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# REVIEW OF HYDROLOGIC CONDITIONS AND POSSIBLE WELL SITE LOCATIONS for PREVIOUSLY IDENTIFIED CANDIDATE WELL SITES: Fern/BOWL ROAD, VALLE/NORTH ROAD, and JEWEL/ELECTRA DRIVE CRESTLINE VILLAGE WATER DISTRICT CRESTLINE, CALIFORNIA

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For:
Crestline Village Water District
P.O. Box 3347
Crestline, CA 92325

IGC • P.O. Box 3278 • Crestline, CA 92325 • Phone: (909) 338-5902 • Fax: (909) 338-5609 • Email: Mike@igcsocal.com

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# CRESTLINE VILLAGE WATER DISTRICT
# CRESTLINE, CALIFORNIA

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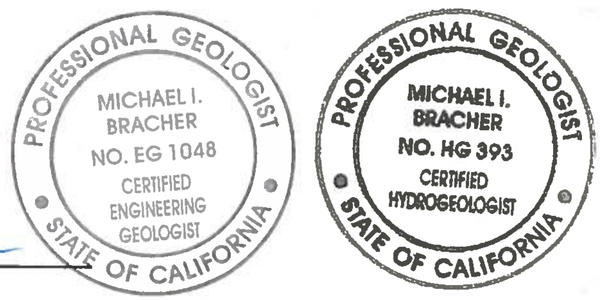


Michael I. Bracher, P.G., HG

Principal Geologist

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## PROJECT DESCRIPTION

Previous studies have identified possible well site areas within the District. The first phase of those studies was to develop an understanding of the regional geology and hydrogeology based on existing information. The second phase resulted in the identification and ranking of possible well site areas within the District. Fifteen candidate site areas were identified based upon interpreted subsurface conditions, proximity to other well, springs, and creeks, as well as proximity to existing water service infrastructure, elevation of site, and interpreted potential reasonable yield.

Subsequent to those studies, four of the candidate site areas were studied in more detail followed by drilling, testing, and installation of deep vertical water supply wells.

More recently, two additional areas including the Basel Drive and Adams Trust (North Road) areas have been studied.

The purpose of this phase of the project is to review geologic conditions at three additional site areas with a more detailed analysis of geologic conditions at selected possible well site locations. The three site areas reviewed during this phase include the areas in and around Fern/ Bowl Road, Valle/ North Road, and Jewel/ Electra Drive. Evaluations of the geologic and groundwater resource conditions at the three site areas are presented in this report.

## EXISTING ENVIRONMENT

The following sections describe the pertinent information collected regarding the existing geologic and hydrologic conditions in the three selected study areas. This information includes a review of available geologic reports, aerial photographs, and geologic reconnaissance of the subject areas.

Geologic considerations for the region including a general overview of the physiography, stratigraphy, and geologic structure within the district were presented in the *Preliminary Report, Crestline Groundwater Resources Exploration Program*, prepared for the District by Independent Geo-Environmental Consultants (IGC), 1997.

### Physiography

The Crestline Village Water District is located within the west-central San Bernardino Mountains, which are a portion of the Transverse Ranges geomorphic province of California. The San Bernardino Mountains Block has generally been uplifted along an east-west axis in response to compressional forces created by right-lateral movement along the San Andreas Fault combined with left-lateral, reverse, and normal fault movements along other faults within the greater San Andreas Fault system. The active San Andreas Fault zone is located along the base of the distinctive and sharp southern boundary and face of the San Bernardino Mountains Block, while an intricate system of low angle thrust and reverse faults define the northern margins of the mountain block and separate it from the Mojave Desert Block.

Within the San Bernardino Mountains structural block there are numerous splays of the San Andreas Fault, many of which, have been abandoned over time as the mountains block has been uplifted and activity within the system has stepped to the southwest. Additionally, during uplift and deformation of the structural block, many local faults have developed in response to uplift, folding, fracturing, and juxtaposition of the various rock units within the block.

