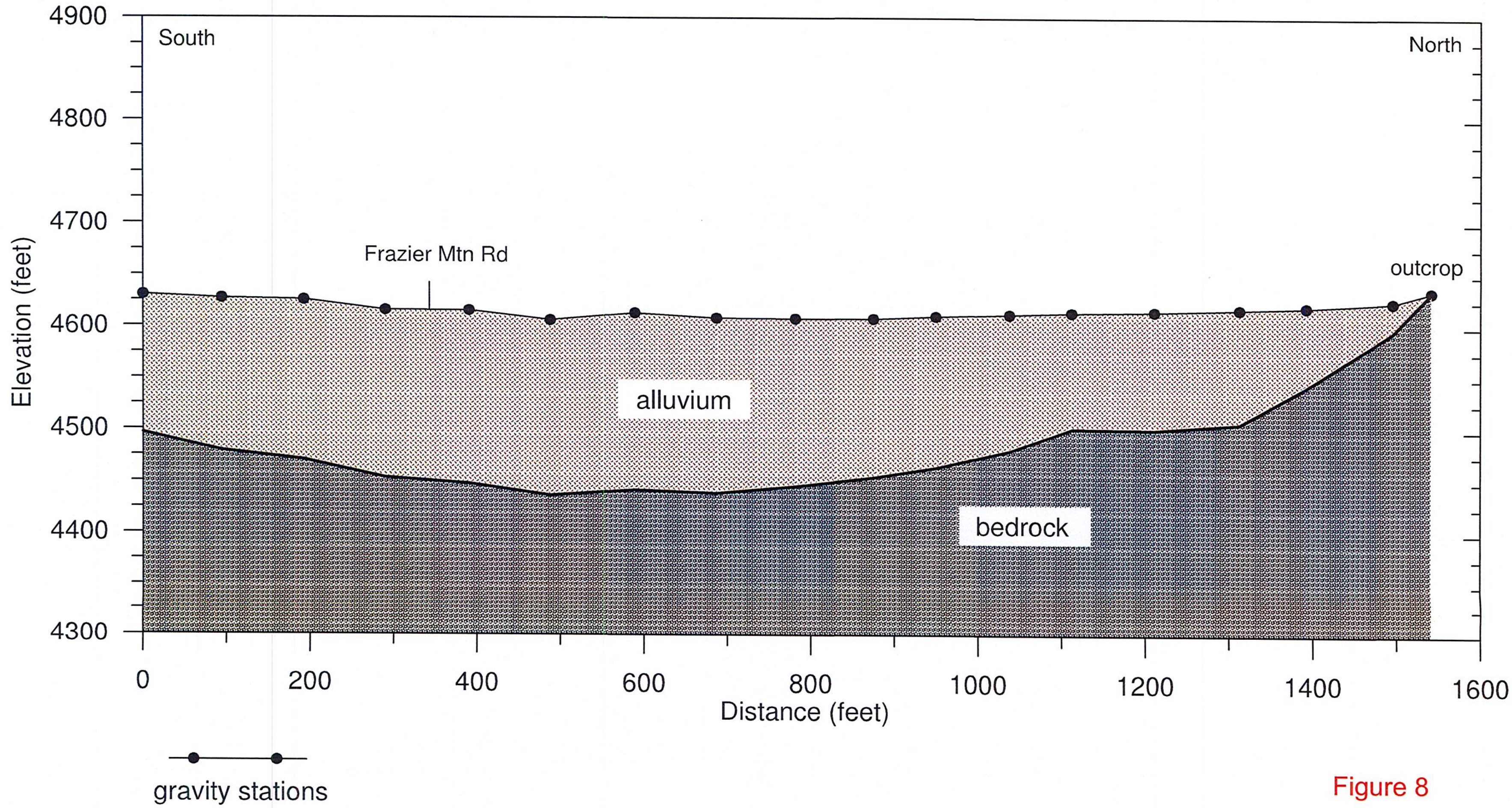
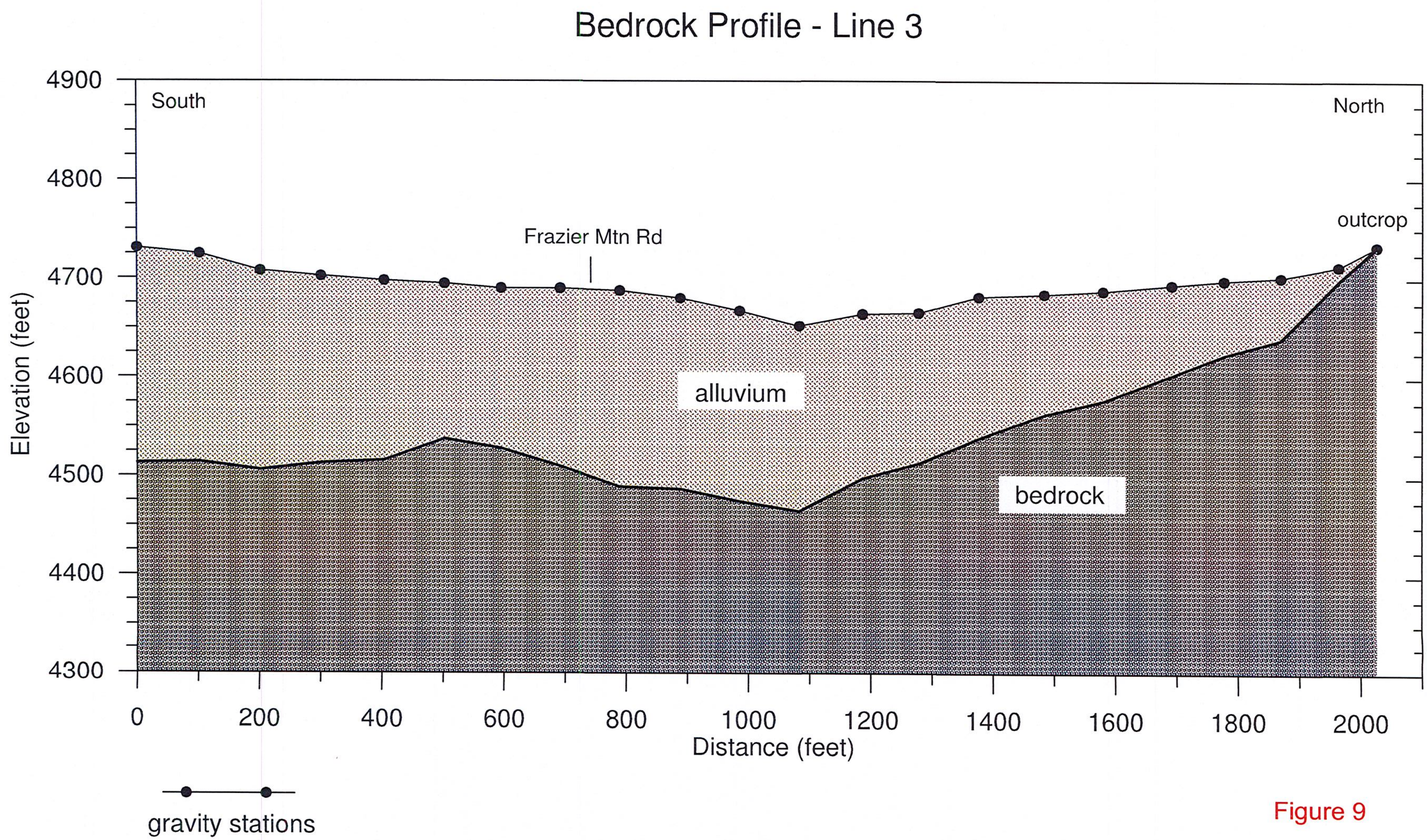


Figure 8



Bedrock Profile - Line 3
4900
4800
4700
4600
4500
4400
4300
Elevation (feet)
South
North
Frazier Mtn Rd
outcrop
alluvium
bedrock
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Distance (feet)
gravity stations

