DRAFT Technical Memorandum

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To:	Ron Craig RBF Consulting
From:	Dennis E. Williams, Ph.D. President GEOSCIENCE Support Services, Inc.
Date:	February 28, 2007
Subject:	Preliminary Geohydrologic Evaluation of Artificial Recharge Potential – Proposed Butterfield Development, Banning, California

1.0 INTRODUCTION

This technical memorandum summarizes a preliminary evaluation of artificial recharge potential for Pardee Homes' proposed Butterfield Development (i.e. the Project Area), to be located in Banning, California (see Figure 1). The specific plan for the proposed development includes approximately 5,000 dwelling units centered on a golf course. The golf course is designed around Smith Creek, which is an existing ephemeral stream bed that trends in a north-south direction through the center of the proposed development. The projected water demand of the development is estimated to be approximately 0.61 acre-ft/dwelling unit/year, for a total of 3,050 acre-ft/yr. Water demand would be met through pumping from City of Banning wells. In order to enable the City of Banning to offset proposed project pumping, Pardee Homes is considering using Smith Creek and possibly other portions of the development for artificial recharge of imported water. The purpose of this technical memorandum is to summarize a preliminary evaluation of artificial recharge potential along Smith Creek, based on existing data.

1.1 Project Description

The Project Area is located on approximately 2,000 acres in the western portion of the City of Banning (see Figure 1). The main portion of the property is bounded by Wilson Street on the south, Highland Springs Avenue on the west, Brookside Avenue on the north and Highland Home Avenue on the east (see Figure 2). Two smaller residential areas are proposed northeast of Brookside Avenue and east of Highland Home Road. The existing drainage channel for Smith Creek trends approximately north-south through the center of the main portion of the Project Area. The natural drainage course of Smith Creek will be slightly altered for the project.

1.2 Purpose and Scope

Approximately 5,000 dwelling units (DUs) are planned for development. Assuming a water demand of 0.61 acre-ft/DU, the total annual water demand is estimated to be 3,050 acre-ft/yr. Smith Creek is being considered for possible artificial recharge facilities to supplement the current ground water supply in order to accommodate the additional water demand needed for development.

The purpose of this technical memorandum is to provide a preliminary evaluation of the artificial recharge potential of the portion of Smith Creek located within the Project Area. This preliminary evaluation is based entirely on existing data. However, data gaps have been identified and a generalized approach developed to collect data necessary to address data gaps and more fully assess the feasibility of artificial recharge along Smith Creek.

1.3 Sources of Data

The primary sources of information used in this study included aerial photos, geology maps, United States Geology Survey (USGS) studies, California Department of Water Resources

(DWR) driller's logs, and previous geologic investigations specific to the proposed development. Key reports and sources of information included:

- GEOCON, 2005a. Geotechnical Investigation, Deutsch Property, Highland Springs Avenue and Wilson Street, Banning, California.
- GEOCON, 2005b. Report of Double-Ring Infiltrometer and Percolation Testing, Deutsch Banning Property, Banning, California.
- GEOSCIENCE, 1991. City of Banning Water Wells C-4, C-5, C-6 and R-1, Results of Drilling, Testing and Recommended Pump Design.
- GEOSCIENCE, 2002. Draft Geohydrologic Investigation, Noble Creek Artificial Recharge Study.
- GEOSCIENCE, 2003. Determination of Maximum Perennial Yield for the City of Banning.
- RBF Consulting, 2007. Butterfield Specific Plan, Land Use Basemap.
- USGS, 2006. Geophysical and lithologic logs for the USGS Monitoring Well on Highland Springs Road.

A complete list of references is provided at the end of this technical memorandum.

2.0 GEOHYDROLOGY OF THE PROJECT AREA

The Project Area is located within the San Gorgonio Pass at the base of the San Bernardino Mountains in Banning, California (see Figure 1). The San Gorgonio Pass is an elongated lowland area between the San Bernardino Mountains to the north, the San Jacinto Mountains to the south and the San Timoteo Badlands to the southwest. The Project Area is located in the north-central portion of San Gorgonio Pass in the Beaumont Ground Water Storage Unit.

2.1 Regional Geologic Setting

The principal geologic units previously identified in the San Gorgonio Pass area (shown on Figure 3) include (from oldest to youngest):

- An igneous/metamorphic basement complex,
- The San Timoteo Formation (QTst)
- Older Alluvium (Qoa)
- Younger Alluvium (Qal)

The basement complex in the northern portion of the San Gorgonio Pass area outcrops in the San Bernardino Mountains north of the Project Area and consists of metamorphic gneiss and granitic rocks (see Figure 3). In the southern portion of the San Gorgonio Pass, the basement complex consists of granitic rocks associated with the San Jacinto Mountains. The top of the basement complex is considered the effective base of fresh water aquifers within the region.

The San Timoteo Formation is a late Pliocene to early Pleistocene (1.3 to 1.5 million years old) sedimentary unit that outcrops primarily in the San Timoteo Badlands in the south and western portions of the San Gorgonio Pass area (Dibblee, 1981). This unit is of fluvial and lacustrine origin (freshwater) and consists of poorly cemented sandstone and siltstone interbeds with localized, lenticular channel deposits of coarse-grained sandstone and gravel to cobble conglomerate (Rewis et al., 2006). The San Timoteo Formation does not outcrop in the Project Area. However, it has been described in deep ground water production wells located in the central portion of the Beaumont Storage Unit (GEOSCIENCE, 2002).