## Stratigraphy

The San Bernardino Mountains Block consists of a complex of Mesozoic age granitoid plutons (crystalline granitic rocks) that have intruded late Precambrian and Paleozoic age metaplutonic and metasedimentary rocks (marble, quartzite, schist, and gneiss). The older metaplutonic and metasedimentary rocks are generally found along the ridgelines and as juxtaposed sub-blocks within the mountains or as smaller blocks that may be found as inclusions of various sizes within the crystalline granitic rocks. The deformed mountain block was also intruded along fractures and shears by magma forming dikes of quartz-rich crystalline granitic rock during the Miocene.

The larger valley basins contain Tertiary and Quaternary age, sedimentary deposits of moderately to well consolidate conglomerate, fine grained to conglomeratic arkose, and siltstone. Active drainage courses generally contain recent alluvium consisting of sand, silt, and gravel to boulder size rocks.

The geologic formations in the original report were based on previous work in the area as described by Miller (1979). These descriptions have been modified based on more recent work by Morton and Miller (2003) combined with aerial photographic interpretation and field work performed during this investigation. The geologic formations are discussed below in order of age from youngest to oldest.

**Tertiary Crystalline Dike rocks:** Tabular bodies of light colored aphanitic to macro-crystalline igneous rock that cut across the structure of adjacent rocks. Dikes are formed by the intrusion of magma into cracks and fractures within the parent rock after deformation of the main rock mass. Dikes often occur in sets or swarms ranging from a few inches to several feet in thick and in this area they are generally younger and much more resistant to weathering than the surrounding parent rock.

**Mesozoic Age Crystalline rocks.** This complex of Mesozoic age igneous granitic rocks includes a group of plutons of various compositions intruded within the San Bernardino Mountains during the Mesozoic age.

- **Biotite quartz monzonite:** This is a light colored medium-grained igneous rock with a poorly developed subtle foliation, and containing small light pink pheoncrysts of potassium feldspar.

- **Hornblend-biotite granodiorite:** This is a medium colored, medium to coarse-grained igneous rock with poorly developed foliation and small scattered pheoncrysts of potassium feldspar. This rock unit is noted to have intruded older gneiss and schist as well as containing inclusions of older gneiss and schist.
- **Biotite-hornblend granodiorite:** This is a medium to darker colored, medium to coarse-grained igneous rock with strong foliate structure and large pink pheoncrysts of potassium feldspar.
- **Biotite-hornblend monzonite:** This is a darker colored, medium-grained igneous rock with foliate and often a folded appearance.

**Precambrian to Paleozoic Metaplutonic and Metasedimentary rocks.** This complex of Precambrian and Paleozoic age metaplutonic and metasedimentary rocks (marble, quartzite, schist, gneiss, and some minor granitic rocks) represent the prebatholithic rocks of the area and are generally similar to those of the Mojave Desert. Now they may be observed as roof pendants, which cap the igneous granitic rocks along the ridges of the mountains and have been completely eroded away in other areas.

- **Gneiss:** Rocks included in this group generally consist of highly to moderately fractured and moderately weathered metaplutonic and metasedimentary rocks. Metaplutonic rocks in this group range from soft and friable hornblend-rich granodiorite to hard banded Biotite-quartz-plagioclase gneiss. Metasedimentary rocks in this group include hornfels, quartzite, and some marble.
- **Schist:** Rocks included in this group generally include highly to moderately weathered metasedimentary and metaplutonic rocks occurring as schist or as rocks with high schistosity dominating its fabric.

## Structure

Geologic structures within the study areas have a very significant influence on the occurrence and movement of ground water. Dominant structural features in these areas include westerly to northwesterly trending faults, with associated northeasterly dipping contacts and foliation patterns within and between the bedrock units.

The predominant faulting pattern in the region trends westerly to northwesterly, whether active, potentially active, or inactive and are directly associated with the San Andreas Fault system. Other fault patterns include normal and reverse faults, which have occurred as a result of uplift and folding associated with movements and uplift along the San Andreas Fault system.