Figure 9

Bedrock Profile - Line 4

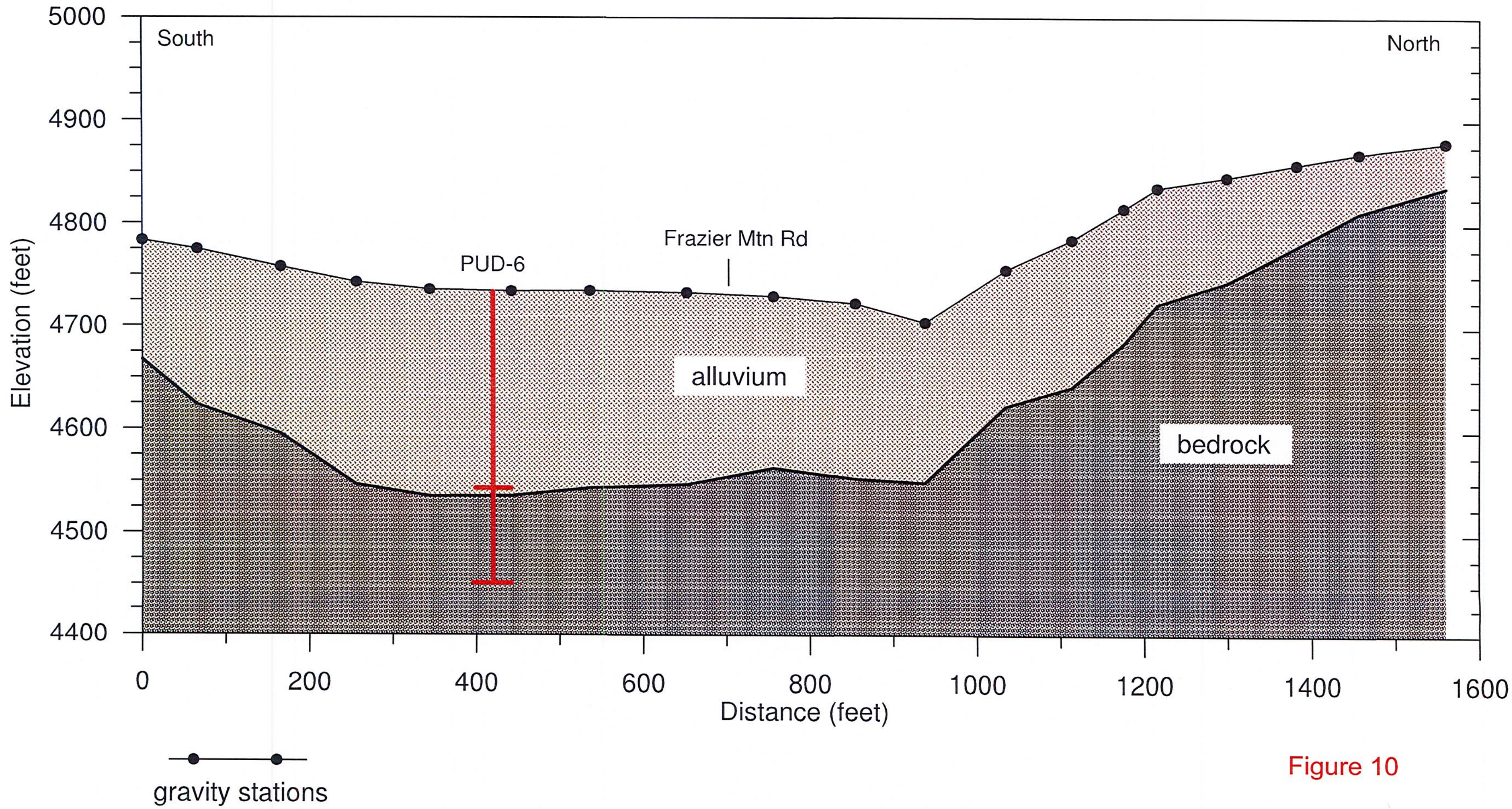


Figure 10

Bedrock Profile - Line 5

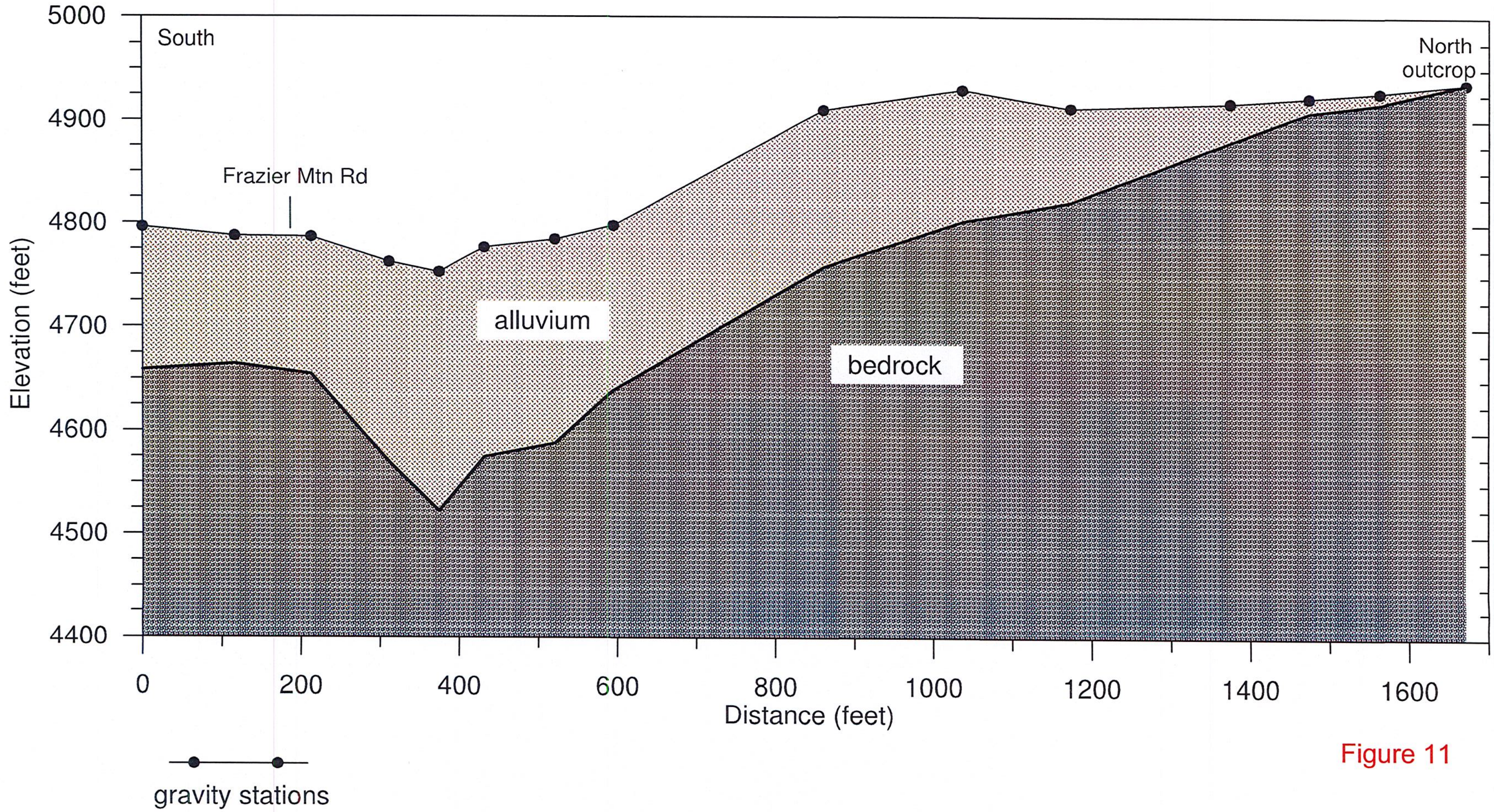


Figure 11

Bedrock Profile - Line 6

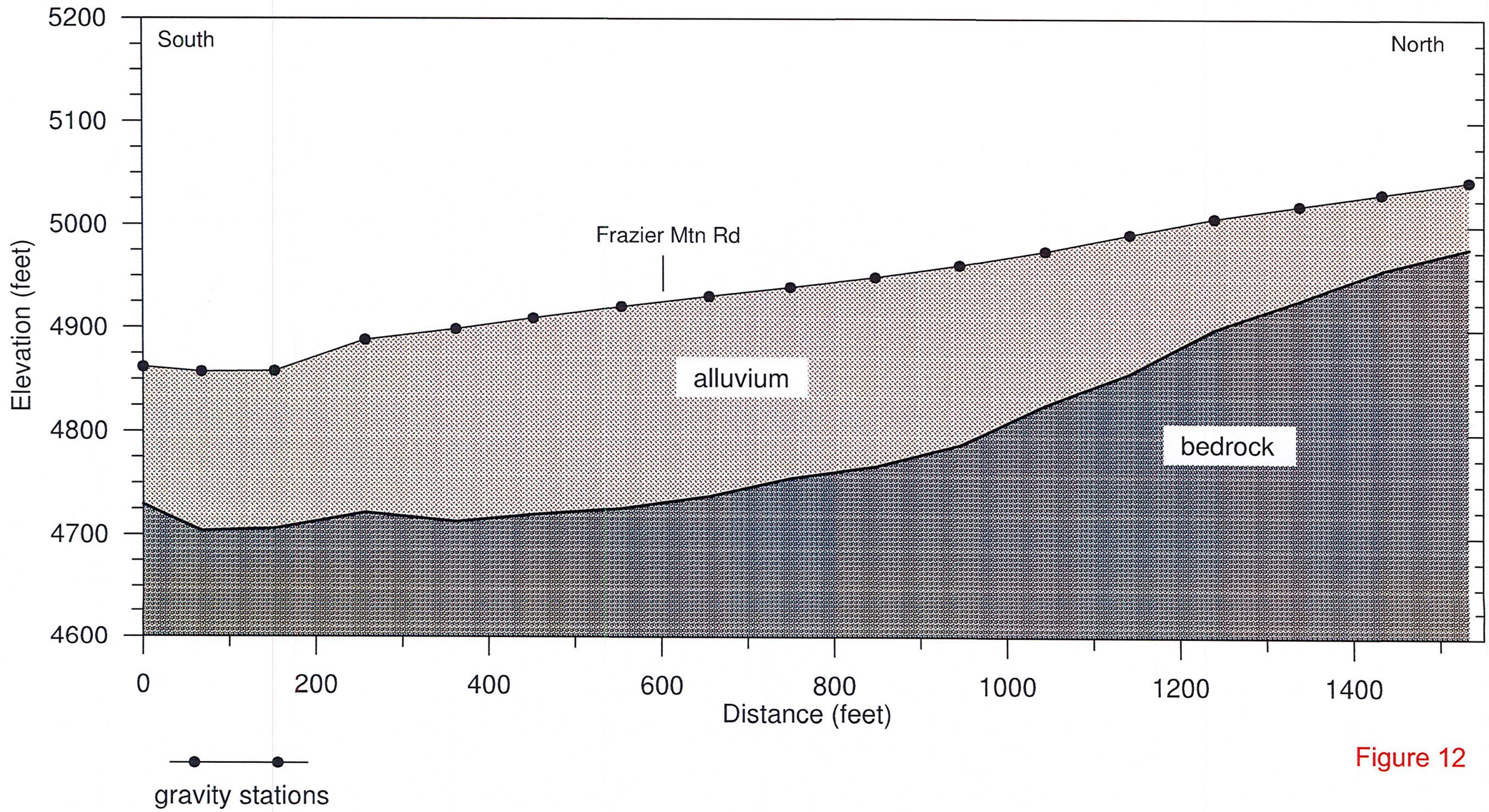


Figure 12

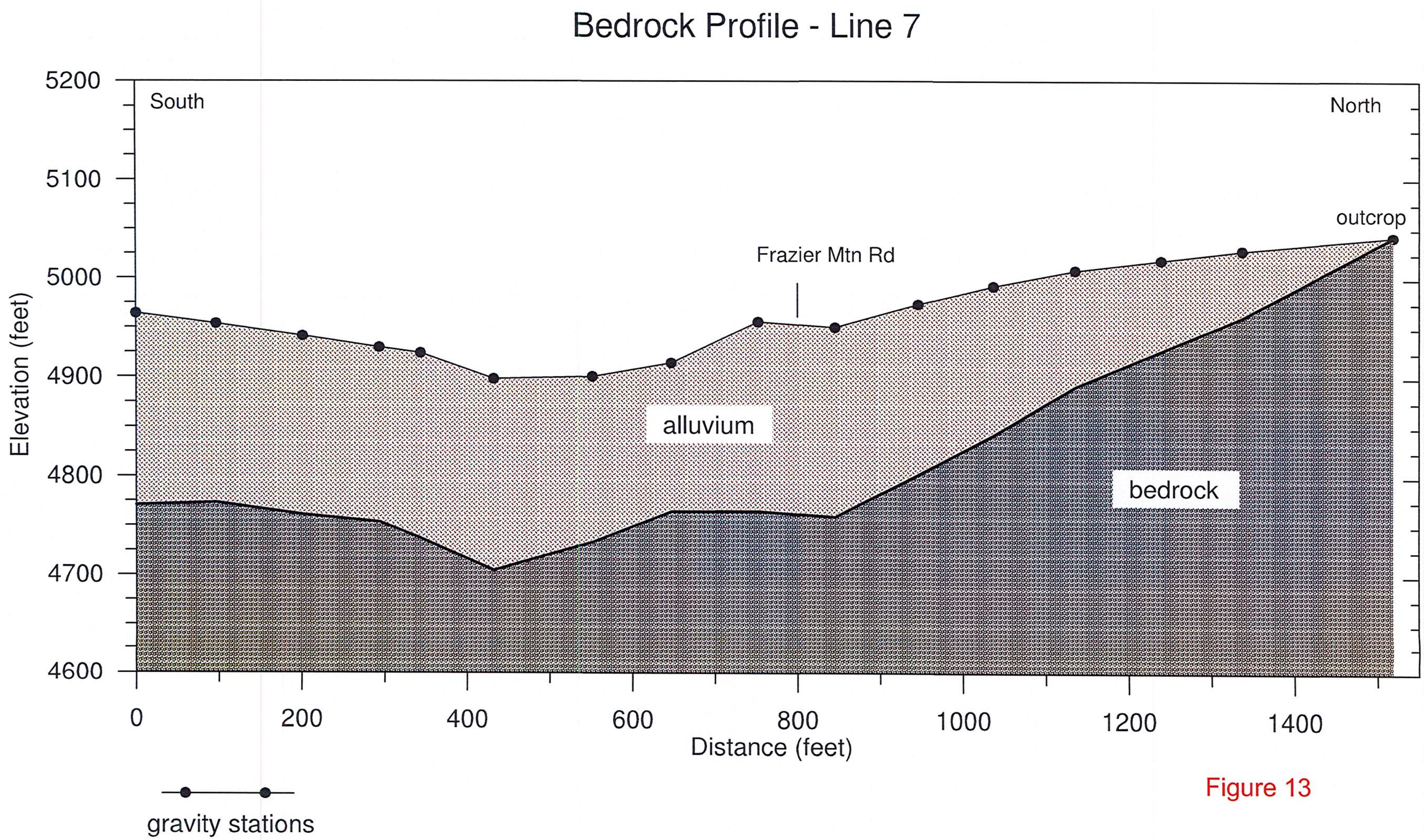