Alluvial sediments in the Project Area are the result of weathering of the granitic and metamorphic rocks in the San Bernardino Mountains. The alluvial sediments are grouped into an older unit and a younger unit. The older alluvium has been mapped by Dibblee (2003) as Pleistocene in age (approximately 10,000 to 2 million years old) and consists of varying thicknesses of interbedded sand, gravel, silt, cobbles, and boulders. This unit occurs as an alluvial fan deposit and has been mapped at the ground surface within the southwest half of the Project Area (see Figure 3). The younger alluvium is stratigraphically above the older alluvium and consists primarily of recent (Holocene) deposits of sand, gravel, cobbles, and boulders with minor interbedded silt layers. Younger alluvium has been mapped by Rewis et al., 2006 in the north-central portion of the Project Area primarily along the Smith Creek channel.

The regional geology of the San Gorgonio Pass area is largely a function of faulting associated with the San Andreas Fault system. Faults in the vicinity of the proposed development include the Banning, and McMullin faults, as well as unnamed inferred faults to the south and southeast (see Figure 3). The faults are significant from a geohydrologic perspective because they form barriers to ground water flow and, based on this characteristic, form the boundaries of the ground water storage units in the area (Rewis, et al., 2006).

The Banning Fault is a strike-slip fault which runs through the northern portion of the proposed development. It represents a major structural feature between the San Bernardino Mountains and the San Gorgonio Pass. It also comprises the northern boundary of the Beaumont Ground Water Storage Unit. The fault trends northwest/southeast across the development property, but becomes east/west trending to the east of the development.

The McMullen Fault cuts through the northeastern portion of the proposed development and represents a portion of the eastern boundary between the Beaumont and Banning Ground Water Storage Units. This fault, along with other northeast/southwest trending faults that have previously not been named, is inferred based on differences in static ground water levels and the effects of pumping by nearby wells (Rewis et al., 2006).

2.2 Regional Geohydrologic Setting

The Project Area is located within the San Gorgonio Pass Ground Water Basin, as originally defined by Bloyd (1971). The basin is compartmentalized into fault-bounded ground water storage units. These storage units include:

- The San Timoteo Storage Unit,
- The Singleton Storage Unit,
- The Beaumont Storage Unit,
- The South Beaumont Storage Unit,
- The Banning Bench Storage Unit,
- The Banning Storage Unit, and
- The Cabazon Storage Unit.

The Project Area is located within the Beaumont Storage Unit (see Figure 1), and for purposes of this report, detailed discussion of the other storage units is deferred to Rewis et al, 2006.

The boundaries of the Beaumont Storage Unit are defined by buried faults postulated from ground water level differences, differences in surface geology and geophysical data (Rewis et al, 2006). These faults include the San Gorgonio Pass Fault to the northwest, the Banning Fault to the north, unnamed faults to the east, and the McInnes Fault to the south (see Figure 3). The surface area of the Beaumont Storage Unit is approximately 28 square miles (approximately 12 miles long and 3 miles wide) and is oriented in a northwest-southeast direction.

Ground water within the Beaumont Storage Unit occurs primarily in the older alluvium and San Timoteo Formation. Three aquifers have been identified: shallow, intermediate and deep (GEOSCIENCE, 2002). The shallow aquifer system was noted in the north-central portion of the Beaumont Storage Unit (GEOSCIENCE, 2002) and is not utilized for ground water production. The intermediate aquifer system occurs within the Older Alluvium and is the primary production aquifer for area wells. A deep aquifer system occurs within the San Timoteo Formation and has been increasingly utilized for ground water production in the central and western portion of the storage unit. However, the presence and yield of this aquifer has not been evaluated in the vicinity of the Project Area. Regional ground water flow in the eastern Beaumont Storage Unit is to the south-southeast, toward Banning (Rewis et al., 2006).

2.3 Geohydrology of the Project Area

Current knowledge of the geology and geohydrology of the Project Area are based on geotechnical investigations performed in 2005 by GEOCON, data from a USGS monitoring well located on Highland Springs Avenue, and data from a City of Banning production well, located immediately south of Wilson Avenue on the southern end of the Project Area. During the GEOCON geotechnical investigations, 14 shallow boreholes were drilled to depths ranging from 21 to 61.5 ft (see Figure 2). In addition, three double-ring infiltrometer tests were conducted along the Smith Creek channel (see Figure 2). Data available from the USGS monitoring well (see Figure 2 for location), which is a nested monitoring well with four depth-specific screened intervals) includes borehole geophysical logs, borehole lithologic logs, and ground water levels. Data from Banning Well No. C-4 includes lithology, aquifer permeability, and ground water quality.

2.3.1 Lithology

Unconsolidated alluvial sediments in the upper 60 ft beneath the Project Area consist primarily of fine to coarse sand with lesser amounts of silt and gravel. These sediments appear to be relatively permeable and would facilitate artificial recharge. Furthermore, the observed lithologic characteristics appear to be laterally continuous throughout the project area, with no significant change in grain size distribution with respect to proximity of the main drainage. Based on existing borehole logs, no significant fine-grained (clay) layers have been observed in the upper 60 ft bgs.

Deeper unconsolidated sediments have been documented from the USGS monitoring well and Banning Well C-4 (see Figure 4). The USGS monitoring well was drilled to a total depth of 905 ft bgs. Sediments encountered above the ground water table (approximately 570 ft bgs) consisted predominantly of fine to medium-grained sand with lesser amounts of silt and clay. The percentage of clay in the samples from the borehole increased at depths between 420 and 520 ft bgs. Banning Well C-4 was drilled to a total depth of 1,065 ft bgs. Soils encountered during the drilling of the well are described as fine to coarse grained sand, with lesser amounts of gravel, silt and clay. Only two fine grained layers (i.e. predominantly silt and clay) were encountered above the ground water table (above approximately 377 ft bgs). Neither of these fine-grained layers was greater than 10 ft in thickness.