Faults not only act as partial barriers to ground water movement within the various bedrock units between faults, but they can also affect both the quality and occurrence of ground water within the area.

## Hydrology and Hydrogeology

Groundwater in the mountain area is generally confined to open fracture zones in hard metamorphic and granitic rocks. There is no permanent groundwater table in the mountains and groundwater storage generally occurs within the fractured bedrock zones. When cut off by partial barriers such as faults, shear zones, or contacts between bedrock units, the stored groundwater may often be seen at the surface occurring as a spring or seep.

Typically, most fracture zones containing usable quantities of water are encountered within about 200 to 300 feet of the surface. Faults tend to act as partial barriers to groundwater flow, cutting across fracture zones and closing them by off-setting the fracture zone or by sealing off the zone with gouge and thus stopping or slowing the down gradient movement of water within the fracture zone. Often, mountain area springs occur where a fault causes water to build up, within a fracture zone, on the upstream side of the barrier until the water can exit the fracture zone at the ground surface. Groundwater movement in these systems is fed by snow melt and runoff, which percolates into the fractures along drainage courses and may discharge down gradient as a spring, enter the drainage course feeding the surface flow or re-enter the fracture zone and continue to move down gradient beneath the surface. Historically, groundwater production in the area has consisted of drilling horizontal wells into existing springs or the source areas for the springs.

In the study area, barriers to down gradient groundwater flow consist of westerly and northwesterly trending faults, shear zones, and contacts between geologic units.

Groundwater resources in the selected areas can be considered, in a simplified sense, as a series of blocks. Water is contained within the fractures and foliations within the blocks and the contacts between the blocks represent the barriers to flow.

## POSSIBLE WELL SITES

This phase of study focuses on developing an understanding of the groundwater resources at the three potential site areas: **Fern/ Bowl Road; Valle/ North Road; and Jewel/ Electra Drive.** Potential well site for these areas are shown on Figure 1.

All three sites appear suitable for sufficient groundwater production; however, the District already owns property in the **Jewel/ Electra Drive** area so a site in that area may be the easiest to develop in a short period of time. It could also have the most negative impact on other existing horizontal wells within the same recharge area.

## Fern/ Bowl Road Area

## Statigraphy

The Fern/ Bowl Road area is underlain by a large block of roof pendant of older metaplutonic rock of Precambrian age. These older metaplutonic and metasedimentary rocks are in turn underlain by a complex of igneous granitic rocks associated with the southern California batholith. The geologic formations within the area are discussed below in order of age from youngest to oldest.

**Mesozoic Crystalline rocks:** Though not exposed in the area, this complex of igneous granitic rocks does, at some depth, underlie the Precambrian rocks at the site. This complex likely includes:

- **Biotite quartz Monzonite (Kqm):** Light colored, medium-grained igneous rock;
- **Hornblend-biotite granodiorite (Mzg):** Medium colored, medium to coarse-grained igneous rock with poorly developed foliate structure;
- **Biotite-hornblend granodiorite (Jrg):** Medium to dark colored, medium to coarse-grained igneous rock with strong foliate structure; and
- **Biotite-hornblend Monzonite (Trm):** darker colored, medium-grained igneous rock with foliate and often folded appearance.

**Precambrian Metaplutonic and Metasedimentary rocks:** This complex is exposed in the Fern Drive area and includes gneiss, schist, and some hornfels, quartzite, and dolomitic marble.

- **Gneiss (pCg):** Rocks in this group generally consist of highly weathered and soft hornblend-rich granodiorite to very hard, banded and fractured Biotite-quartz-plagioclase gneiss. Also in this group are some hornfels, quartzite, and dolomitic marble;
- **Schist (pCs):** Rocks included in this group are generally highly to moderately weathered metasedimentary and metaplutonic rocks occurring as schist or schistose structure.

## Structure

Dominant structural features in this area include the eastern portion of a large wedge-shaped block bounded by westerly, northwesterly, and northeasterly trending faults. Additionally, the stresses related to faulting have resulted in stress release fracture zones, shear zones, and ancient landslides.