Bedrock Profile - Line 7
South
North
outcrop
Frazier Mtn Rd
alluvium
bedrock
Elevation (feet)
5200
5100
5000
4900
4800
4700
4600
0
200
400
600
800
1000
1200
1400
Distance (feet)
gravity stations

Figure 13

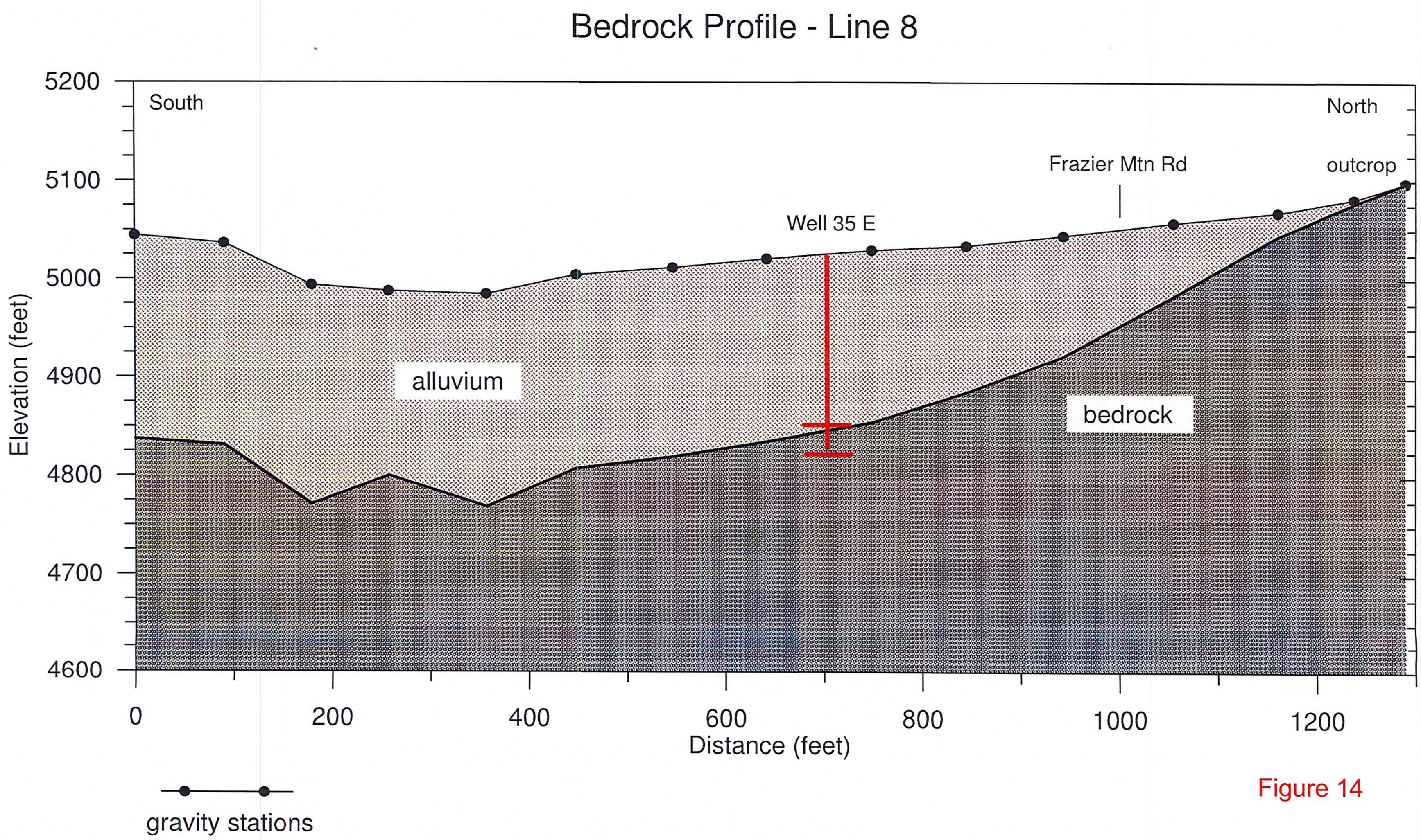
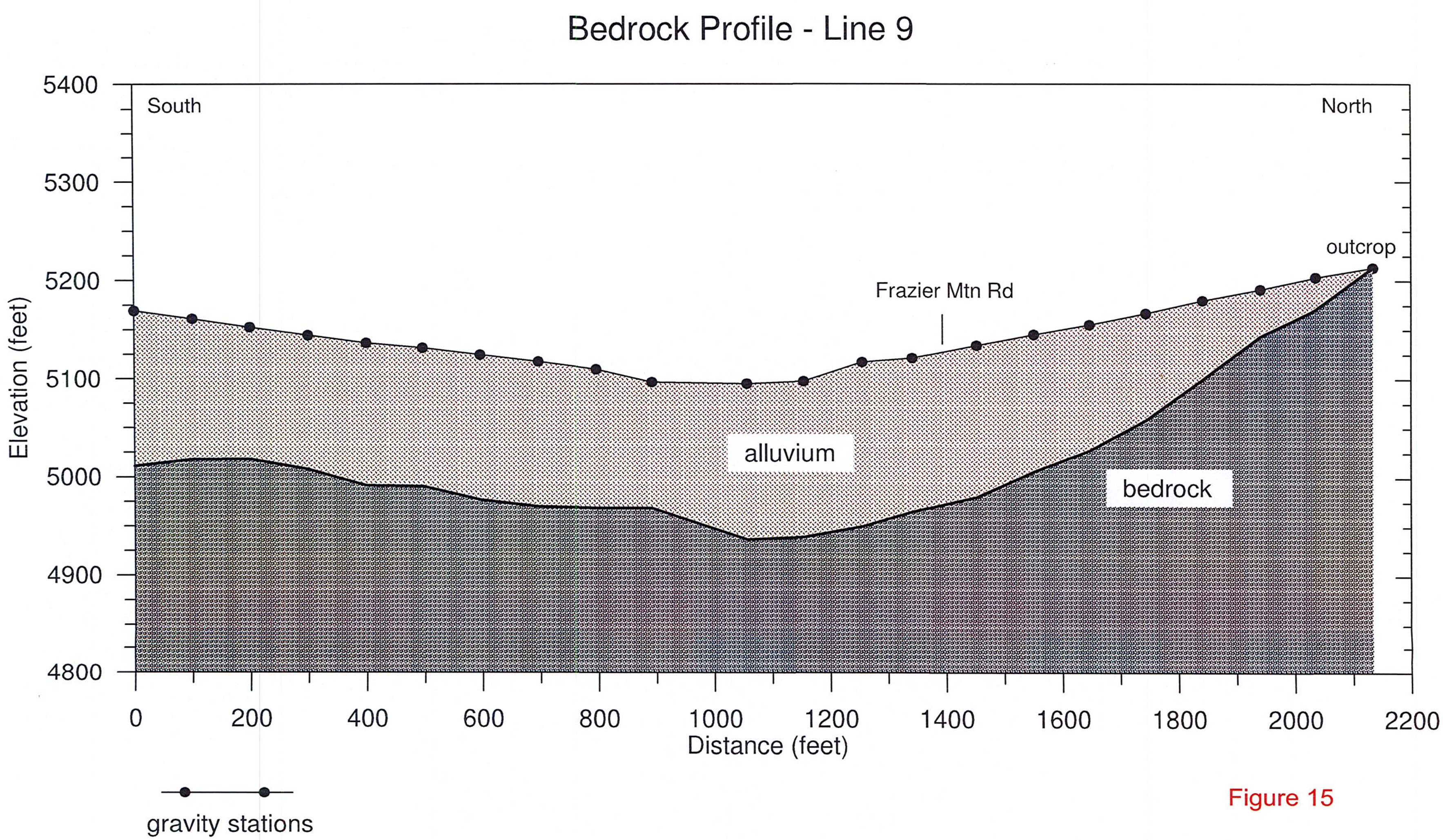