2.3.2 Depth to Ground Water

Ground water beneath the Project Area occurs at depths ranging from approximately 377 ft below ground surface (bgs) south of Wilson Street (Well No. C-4 measured on 1-May-06) to 570 ft bgs in the USGS monitoring well located on Highland Springs Avenue adjacent to the western boundary of the project area (see Table 1 and Figure 4). As described above, the ground water flows to the southeast beneath the Project Area.

2.3.3 Shallow Soil Permeability

Double-ring infiltrometer testing[1] conducted at three locations along Smith Creek shows that the shallow soil permeability is relatively high. Infiltration rates measured at the P-1 location (see Figure 2 for location) were approximately 6 ft/day. Infiltration rates at P-2 and P-3 were reportedly higher than P-1 (GEOCON, 2005b). Although the percolation rates measured from the infiltrometer testing are indicative of near-surface conditions, the relatively high rates measured from the testing suggest high infiltration potential in near-surface materials.

[1] The double-ring infiltrometer is a well recognized and documented technique for directly measuring soil infiltration rates. A typical double-ring infiltrometer is constructed from thin-walled steel pipe with the inner and outer cylinder diameters being 20 to 30 cm, respectively.

3.0 PRELIMINARY EVALUATION OF ARTIFICIAL RECHARGE POTENTIAL

An area has been delineated along the Smith Creek channel for potential artificial ground water recharge facilities within the Project Area (see Figure 2). The designated total artificial recharge area is approximately 22 acres[2]. In addition, two large ponds covering an area of approximately 9 acres are included at the north end of the property for use as surface water storage.

In making preliminary estimates of artificial recharge potential, the primary factors that impact recharge potential is the area available for artificial recharge and the infiltration rate. For planning purposes, it was assumed that 60 percent of the total area identified for artificial recharge facilities (i.e. 60 percent of 22 acres or approximately 13 acres) is available for artificial recharge[3]. The other 40 percent would be used for basin berms, landscaping, access roads and other facilities. For assumed infiltration rates, preliminary testing suggests short-term rates greater than 6 ft/day. However, long-term average infiltration rates are typically lower due to reduction in recharge from clogging. Therefore, for this preliminary evaluation, a range of long-term average infiltration rates of 1 to 2 ft/day are assumed. Finally, to account for recharge area maintenance and rehabilitation (to periodically restore infiltration rates), the basins are assumed to be in operation nine months of the year (270 days) with three months allowed for cleaning and other maintenance.

Given the assumed range of infiltration rates of 1 to 2 ft per day and an effective recharge area of 13 acres, the artificial recharge potential for the Project Area is estimated to range from approximately 13 to 26 acre-ft/day. Assuming this recharge rate is maintained 270 days of the year, a preliminary estimate of annual artificial recharge potential for the Project ranges from

[2] The artificial recharge area was estimated using a Geographic Information System based on AutoCadd files of the proposed project provided by RBF Consulting.

[3] Planning-level estimate based on final design plans from the Beaumont Cherry Valley Water District Noble Creek Artificial Recharge Facility.

approximately 3,500 to 7,000 acre-ft/yr. This amount of artificial recharge would exceed the projected water demand of the project, estimated to be approximately 3,050 acre-ft/year.

Although the 9-acre storage ponds at the north end of the Project Area could potentially be designed and used for artificial recharge, preliminarily it does not appear that they would be necessary as the Smith Creek channel recharge area (13 acres) appears to be adequate to balance water demand production pumping.

4.0 CONCLUSIONS

The following conclusions have been developed based on a preliminary evaluation of existing data:

- Shallow soil infiltration rates in the vicinity of Smith Creek, as measured using double-ring infiltrometers, are favorable for artificial recharge. Based on preliminary testing and lithology data, a long-term recharge rate of 1 to 2 ft/day is assumed.

- Borehole logs from existing shallow boreholes in the Project Area show that sediments consist primarily of permeable sand and gravel in the upper 60 ft bgs, which is favorable for artificial recharge. However, the soil characteristics between 60 ft bgs and the ground water table have not been investigated beneath the Project Area (see Figure 4).

- Borehole logs from deeper wells in the vicinity (but outside) of the Project Area show that, in general, deeper sediments (below 100 ft bgs) appear favorable to facilitate percolation of water to the ground water table. The lateral extent of clay layers observed directly above the ground water table near the northern portion of the proposed development should be more fully investigated.

- The area preliminarily identified for artificial recharge along the Smith Creek Channel is approximately 22 acres. Assuming that 60 percent of the 22-acre area is available for recharge, the effective recharge area would be 13 acres. Assuming an average long-term recharge rate of 1 to 2 ft/day and an effective recharge area of 13 acres, approximately 3,500 to 7,000 acre-ft/yr of water could be recharged annually along the Smith Creek channel assuming a 9-month recharge period.

- The available geohydrologic data in the Project Area are not adequate to fully assess the feasibility of artificial recharge along Smith Creek. A primary data gap is the depth(s) and lateral extent of fine-grained layers below 60 ft bgs. The presence of such layers, if continuous beneath the Project Area, can impede the downward percolation of surface water. In addition, more refined estimates of long-term infiltration rate are needed to enable preliminary design of artificial recharge facilities.