Bedrock Profile - Line 8
South
North
outcrop
Frazier Mtn Rd
Well 35 E
alluvium
bedrock
Elevation (feet)
5200
5100
5000
4900
4800
4700
4600
0
200
400
600
800
1000
1200
Distance (feet)
gravity stations

Figure 14



Bedrock Profile - Line 9
5400
5300
5200
5100
5000
4900
4800
Elevation (feet)
South
North
outcrop
Frazier Mtn Rd
alluvium
bedrock
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Distance (feet)
gravity stations

Figure 15

Bedrock Profile - Line 10

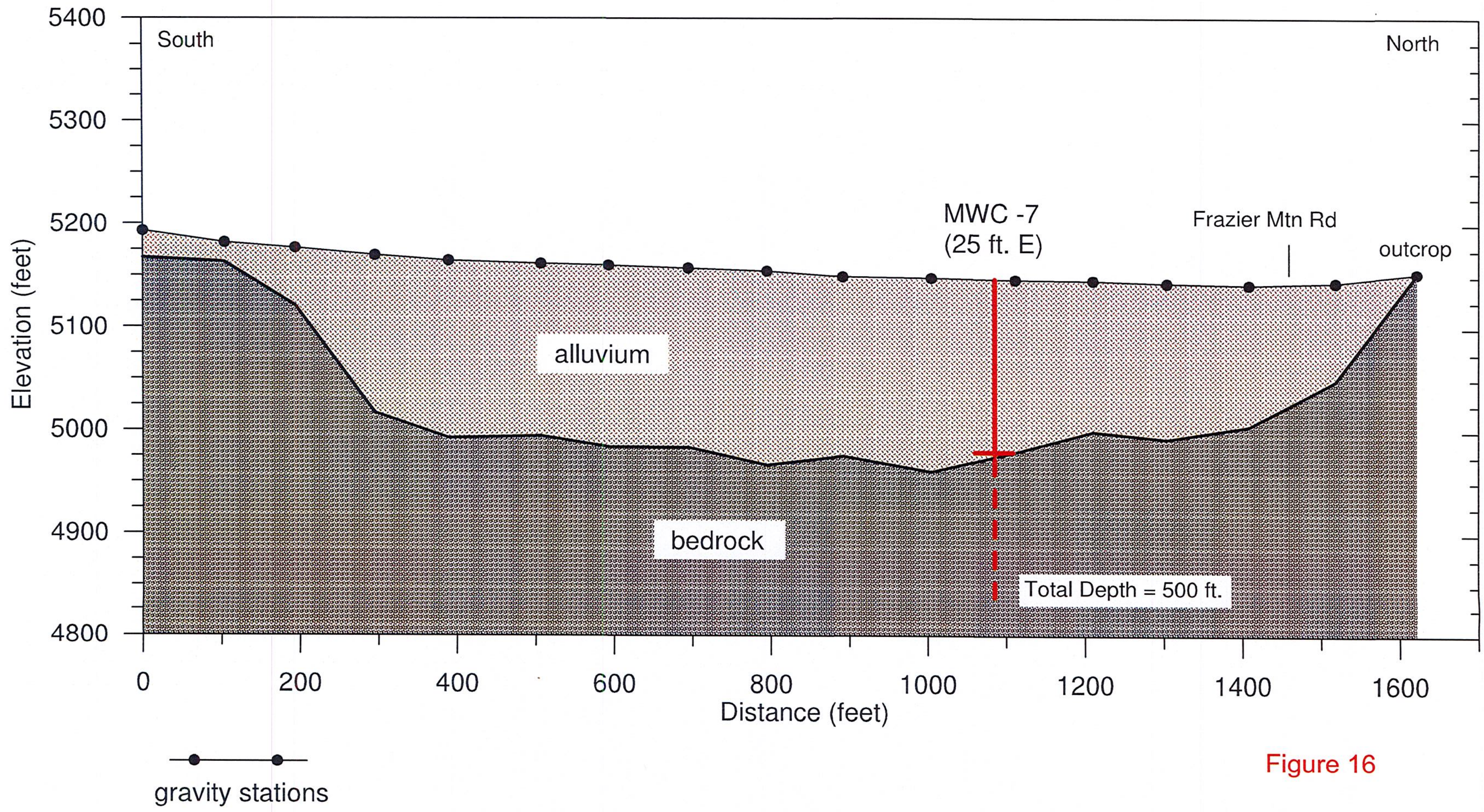


Figure 16

Appendix A

Gravity Survey Principal Facts

Please Note: To locate gravity stations at the survey site, use the latitude / longitude coordinates listed in Appendix B that are based on the WGS 84 North American Datum.

Gravity Traverse 0

STA ID	LAT (N) (DD MM.mmmm)	LONG (W) (DD MM.mmmm)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L0-0	34 49.0537	-118 55.9818	4529.3	979376.121	1.696	0.070	-68.046
L0-1	34 49.0702	-118 55.9799	4519.9	979376.757	1.630	0.063	-68.069
L0-2	34 49.0865	-118 55.9813	4514.5	979377.215	1.577	0.057	-68.020
L0-3	34 49.1036	-118 55.9818	4507.5	979377.721	1.529	0.052	-68.006
L0-4	34 49.1199	-118 55.9818	4498.5	979378.293	1.489	0.047	-68.042
L0-5	34 49.1345	-118 55.9795	4488.4	979378.748	1.459	0.045	-68.246
L0-7	34 49.1732	-118 55.9772	4454.7	979381.024	1.335	0.037	-68.178
L0-8	34 49.1808	-118 55.9772	4460.5	979380.694	1.304	0.038	-68.199
L0-9	34 49.1945	-118 55.9776	4487.0	979379.335	1.241	0.038	-68.055
L0-10	34 49.2107	-118 55.9813	4500.8	979378.631	1.175	0.040	-68.018
L0-11	34 49.2270	-118 55.9831	4506.0	979378.486	1.122	0.042	-67.922
L0-12	34 49.2435	-118 55.9813	4510.7	979378.287	1.079	0.045	-67.903
L0-13	34 49.2597	-118 55.9813	4516.5	979378.045	1.047	0.047	-67.852
L0-14	34 49.2762	-118 55.9808	4521.8	979377.805	1.024	0.050	-67.815
L0-15	34 49.3103	-118 55.9937	4536.9	979377.143	0.998	0.068	-67.629
L0-16	34 49.3268	-118 55.9955	4535.8	979377.360	1.000	0.089	-67.477
L0-17	34 49.3433	-118 55.9932	4535.2	979377.540	1.010	0.125	-67.315
L0-18	34 49.3591	-118 55.9941	4536.0	979377.634	1.055	0.237	-67.036

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 1

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	outr	BOUG ANOM (mGals)
L1-1	34 49.0411	-118 56.4528	4631.9	979373.446	2.472	0.395	-63.450
L1-2	34 49.0558	-118 56.4519	4621.3	979373.622	2.374	0.344	-64.080
L1-3	34 49.0718	-118 56.4514	4602.7	979373.461	2.313	0.329	-65.457
L1-4	34 49.0883	-118 56.4514	4589.0	979372.926	2.239	0.277	-66.961
L1-5	34 49.1043	-118 56.4537	4574.6	979371.942	2.131	0.212	-69.006
L1-6	34 49.1192	-118 56.4459	4568.1	979371.004	2.023	0.140	-70.533
L1-7	34 49.1352	-118 56.4427	4568.2	979369.794	1.931	0.100	-71.891
L1-8	34 49.1515	-118 56.4404	4575.3	979369.000	1.840	0.070	-72.403
L1-9	34 49.1677	-118 56.4340	4573.0	979373.779	1.747	0.048	-67.897
L1-10	34 49.1824	-118 56.4290	4565.8	979374.313	1.679	0.038	-67.895
L1-11	34 49.1982	-118 56.4207	4564.8	979374.559	1.608	0.034	-67.807
L1-12	34 49.2155	-118 56.4171	4564.8	979374.704	1.528	0.040	-67.760
L1-13	34 49.2293	-118 56.4120	4576.7	979374.151	1.457	0.056	-67.678
L1-14	34 49.2455	-118 56.4111	4585.6	979373.690	1.341	0.057	-67.740
L1-15	34 49.2613	-118 56.4111	4601.7	979372.960	1.247	0.052	-67.626
L1-16	34 49.2776	-118 56.4079	4610.5	979372.573	1.178	0.050	-67.582
L1-17	34 49.2979	-118 56.4070	4619.3	979372.217	1.116	0.051	-67.498
L1-18	34 49.3140	-118 56.4052	4628.5	979371.808	1.075	0.052	-67.421
L1-19	34 49.3316	-118 56.4006	4638.1	979371.370	1.032	0.051	-67.350
L1-20	34 49.3446	-118 56.3956	4646.4	979370.974	1.004	0.049	-67.297

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 2

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	outr	BOUG ANOM (mGals)
L2-0	32 38.6802	110 46.3302	4075.0	979163.790	0.000	0.000	-128.077
L2-1	34 49.1846	-118 56.6570	4630.2	979370.502	1.958	0.170	-67.441
L2-2	34 49.1952	-118 56.6432	4626.9	979370.808	1.874	0.107	-67.494
L2-3	34 49.2064	-118 56.6290	4625.4	979371.048	1.805	0.074	-67.460
L2-4	34 49.2183	-118 56.6158	4615.6	979371.732	1.751	0.054	-67.455
L2-5	34 49.2325	-118 56.6048	4615.4	979371.792	1.698	0.039	-67.495
L2-6	34 49.2453	-118 56.5929	4606.1	979372.426	1.644	0.029	-67.503
L2-7	34 49.2597	-118 56.5823	4613.3	979372.066	1.584	0.023	-67.513
L2-8	34 49.2714	-118 56.5686	4608.7	979372.455	1.512	0.016	-67.499
L2-9	34 49.2856	-118 56.5599	4608.1	979372.606	1.455	0.015	-67.463
L2-10	34 49.3009	-118 56.5535	4608.3	979372.707	1.418	0.016	-67.408
L2-11	34 49.3149	-118 56.5517	4610.6	979372.651	1.392	0.018	-67.366
L2-12	34 49.3311	-118 56.5498	4612.6	979372.653	1.367	0.021	-67.287
L2-13	34 49.3474	-118 56.5544	4614.6	979372.668	1.358	0.027	-67.178
L2-14	34 49.3645	-118 56.5521	4615.7	979372.612	1.351	0.039	-67.191
L2-15	34 49.3806	-118 56.5457	4617.9	979372.505	1.342	0.060	-67.175
L2-16	34 49.3966	-118 56.5503	4620.1	979372.525	1.370	0.100	-66.981
L2-17	34 49.4128	-118 56.5439	4625.0	979372.415	1.382	0.194	-66.713
L2-18	34 49.4215	-118 56.5457	4635.6	979371.850	1.397	0.289	-66.545

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 3

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L3-0	34 49.1162	-118 56.7952	4730.8	979363.891	2.282	0.242	-67.527
L3-1	34 49.1329	-118 56.7924	4724.7	979364.438	2.196	0.212	-67.485
L3-2	34 49.1492	-118 56.8007	4707.7	979365.595	2.172	0.168	-67.438
L3-3	34 49.1645	-118 56.8094	4702.1	979366.127	2.114	0.120	-67.370
L3-4	34 49.1805	-118 56.8163	4697.8	979365.526	2.062	0.091	-68.334
L3-5	34 49.1972	-118 56.8167	4694.8	979367.056	1.996	0.070	-67.093
L3-6	34 49.2121	-118 56.8208	4690.3	979367.297	1.933	0.052	-67.224
L3-7	34 49.2286	-118 56.8199	4690.2	979367.312	1.856	0.042	-67.323
L3-8	34 49.2451	-118 56.8181	4687.8	979367.447	1.799	0.038	-67.416
L3-9	34 49.2611	-118 56.8222	4680.4	979367.976	1.775	0.033	-67.387
L3-10	34 49.2771	-118 56.8231	4667.7	979368.790	1.741	0.033	-67.386
L3-11	34 49.2934	-118 56.8227	4652.7	979369.733	1.750	0.032	-67.361
L3-12	34 49.3105	-118 56.8231	4664.8	979369.169	1.736	0.034	-67.236
L3-13	34 49.3259	-118 56.8222	4665.8	979369.219	1.717	0.041	-67.156
L3-14	34 49.3421	-118 56.8227	4682.2	979368.318	1.698	0.050	-67.111
L3-15	34 49.3600	-118 56.8204	4684.9	979368.305	1.684	0.065	-66.985
L3-16	34 49.3760	-118 56.8181	4688.1	979368.178	1.681	0.085	-66.927
L3-17	34 49.3945	-118 56.8181	4694.2	979367.896	1.695	0.120	-66.820
L3-18	34 49.4087	-118 56.8149	4698.7	979367.695	1.696	0.159	-66.732
L3-19	34 49.4243	-118 56.8094	4701.9	979367.503	1.712	0.235	-66.661
L3-20	34 49.4396	-118 56.8117	4713.0	979366.972	1.732	0.369	-66.393
L3-21	34 49.4499	-118 56.8117	4733.2	979365.802	1.690	0.464	-66.313

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 4

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L4-0	34 49.1267	-118 57.1486	4783.4	979360.028	3.091	0.562	-67.125
L4-1	34 49.1348	-118 57.1399	4775.0	979360.746	3.090	0.504	-66.981
L4-2	34 49.1444	-118 57.1234	4757.9	979361.836	3.062	0.423	-67.040
L4-3	34 49.1533	-118 57.1088	4743.0	979362.794	2.934	0.303	-67.232
L4-4	34 49.1721	-118 57.1074	4735.7	979363.546	2.757	0.169	-67.254
L4-5	34 49.1883	-118 57.1014	4734.3	979363.866	2.624	0.108	-67.235
L4-6	34 49.2041	-118 57.0969	4735.0	979364.033	2.512	0.073	-67.200
L4-7	34 49.2231	-118 57.0909	4733.4	979364.327	2.383	0.052	-67.173
L4-8	34 49.2430	-118 57.0946	4729.7	979364.732	2.324	0.069	-67.061
L4-9	34 49.2590	-118 57.0905	4723.2	979365.148	2.268	0.104	-67.078
L4-10	34 49.2746	-118 57.0941	4704.6	979366.178	2.241	0.203	-67.115
L4-11	34 49.2920	-118 57.0978	4756.0	979363.479	2.046	0.288	-66.867
L4-12	34 49.3069	-118 57.1060	4785.3	979361.903	1.811	0.305	-66.928
L4-13	34 49.3190	-118 57.1202	4815.7	979360.337	1.640	0.300	-66.864
L4-14	34 49.3270	-118 57.1404	4835.7	979359.350	1.540	0.302	-66.763
L4-15	34 49.3407	-118 57.1490	4845.9	979358.934	1.498	0.228	-66.698
L4-16	34 49.3542	-118 57.1605	4858.1	979358.416	1.479	0.184	-66.573
L4-17	34 49.3659	-118 57.1724	4868.7	979357.972	1.446	0.164	-66.447
L4-18	34 49.3819	-118 57.1852	4879.3	979357.491	1.417	0.132	-66.375