5.0 RECOMMENDATIONS

To more fully assess the feasibility of the proposed artificial recharge program within the Project Area, it is recommended to collect additional data regarding deep soil characteristics and percolation potential in the vicinity of Smith Creek. Specifically, the types of data necessary for further evaluation include:

- Detailed lithologic data, particularly for depths between approximately 50 ft bgs and the regional ground water table (approximately 380 to 570 ft bgs),
- Soil permeability data,
- Thickness, geometry and lateral continuity of fine-grained layers, and
- Ground water level data to evaluate flow directions and hydraulic gradients beneath the Project Area.

The scope of work to collect the data necessary to more fully evaluate artificial recharge feasibility should be conducted in two phases. Phase I would involve drilling ten deep uncased soil boreholes throughout the Project Area, as shown on Figure 5. Soil samples collected during the drilling of the boreholes would be logged in the field. In addition, borehole geophysical logs would be obtained from each borehole to further evaluate the stratigraphy of the area. Selected soil samples would be submitted to a geotechnical laboratory for analysis of vertical hydraulic conductivity and porosity. The data collected would be used to assess the lithology of the deep unsaturated zone beneath the site, permeability of sediments, and thickness and lateral extent of fine-grained layers beneath the Project Area.

Phase II of the artificial recharge feasibility study would involve a long-term pilot artificial recharge test. Based on soil stratigraphic data from the drilling program, an approximate 1-acre area within or adjacent to the Smith Creek channel would be identified for construction of a pilot test basin. Water, from a source to be determined, would be discharged to the basin for an extended period to assess infiltration and percolation rates. Soil instrumentation, placed in boreholes in the basin, would be used to monitor the percolation of water from the basin surface to the native ground water surface. Monitoring wells would be constructed to enable measurement of changes in ground water levels that would indicate recharge of the aquifer system. Ground water samples would also be collected from the monitoring wells and analyzed for changes in ground water quality during the test.

The logistics of designing a field drilling and pilot test program for the Project Area would require a detailed work plan, which is beyond the scope of this report. The work plan would include a detailed description of the proposed recharge area from field reconnaissance, locations of proposed soil boreholes, a sampling and analysis protocol, conceptual design plans for the pilot spreading basin(s), a pilot test monitoring protocol, and a planning level cost for conducting both Phase I (test drilling) and Phase II (pilot testing).

6.0 REFERENCES

Bloyd, R. M., 1971. Underground Storage in the San Gorgonio Pass Area, Southern California, U. S. Geological Survey Water Supply Paper 1999 D.

Dibblee, T.W., 1981. Geology of the San Jacinto Mountains and Adjacent Areas, in: A.R. Brown and R.W. Ruff, eds., Geology of the San Jacinto Mountains, Annual Field Trip Guidebook No. 9, South Coast Geological Society, p. 1-49.

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GEOCON, 2005a. Geotechnical Investigation - Deutsch Property Highland Springs Avenue and Wilson Street Banning, California. Prepared for Pardee Home, June 2005.

GEOCON, 2005b. Report of Double-Ring Infiltrometer and Percolation Testing - Deutsch Banning Property Banning, California. Prepared for Pardee Home, October 2005.

Rewis, D.L., A.H. Christensen, J.C. Matti, J.A. Hevesi, T. Nishikawa, and P. Martin, 2006. Geology, Ground-Water Hydrology, Geochemistry, and Ground-Water Simulation of the Beaumont and Banning Storage Units, San Gorgonio Pass Area, Riverside County, California. U.S. Geological Survey Scientific Investigations Report 2006-5026.

Table 1

Well Completion and Water Level Details
Proposed Butterfield Development Project Area

State Well Number	Owner	Local Name	Total Depth [ft bgs]	Screened Interval [ft bgs]	Depth To Static Water Level [ft bgs]	Date Measured	Sourse of Data
3S/1W-12K01	City of Banning	Well C-3	1,050	380-820, 880-900, 970-990, 1,020-1,040	381	5/1/2006	SBVMWD/WMWD Cooperative Well Measuring Program
3S/1W-12B02S	City of Banning	Well C-4	1,030	390-1,010	377.2	5/1/2006	SBVMWD/WMWD Cooperative Well Measuring Program
3S/1E-06N	San Gorgonio Pass Water Agency	Well M-9	1,200	600-1,200	396.1	4/1/2006	SBVMWD/WMWD Cooperative Well Measuring Program
3S/1E-6P01	San Gorgonio Pass Water Agency	Well M-3	1,000	360-1,000	413	1/1/2006	SBVMWD/WMWD Cooperative Well Measuring Program
2S/1W-35J1	USGS	USGS Nested Monitoring Well	900	880-900,	575.4	11/6/2006	USGS
2S/1W-35J2	USGS		770	750-770	574.9	11/6/2006	USGS
2S/1W-35J3	USGS		630	610-630	573.3	11/6/2006	USGS
2S/1W-35J4	USGS		260	240-260	Dry	11/6/2006	USGS
03S/01E-07E001S	City of Banning	Well C-2	710	-	367.3	5/1/2006	SBVMWD/WMWD Cooperative Well Measuring Program

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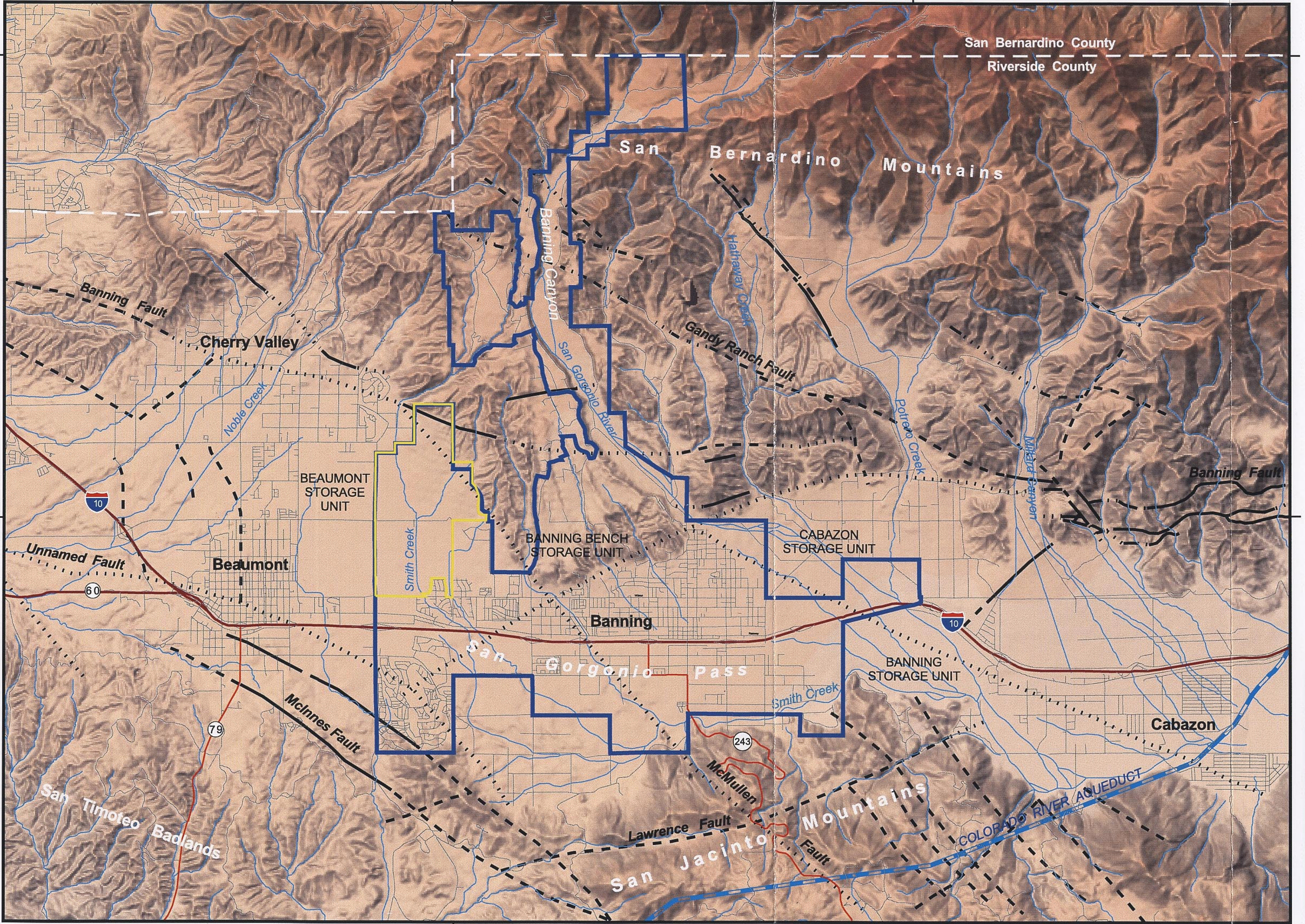
PRELIMINARY GEOHYDROLOGIC EVALUATION OF ARTIFICIAL RECHARGE POTENTIAL
PROPOSED BUTTERFIELD DEVELOPMENT, BANNING, CALIFORNIA



Prepared by: DWB

Map Projection:
UTM 1927 (Zone 11)
Central Meridian: -117 degrees

Source of Faults:
Modified from R.M. Bloyd, Jr. USGS Water Supply Paper 1999-D, Plate 1, 1971.

NORTH

0 1 2 Miles

GENERAL PROJECT LOCATION

EXPLANATION

- Project Area Boundary (Proposed Butterfield Development)
- City of Banning Boundary
- white line: County Boundary