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 5

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	outr	BOUG ANOM (mGals)
L5-0	34 49.1615	-118 57.3381	4795.9	979359.518	3.253	0.518	-66.815
L5-1	34 49.1798	-118 57.3312	4787.4	979360.407	3.163	0.333	-66.740
L5-2	34 49.1959	-118 57.3289	4786.6	979360.653	3.023	0.247	-66.788
L5-3	34 49.2121	-118 57.3276	4762.5	979361.972	2.853	0.228	-67.127
L5-4	34 49.2229	-118 57.3294	4752.9	979362.483	2.714	0.238	-67.336
L5-5	34 49.2318	-118 57.3244	4776.7	979361.429	2.598	0.252	-67.079
L5-6	34 49.2464	-118 57.3225	4784.6	979361.004	2.437	0.308	-67.152
L5-7	34 49.2586	-118 57.3212	4797.9	979360.443	2.314	0.422	-66.940
L5-14	34 49.3032	-118 57.3495	4910.1	979354.702	1.609	0.247	-66.901
L5-15	34 49.3309	-118 57.3651	4929.2	979353.948	1.511	0.136	-66.757
L5-16	34 49.3545	-118 57.3225	4912.2	979355.264	1.487	0.098	-66.557
L5-17	34 49.3879	-118 57.3280	4917.2	979355.341	1.462	0.088	-66.265
L5-18	34 49.4041	-118 57.3230	4922.2	979355.229	1.436	0.086	-66.127
L5-19	34 49.4188	-118 57.3230	4927.2	979354.985	1.416	0.089	-66.110
L5-20	34 49.4366	-118 57.3207	4935.5	979354.589	1.397	0.088	-66.052

Note: Latitude / Longitude coordinates based on 1927 North American Datum

L6.BOU

Gravity Traverse 6

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L6-0	34 49.1100	-118 57.7258	4861.6	979354.803	4.111	0.605	-66.578
L6-1	34 49.1206	-118 57.7217	4857.2	979355.347	3.939	0.392	-66.695
L6-2	34 49.1343	-118 57.7185	4857.8	979355.495	3.663	0.227	-66.972
L6-3	34 49.1512	-118 57.7144	4888.0	979354.310	3.345	0.138	-66.775
L6-4	34 49.1684	-118 57.7107	4898.7	979353.934	3.031	0.106	-66.880
L6-5	34 49.1828	-118 57.7066	4909.4	979353.561	2.781	0.095	-66.895
L6-6	34 49.1993	-118 57.7029	4920.9	979353.090	2.552	0.090	-66.933
L6-7	34 49.2155	-118 57.6979	4931.0	979352.663	2.398	0.097	-66.925
L6-8	34 49.2307	-118 57.6942	4939.8	979352.360	2.236	0.110	-66.871
L6-9	34 49.2467	-118 57.6910	4949.6	979351.948	2.091	0.114	-66.859
L6-10	34 49.2629	-118 57.6901	4961.3	979351.442	1.973	0.114	-66.806
L6-11	34 49.2794	-118 57.6883	4975.3	979350.858	1.874	0.116	-66.670
L6-12	34 49.2954	-118 57.6869	4991.6	979350.063	1.791	0.119	-66.594
L6-13	34 49.3114	-118 57.6846	5007.2	979349.373	1.719	0.122	-66.436
L6-14	34 49.3277	-118 57.6837	5019.5	979348.813	1.657	0.124	-66.346
L6-15	34 49.3437	-118 57.6846	5030.9	979348.293	1.612	0.124	-66.249
L6-16	34 49.3604	-118 57.6855	5043.0	979347.680	1.574	0.120	-66.204

Note: Latitude / Longitude coordinates based on 1927 North American Datum

L7.BOU

Gravity Traverse 7

STA ID	LAT (N) (DD MM.mmmm)	LONG (W)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L7-0	34 49.1283	-118 57.9520	4963.8	979350.146	2.992	0.130	-66.725
L7-1	34 49.1439	-118 57.9474	4953.7	979350.883	2.957	0.115	-66.670
L7-2	34 49.1604	-118 57.9410	4941.4	979351.653	2.955	0.100	-66.674
L7-3	34 49.1750	-118 57.9359	4930.0	979352.376	2.970	0.088	-66.654
L7-4	34 49.1830	-118 57.9337	4924.5	979352.656	2.986	0.086	-66.702
L7-5	34 49.1965	-118 57.9268	4898.5	979354.215	2.977	0.087	-66.726
L7-6	34 49.2146	-118 57.9172	4901.0	979354.130	2.984	0.153	-66.612
L7-7	34 49.2297	-118 57.9117	4914.9	979353.384	2.884	0.276	-66.526
L7-8	34 49.2467	-118 57.9066	4956.4	979351.220	2.464	0.199	-66.724
L7-9	34 49.2622	-118 57.9048	4950.9	979351.607	2.486	0.147	-66.719
L7-10	34 49.2776	-118 57.8970	4974.6	979350.364	2.390	0.172	-66.635
L7-11	34 49.2927	-118 57.8947	4992.9	979349.489	2.284	0.177	-66.533
L7-12	34 49.3082	-118 57.8893	5008.9	979348.770	2.219	0.174	-66.382
L7-13	34 49.3247	-118 57.8838	5019.2	979348.321	2.179	0.193	-66.260
L7-14	34 49.3401	-118 57.8773	5028.9	979347.863	2.143	0.230	-66.155
L7-15	34 49.3691	-118 57.8687	5042.7	979347.199	2.122	0.442	-65.841

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 8

STA ID	LAT (N) (DD MM.mmmm)	LONG (W) (DD MM.mmmm)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L8-0	34 49.1018	-118 58.4615	5044.4	979345.835	2.623	0.170	-66.500
L8-1	34 49.1164	-118 58.4656	5036.3	979346.245	2.720	0.175	-66.494
L8-2	34 49.1313	-118 58.4647	4993.8	979348.531	2.919	0.180	-66.568
L8-3	34 49.1444	-118 58.4619	4987.9	979348.959	3.046	0.156	-66.411
L8-4	34 49.1606	-118 58.4578	4985.0	979349.116	3.035	0.082	-66.535
L8-5	34 49.1755	-118 58.4546	5004.3	979348.110	3.015	0.058	-66.448
L8-6	34 49.1917	-118 58.4546	5012.0	979347.683	3.020	0.060	-66.431
L8-7	34 49.2075	-118 58.4564	5020.8	979347.176	3.030	0.081	-66.402
L8-8	34 49.2249	-118 58.4514	5029.1	979346.686	3.067	0.111	-66.352
L8-9	34 49.2407	-118 58.4491	5033.9	979346.428	3.131	0.166	-66.226
L8-10	34 49.2570	-118 58.4500	5044.3	979345.817	3.178	0.248	-66.106
L8-11	34 49.2755	-118 58.4528	5057.5	979345.060	3.249	0.386	-65.894
L8-12	34 49.2929	-118 58.4514	5067.9	979344.373	3.337	0.618	-65.660
L8-13	34 49.3057	-118 58.4523	5081.3	979343.429	3.351	0.854	-65.566
L8-14	34 49.3142	-118 58.4505	5097.7	979342.346	3.293	0.995	-65.599

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 9

STA ID	LAT (N) (DD MM.mmmm)	LONG (W) (DD MM.mmmm)	ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	TERR CORR outr	BOUG ANOM (mGals)
L9-0	34 48.9601	-118 59.2593	5169.3	979339.945	1.624	0.228	-65.643
L9-1	34 48.9757	-118 59.2662	5161.1	979340.514	1.641	0.226	-65.570
L9-2	34 48.9912	-118 59.2722	5152.7	979341.114	1.636	0.200	-65.529
L9-3	34 49.0070	-118 59.2781	5144.4	979341.645	1.638	0.172	-65.542
L9-4	34 49.0226	-118 59.2850	5136.7	979342.083	1.668	0.149	-65.585
L9-5	34 49.0391	-118 59.2859	5131.6	979342.394	1.715	0.141	-65.563
L9-6	34 49.0546	-118 59.2918	5124.5	979342.792	1.760	0.115	-65.592
L9-7	34 49.0707	-118 59.2973	5117.7	979343.170	1.833	0.094	-65.592
L9-8	34 49.0867	-118 59.3015	5109.8	979343.620	1.928	0.080	-65.556
L9-9	34 49.1020	-118 59.3065	5096.9	979344.385	2.032	0.063	-65.498
L9-10	34 49.1277	-118 59.3170	5095.3	979344.332	2.103	0.036	-65.644
L9-11	34 49.1432	-118 59.3221	5097.8	979344.188	2.122	0.033	-65.640
L9-12	34 49.1590	-118 59.3285	5117.5	979342.984	2.124	0.035	-65.685
L9-13	34 49.1725	-118 59.3340	5121.6	979342.751	2.184	0.035	-65.627
L9-14	34 49.1901	-118 59.3399	5134.6	979341.877	2.295	0.056	-65.619
L9-15	34 49.2062	-118 59.3436	5145.6	979341.226	2.354	0.076	-65.553
L9-16	34 49.2215	-118 59.3481	5155.8	979340.618	2.407	0.094	-65.502
L9-17	34 49.2373	-118 59.3518	5167.1	979339.959	2.484	0.111	-65.409
L9-18	34 49.2540	-118 59.3518	5180.1	979339.213	2.581	0.132	-65.282
L9-19	34 49.2705	-118 59.3541	5191.5	979338.589	2.678	0.154	-65.126
L9-20	34 49.2863	-118 59.3559	5203.5	979337.846	2.779	0.167	-65.061
L9-21	34 49.3021	-118 59.3596	5213.3	979337.284	2.913	0.181	-64.910