Road Classifications

- Freeway
- State Highway
- Street
- River or Creek

Faults

- Approximate
- Concealed or Inferred
- Mapped at Surface

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California County Inset

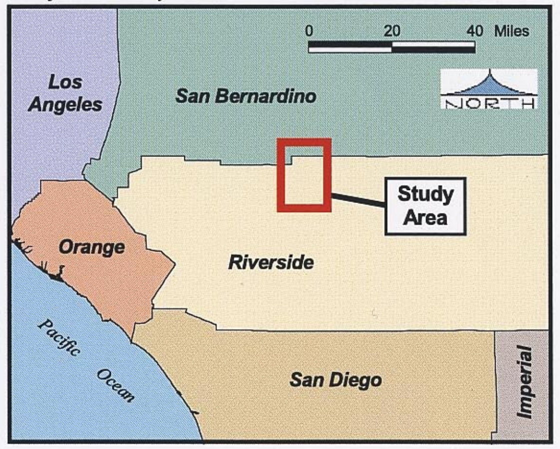

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Figure 1

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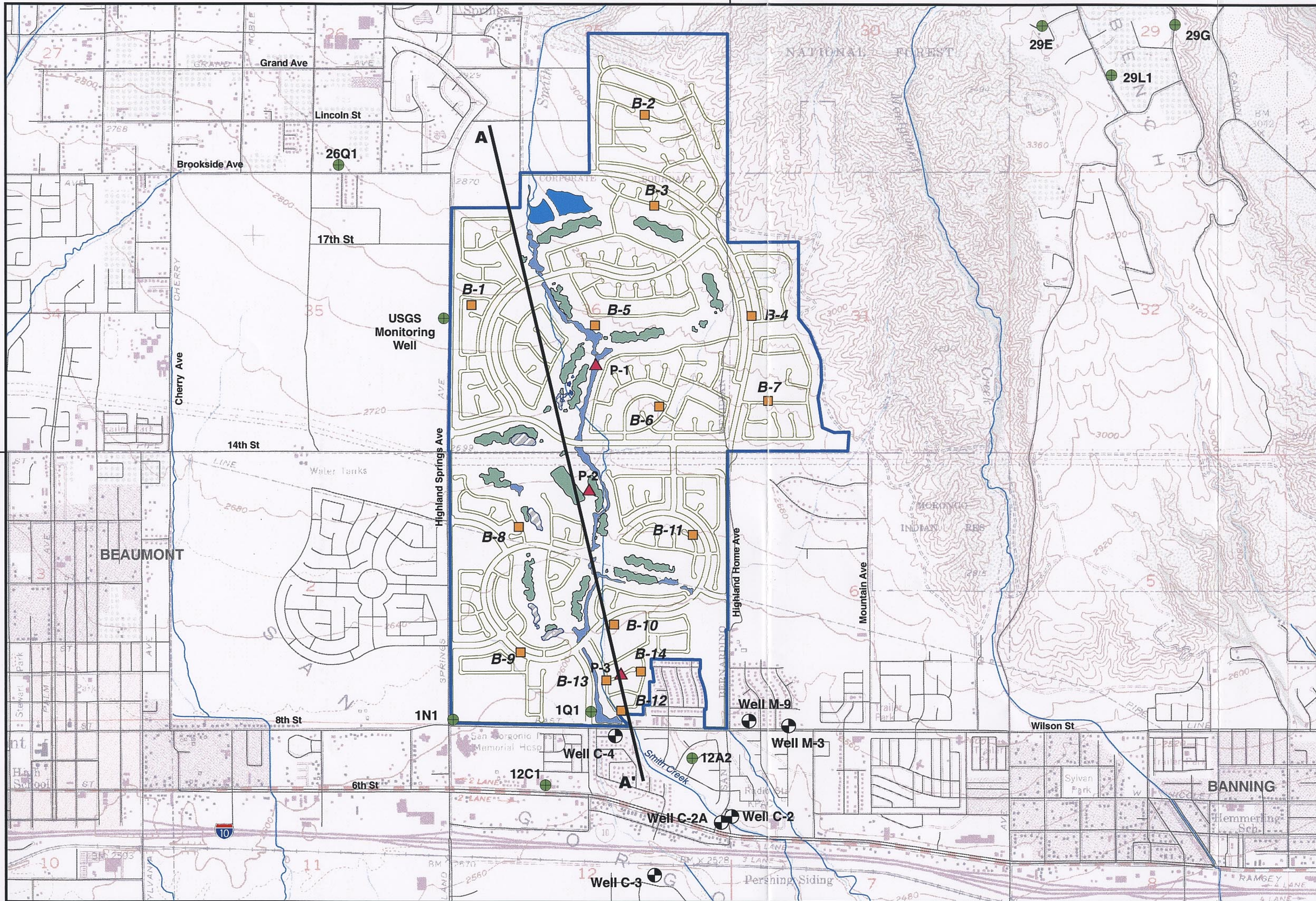
RBF CONSULTING / PARDEE HOMES

PRELIMINARY GEOHYDROLOGIC EVALUATION OF ARTIFICIAL RECHARGE POTENTIAL
PROPOSED BUTTERFIELD DEVELOPMENT, BANNING, CALIFORNIA



DETAILED PROJECT LOCATION

EXPLANATION

- Project Area Boundary (Proposed Butterfield Development)
- Potential Artificial Recharge Areas
- Proposed Development Right of Way
- Proposed Golf Course Fairway
- Proposed Surface Water Storage Pond
- Proposed Golf Course Pond
- 26Q1 — Near Project Area Wells with Existing Data (DWR Well log and/or Recent Water Level Data)
- Well C-3 — City of Banning Well
- B-1 — Geotechnical Borehole (GEOCON, 2005a)
- P-1 — Infiltrometer Test Site (GEOCON, 2005b)
- A — A' Cross-Section Location (See Figure 4)
- River or Creek

28-Feb-07

Prepared by: DWB

Map Projection:
UTM, Zone 11 (1927)

NORTH

0 — 2,000 — 4,000 Feet

Source of Proposed Development Features: RBF, 2007.

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Figure 2

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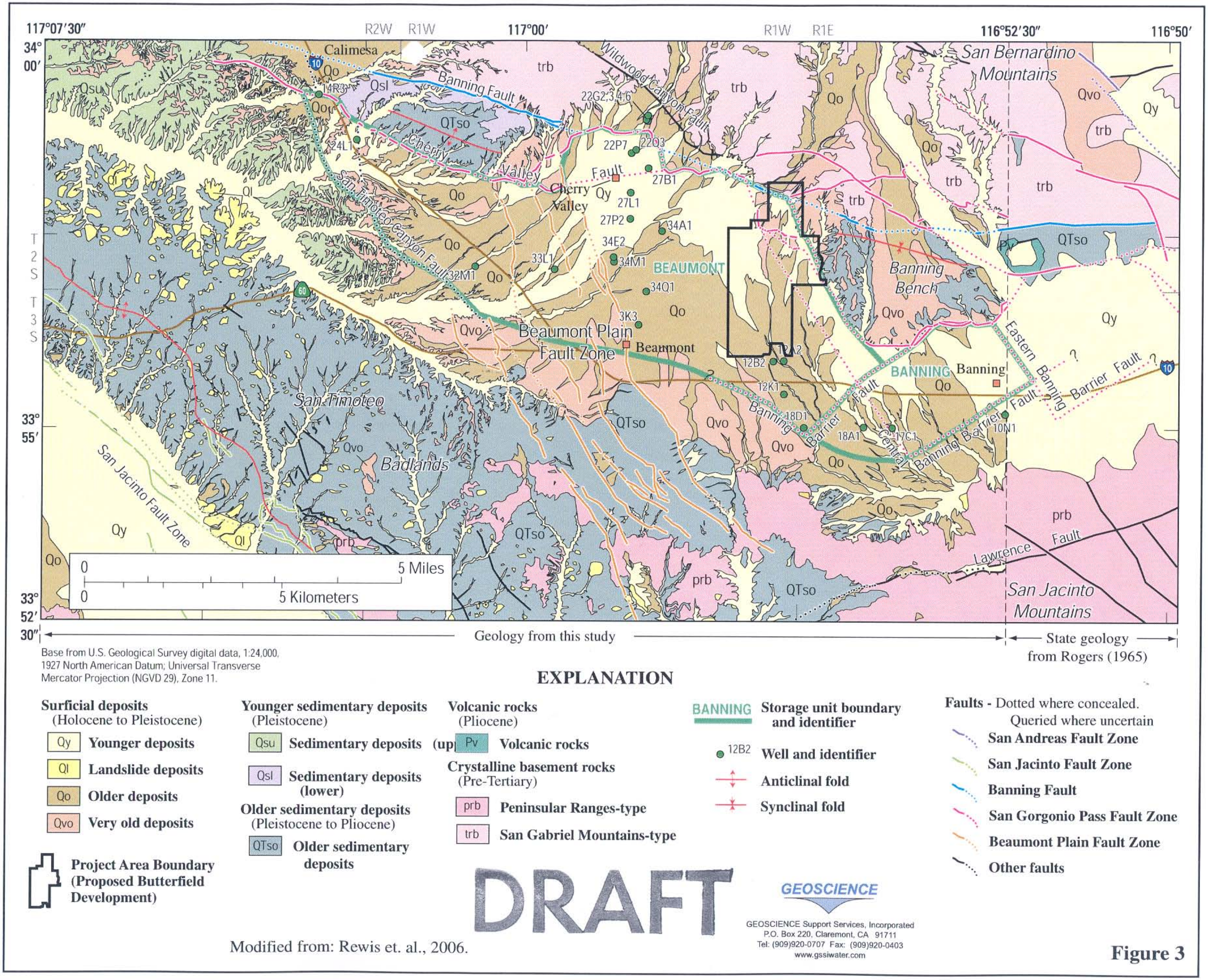
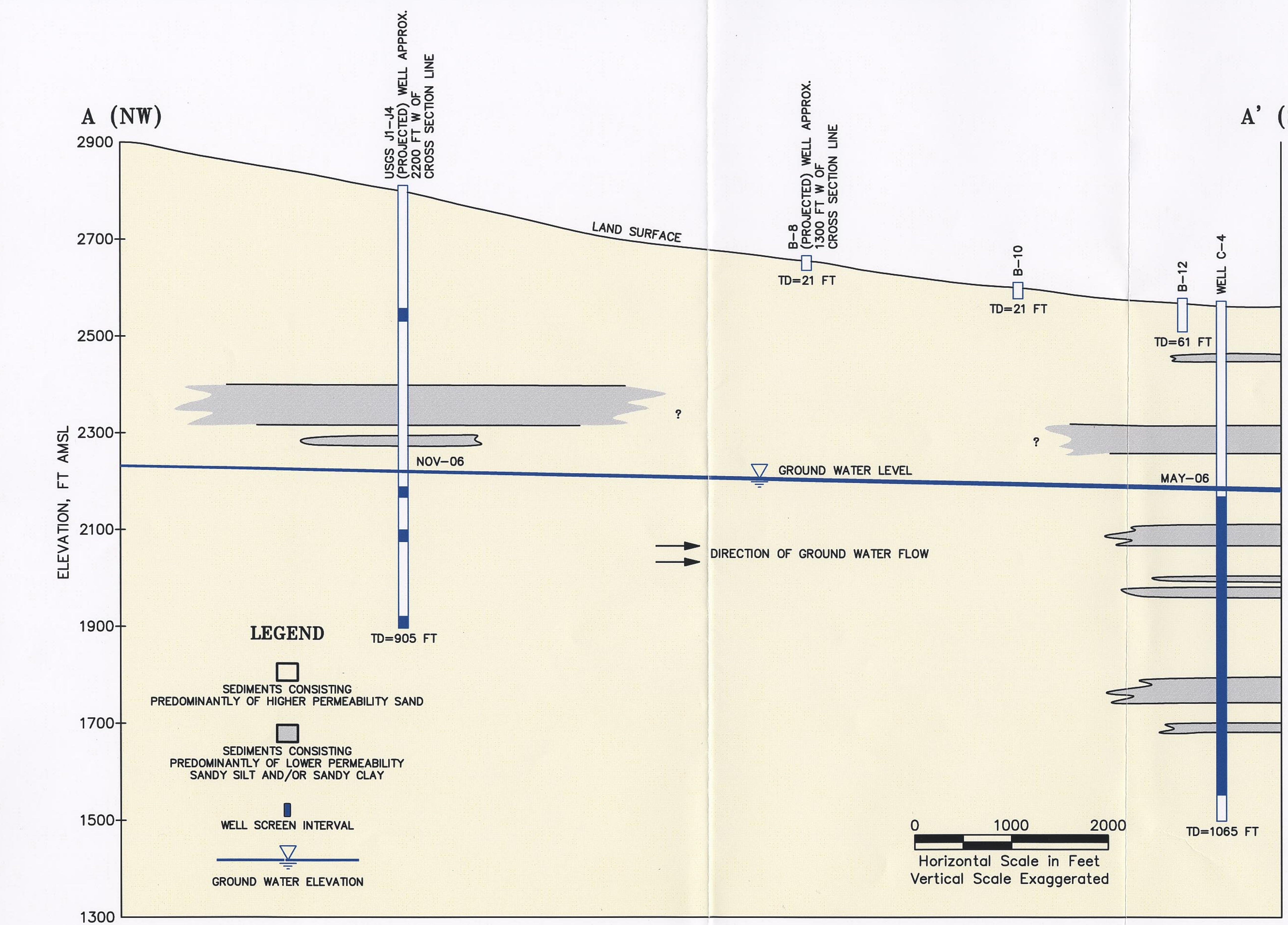