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Gravity Traverse 10

STA ID	LAT (N) (DD MM.mmmm)		LONG (W)		ELEV (feet)	OBS GRAV (mGals)	TERR CORR inr	outr	BOUG ANOM (mGals)
L10-0	34	48.8770	-119	0.1227	5192.8	979338.293	0.336	1.054	-66.233
L10-1	34	48.8935	-119	0.1172	5181.9	979339.115	0.276	1.006	-66.196
L10-2	34	48.9054	-119	0.1048	5177.0	979339.510	0.426	0.607	-66.361
L10-3	34	48.9240	-119	0.1067	5170.0	979339.962	0.409	0.201	-66.777
L10-4	34	48.9404	-119	0.1108	5164.8	979340.291	0.413	0.113	-66.862
L10-5	34	48.9594	-119	0.1062	5162.1	979340.437	0.477	0.116	-66.839
L10-6	34	48.9734	-119	0.1021	5160.6	979340.572	0.469	0.054	-66.883
L10-7	34	48.9899	-119	0.0993	5158.1	979340.766	0.485	0.027	-66.874
L10-8	34	49.0059	-119	0.0943	5155.3	979340.905	0.492	0.015	-66.932
L10-9	34	49.0212	-119	0.0879	5150.2	979341.247	0.537	0.016	-66.872
L10-10	34	49.0388	-119	0.0806	5149.0	979341.232	0.526	0.082	-66.926
L10-11	34	49.0549	-119	0.0696	5147.0	979341.305	0.603	0.161	-66.840
L10-12	34	49.0700	-119	0.0618	5146.4	979341.337	0.638	0.242	-66.750
L10-13	34	49.0839	-119	0.0522	5143.9	979341.416	0.650	0.300	-66.773
L10-14	34	49.0997	-119	0.0435	5142.4	979341.500	0.688	0.356	-66.707
L10-15	34	49.1158	-119	0.0311	5144.7	979341.331	0.751	0.519	-66.533
L10-16	34	49.1311	-119	0.0224	5153.3	979340.810	0.816	0.894	-66.121

Note: Latitude / Longitude coordinates based on 1927 North American Datum

Appendix B

Listing of Gravity Station Locations

Global Positioning System (GPS) Data

Frazier Park Gravity Station Locations
Latitude / Longitude based on WGS 84 North American Datum

Sta ID	Latitude	Longitude	Elev (ft)
"L0-0"	34.817540832	-118.933962218	4529.34
"L0-1"	34.817814034	-118.933931781	4519.94
"L0-2"	34.818086288	-118.933952524	4514.49
"L0-3"	34.818371766	-118.933959657	4507.59
"L0-4"	34.81864225	-118.933964554	4498.57
"L0-5"	34.818884994	-118.933925507	4488.45
"L0-7"	34.819532044	-118.933889108	4454.73
"L0-8"	34.819657945	-118.933883565	4460.56
"L0-9"	34.819885295	-118.933896746	4487.02
"L0-10"	34.820156525	-118.933954378	4500.83
"L0-11"	34.820429269	-118.933988002	4506.07
"L0-12"	34.820701194	-118.933951919	4510.76
"L0-13"	34.820974346	-118.933957179	4516.52
"L0-14"	34.821246761	-118.933945299	4521.87
"L0-15"	34.821814347	-118.934160611	4536.99
"L0-16"	34.822091131	-118.934193229	4535.9
"L0-17"	34.822364611	-118.934150884	4535.22
"L0-18"	34.822628497	-118.934170953	4536.05
"L1-1"	34.817331487	-118.94181146	4631.99
"L1-2"	34.817574517	-118.941794289	4621.36
"L1-3"	34.817843421	-118.941790508	4602.74
"L1-4"	34.818114269	-118.941790643	4589.06
"L1-5"	34.818384565	-118.941824869	4574.59
"L1-6"	34.818630158	-118.941695515	4568.15
"L1-7"	34.818899845	-118.941641359	4568.25
"L1-8"	34.81917025	-118.941605338	4575.36
"L1-9"	34.819440517	-118.941502585	4573.08
"L1-10"	34.819684303	-118.941418818	4565.89
"L1-11"	34.81994594	-118.941276018	4564.86
"L1-12"	34.820237649	-118.941215254	4564.87
"L1-13"	34.820464743	-118.9411315	4576.71
"L1-14"	34.820736962	-118.941115352	4585.67
"L1-15"	34.821000342	-118.941115783	4601.76
"L1-16"	34.82127186	-118.941062368	4610.53
"L1-17"	34.821611085	-118.941047059	4619.35
"L1-18"	34.821875644	-118.941015875	4628.51
"L1-19"	34.822171416	-118.940945962	4638.15
"L1-20"	34.82238925	-118.940859743	4646.46

Sta ID	Latitude	Longitude	Elev (ft)
"L2-0"	34.81955251	-118.945806329	4645.84
"L2-1"	34.819723869	-118.945215225	4630.2
"L2-2"	34.819896437	-118.94498709	4626.93
"L2-3"	34.820083112	-118.944750193	4625.47
"L2-4"	34.82028128	-118.944526622	4615.65
"L2-5"	34.820519456	-118.944346954	4615.44
"L2-6"	34.820732836	-118.94415017	4606.1
"L2-7"	34.820972448	-118.943970705	4613.37
"L2-8"	34.821169662	-118.943741987	4608.72
"L2-9"	34.82140543	-118.943601754	4608.12
"L2-10"	34.821659707	-118.943493937	4608.29
"L2-11"	34.821893324	-118.943461126	4610.65
"L2-12"	34.822161938	-118.943430923	4612.7
"L2-13"	34.822435884	-118.943509188	4614.69
"L2-14"	34.822721561	-118.943466425	4615.75
"L2-15"	34.822985854	-118.943362155	4617.99
"L2-16"	34.82325557	-118.943436961	4620.12
"L2-17"	34.8235235	-118.943331494	4625.02
"L2-18"	34.823670767	-118.94336283	4635.62
"L3-0"	34.818579935	118.947522618	4730.87
"L3-1"	34.818859175	118.947473121	4724.77
"L3-2"	34.819132287	118.947609319	4707.77
"L3-3"	34.819386289	118.947758975	4702.18
"L3-4"	34.819654149	118.947868485	4697.82
"L3-5"	34.819931919	118.947878305	4694.84
"L3-6"	34.820179906	118.947944057	4690.34
"L3-7"	34.820453896	118.947932699	4690.28
"L3-8"	34.8207284	118.947900991	4687.9
"L3-9"	34.820996681	118.947973334	4680.42
"L3-10"	34.821265003	118.947981385	4667.79
"L3-11"	34.821532327	118.947974634	4652.71
"L3-12"	34.821820986	118.947983356	4664.84
"L3-13"	34.822077427	118.947971219	4665.89
"L3-14"	34.82234605	118.947979154	4682.22
"L3-15"	34.822642636	118.947937355	4684.96
"L3-16"	34.822912357	118.947904422	4688.13
"L3-17"	34.823218528	118.947897753	4694.23
"L3-18"	34.823457066	118.947845855	4698.73
"L3-19"	34.82371586	118.947757143	4701.94
"L3-20"	34.823971524	118.947790725	4713.06
"L3-21"	34.824144312	118.947791526	4733.27

Sta ID	Latitude	Longitude	Elev (ft)
"L4-0"	34.81875752	118.953406466	4783.45
"L4-1"	34.818890143	118.953267091	4775.04
"L4-2"	34.819051107	118.952990816	4757.92
"L4-3"	34.819201074	118.952742851	4743.09
"L4-4"	34.819513649	118.952720764	4735.79
"L4-5"	34.819781467	118.952621299	4734.37
"L4-6"	34.82004598	118.952550843	4735.01
"L4-7"	34.820363227	118.952448337	4733.5
"L4-8"	34.820694445	118.952508106	4729.79
"L4-9"	34.820963582	118.952440475	4723.3
"L4-10"	34.821219771	118.952499612	4704.67
"L4-11"	34.821510916	118.952561976	4756.08
"L4-12"	34.821758021	118.952702434	4785.34
"L4-13"	34.821960959	118.952938607	4815.75
"L4-14"	34.822095014	118.953275132	4835.74
"L4-15"	34.82232327	118.953420359	4845.99
"L4-16"	34.822549231	118.953606737	4858.1
"L4-17"	34.822743138	118.953804954	4868.76
"L4-18"	34.82300987	118.954018013	4879.41
"L5-0"	34.819337952	118.956569977	4795.95
"L5-1"	34.819641154	118.956453906	4787.4
"L5-2"	34.819909559	118.956416641	4786.64
"L5-3"	34.820179698	118.956395188	4762.53
"L5-4"	34.820358596	118.956419805	4752.92
"L5-5"	34.820507863	118.956337231	4776.71
"L5-6"	34.820753566	118.956308034	4784.69
"L5-7"	34.820953194	118.956287988	4798.01
"L5-14"	34.821697505	118.956758294	4910.16
"L5-15"	34.822160373	118.957016521	4929.29
"L5-16"	34.822552757	118.956308828	4912.26
"L5-17"	34.823109142	118.956404238	4917.21
"L5-18"	34.823379892	118.956318907	4922.24
"L5-19"	34.823624468	118.956315574	4927.24
"L5-20"	34.823920183	118.956280535	4935.58
"L6-0"	34.818478379	-118.963033383	4861.62
"L6-1"	34.818655868	-118.962965538	4857.26
"L6-2"	34.818881033	-118.962905487	4857.84
"L6-3"	34.819164602	-118.962842942	4888.08
"L6-4"	34.819453104	-118.962776703	4898.8
"L6-5"	34.819691349	-118.962713288	4909.46
"L6-6"	34.819965181	-118.962647321	4920.96

Sta ID	Latitude	Longitude	Elev (ft)
"L6-7"	34.82023573	-118.96256469	4931.08
"L6-8"	34.82049056	-118.962505714	4939.87
"L6-9"	34.820755238	-118.962447956	4949.66
"L6-10"	34.821027578	-118.962435237	4961.36
"L6-11"	34.821299484	-118.962408737	4975.37
"L6-12"	34.821569464	-118.96238529	4991.6
"L6-13"	34.821836754	-118.962343075	5007.28
"L6-14"	34.8221058	-118.962331724	5019.53
"L6-15"	34.822372296	-118.962347659	5030.94
"L6-16"	34.822651735	-118.962358776	5043.01
"L7-0"	34.818785189	-118.966800659	4963.89
"L7-1"	34.819044093	-118.966720214	4953.7
"L7-2"	34.819316111	-118.96661463	4941.47
"L7-3"	34.8195637	-118.966534779	4930.03
"L7-4"	34.819696188	-118.966492813	4924.49
"L7-5"	34.819920697	-118.966379848	4898.57
"L7-6"	34.820223368	-118.966220843	4901.1
"L7-7"	34.820473212	-118.966125615	4914.92
"L7-8"	34.820756127	-118.966046648	4956.44
"L7-9"	34.82101545	-118.96601724	4950.93
"L7-10"	34.821271796	-118.965880799	4974.61
"L7-11"	34.821522757	-118.965843102	4992.96
"L7-12"	34.821783817	-118.965754563	5008.95
"L7-13"	34.822056049	-118.965662852	5019.22
"L7-14"	34.822312179	-118.965559171	5028.97
"L7-15"	34.822794887	-118.96541009	5042.77
"L8-0"	34.818341584	-118.975295156	5044.41
"L8-1"	34.818584349	-118.975360738	5036.31
"L8-2"	34.818831959	-118.975346114	4993.9
"L8-3"	34.819049074	-118.975300291	4987.96
"L8-4"	34.819322038	-118.975230232	4985.08
"L8-5"	34.819571376	-118.975175557	5004.41
"L8-6"	34.819841578	-118.975175716	5012.08
"L8-7"	34.820104141	-118.975206029	5020.88
"L8-8"	34.82039195	-118.975125052	5029.18
"L8-9"	34.820658342	-118.975084211	5033.97
"L8-10"	34.820926044	-118.975099746	5044.38
"L8-11"	34.821235194	-118.975145172	5057.51
"L8-12"	34.821526319	-118.975121701	5067.94
"L8-13"	34.821741463	-118.975136499	5081.4
"L8-14"	34.821881982	-118.975110433	5097.72

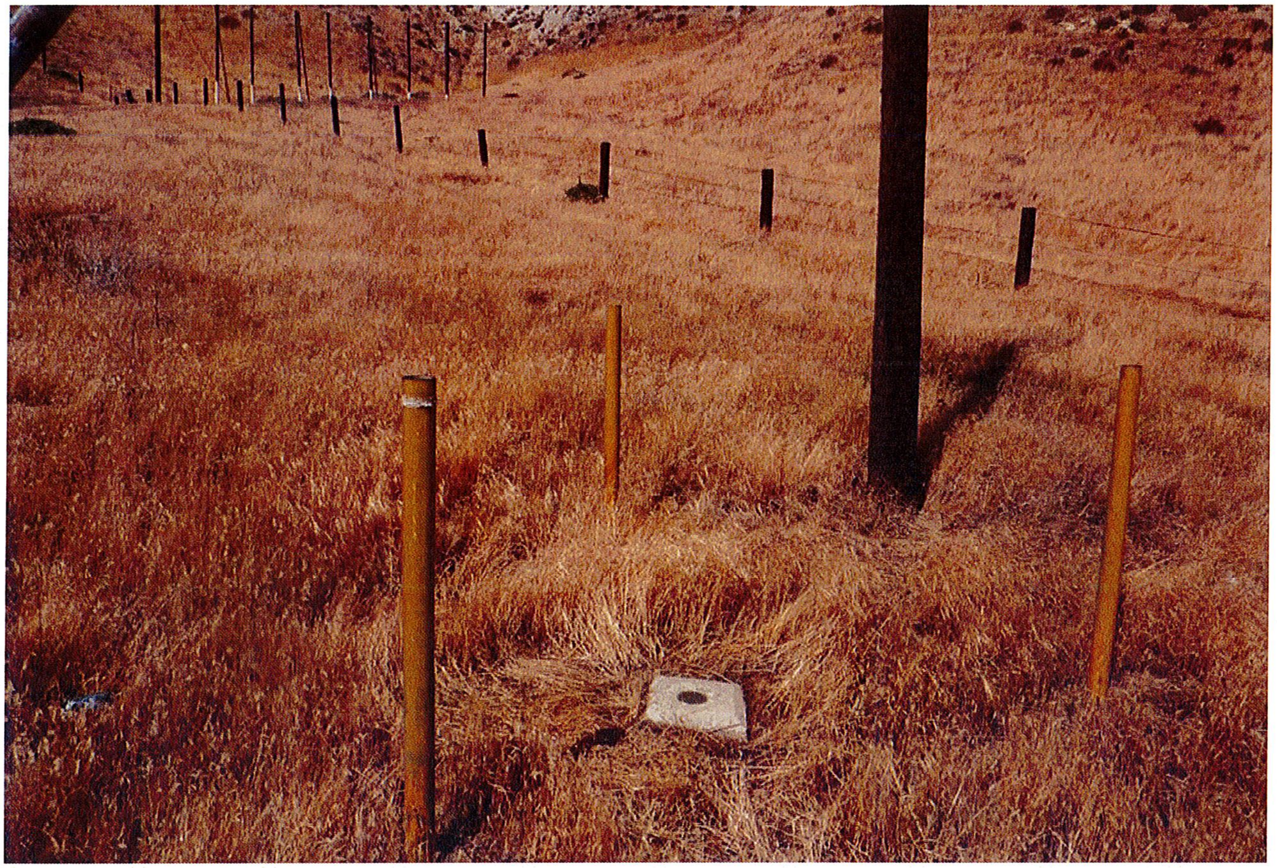
Sta ID	Latitude	Longitude	Elev (ft)
"L9-0"	34.81598091	-118.98859009	5169.35
"L9-1"	34.816240332	-118.988706937	5161.17
"L9-2"	34.816496992	-118.988804476	5152.77
"L9-3"	34.816761561	-118.988904012	5144.49
"L9-4"	34.81702058	-118.989014106	5136.72
"L9-5"	34.817297078	-118.989032607	5131.63
"L9-6"	34.817554861	-118.989132588	5124.56
"L9-7"	34.817821393	-118.989226778	5117.73
"L9-8"	34.81808762	-118.989293906	5109.89
"L9-9"	34.818344767	-118.989376321	5096.97
"L9-10"	34.818770572	-118.989552024	5095.3
"L9-11"	34.819031774	-118.989633126	5097.87
"L9-12"	34.819295434	-118.989745024	5117.52
"L9-13"	34.819518415	-118.989834114	5121.68
"L9-14"	34.819812812	-118.989934363	5134.61
"L9-15"	34.820079293	-118.989995293	5145.62
"L9-16"	34.820336756	-118.990069616	5155.82
"L9-17"	34.820598376	-118.990130579	5167.16
"L9-18"	34.820876755	-118.990129976	5180.13
"L9-19"	34.821153156	-118.99016696	5191.56
"L9-20"	34.82141486	-118.9901986	5203.51
"L9-21"	34.821678774	-118.990257641	5213.32
"L10-0"	34.814595096	-119.002979014	5192.81
"L10-1"	34.814869299	-119.002884635	5181.94
"L10-2"	34.815069798	-119.002684778	5177.01
"L10-3"	34.815378767	-119.002715382	5170.03
"L10-4"	34.815653163	-119.002779565	5164.9
"L10-5"	34.815970229	-119.002703771	5162.16
"L10-6"	34.816201334	-119.002637335	5160.68
"L10-7"	34.81647494	-119.002591796	5158.17
"L10-8"	34.816742702	-119.002508463	5155.34
"L10-9"	34.816998813	-119.002397687	5150.24
"L10-10"	34.817294151	-119.002274331	5149.08
"L10-11"	34.817559369	-119.002097183	5147.07
"L10-12"	34.817810061	-119.001963858	5146.47
"L10-13"	34.81804269	-119.00180127	5143.94
"L10-14"	34.81830589	-119.001657978	5142.42
"L10-15"	34.818573548	-119.001456872	5144.74
"L10-16"	34.818829609	-119.001305878	5153.36

Appendix C

Gravity Survey Base Stations

U.S.G.S. Gravity Base Station -- PB2N03A

Gorman, California



Observed gravity: 979,408.223 mGal

34 47.549 N, 118 50.049 W

Local Field Base Station -- M6Base

Flying J Truck Center -- Lebec, California

Observed gravity: 979,412.992 mGal

34 49.049 N, 118 53.119 W