Modified from: Rewis et. al., 2006.

Figure 3

NW-SE cross section along Smith Creek in the proposed Butterfield Development, Banning, Calif.



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GEOLOGIC CROSS SECTION

A - A'

Figure 4	JN 12976-07
Drawn:	PLP
Checked:	
Approved:	
Date:	28-FEB-07

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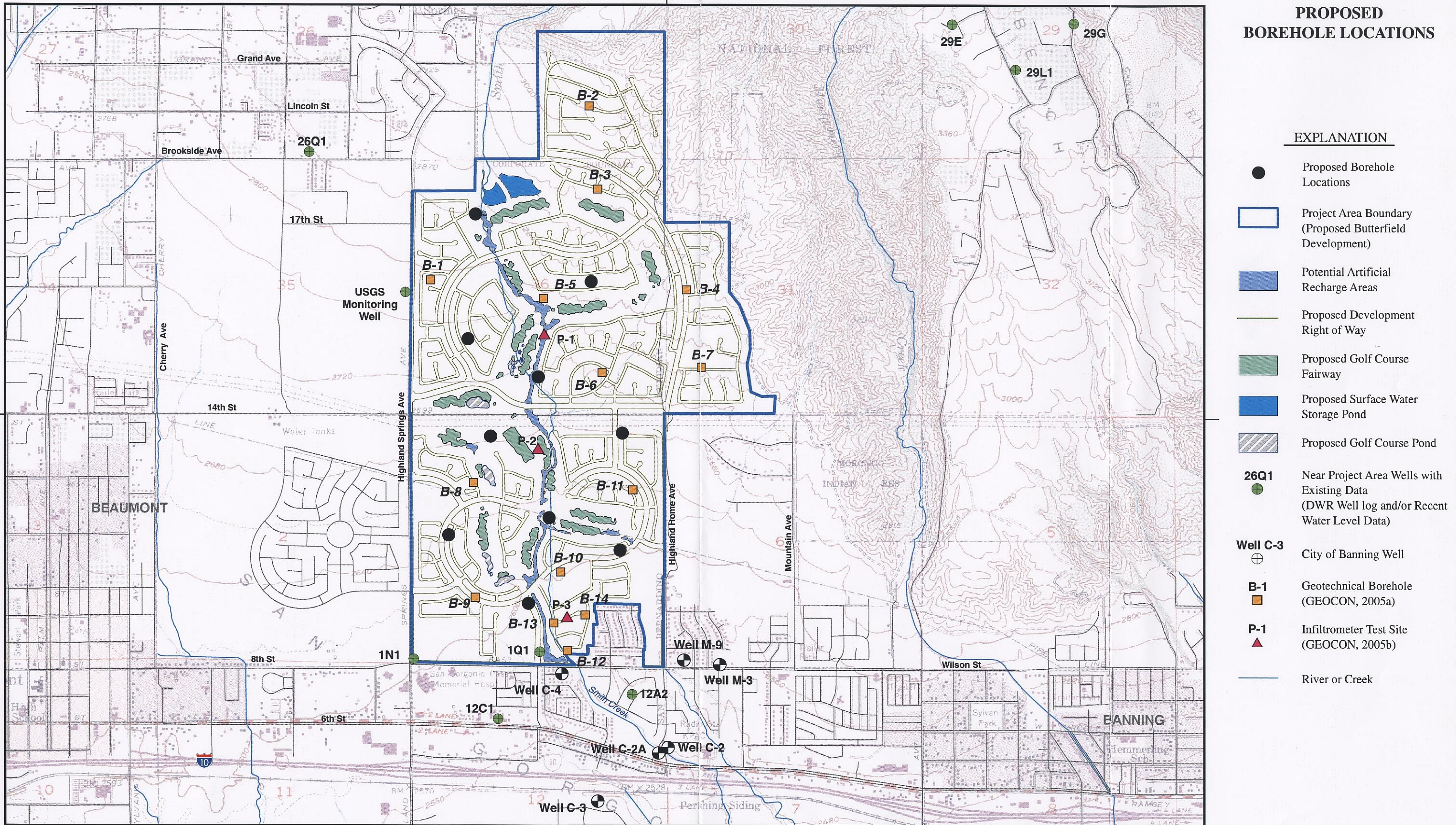
PRELIMINARY GEOHYDROLOGIC EVALUATION OF ARTIFICIAL RECHARGE POTENTIAL
PROPOSED BUTTERFIELD DEVELOPMENT, BANNING, CALIFORNIA

PROPOSED BOREHOLE LOCATIONS



28-Feb-07

Prepared by: DWB

Map Projection:
UTM, Zone 11 (1927)

Source of Proposed Development Features: RBF, 2007.

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Figure 5

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