The laminated internal fabric or foliation patterns within the bedrock generally trend westerly to northwesterly and dip to the north and northeast at about 20 to 30 degrees. Fracture zones trend northwest with high angle dips and faults generally act as partial barriers to ground water movement.

## Storage and Flow Zones

The structures, that are suitable for sufficient groundwater production are isolated and are located in areas that have been developed for residential use making it difficult to find a suitable location for a possible well site. Potential well sites in this area are shown on Figure 2.

## Valle/ North Road

This site is similar to the site called the Adam's Trust Basel Site, evaluated in our October 18, 2012 report; however this site location is, northwest of the Adam's Trust Basel Site, on the northeast side of Valle Road.

## Stratigraphy

The geologic formations within the area are discussed below in order of age from youngest to oldest.

**Mesozoic Crystalline rocks:** This complex includes:

- **Biotite quartz Monzonite (Kqm):** Light colored, medium-grained igneous rock;
- **Hornblend-biotite granodiorite (Mzg):** Medium colored, medium to coarse-grained igneous rock with poorly developed foliate structure;
- **Biotite-hornblend granodiorite (Jrg):** Medium to dark colored, medium to coarse-grained igneous rock with strong foliate structure; and
- **Biotite-hornblend Monzonite (Trm):** darker colored, medium-grained igneous rock with foliate and often folded appearance.

## Structure

Structural features in this area are the same as those described for the Adam's Trust Basel Site in that they include large structural blocks of igneous and metamorphic rocks with a moderate to strong foliation pattern trending westerly and dipping to the north.

The structural blocks are bounded by westerly, northwesterly trending faults and stress release fracture zones and shear zones.

The laminated internal fabric or foliation patterns within the bedrock generally trend westerly to northwesterly and dip to the north and northeast at about 5 to 40 degrees. A major fracture zone trends northwest along upper Houston Creek and there is a confluence of smaller fracture zones in the area just up gradient from the selected site.

## Storage and Flow Zones

Unlike the Adam's Trust Basel Site, which was on privately owned property, this site is located, in an area of undeveloped subdivided residential lots within the District, just east of Valle Drive in the upper Houston Creek area. A potential well in this area should not have any adverse impacts on other existing wells in the area. A potential well in this area is shown on Figure 3.

## Jewel/ Electra Drive

The Jewel Drive/ Electra Drive area contains horizontal wells, several of which had to be abandoned due to the presence of Septic systems in the area. There are active springs and wells in this area but the area appears to be suitable for a vertical well.

## Stratigraphy

The geologic formations within the area include:

- **Biotite quartz Monzonite (Kqm):** Light colored, medium-grained igneous rock; and
- **Hornblend-biotite granodiorite (Mzg):** Medium colored, medium to coarse-grained igneous rock with poorly developed foliate structure.

## Structure

Structural features in this area include large structural block of igneous and metamorphic rocks with a moderate to strong foliation pattern trending westerly and dipping to the north at 20 to 30 degrees.

The two main structural blocks in the area are bounded by westerly trending faults to the north and west of the area and a major northwesterly trending stress release fracture zone extending southeasterly from Dart Canyon along the southwest side of Strawberry Peak.

## Storage and Flow Zones

The structure that appears suitable for sufficient groundwater production are isolated; however, they are located on District property or subdivided residential lots within the District.

The only drawback to this site is that it is uncertain to what extent the negative impacts of a deep vertical well in this area may have on horizontal wells up gradient from the site. Potential well sites in this area are shown on Figure 4.

## Impacts to Water Quality

During drilling, installation, and testing of any proposed wells, some discharge of drill cuttings and pumped water to the ground at the site will be encountered. Chemicals added to drill fluids (detergents); cuttings and turbid discharges from the well may reach area creeks if not properly contained at the well development site.

Cuttings generated during the drilling process will be contained within an excavated pit adjacent to the drilling rig. If sufficient room is not available to excavate an appropriately-sized pit, other containment methods (e.g. a smaller pit with frequent removal of cuttings or removable containers) will be used. Initial discharges from the well are assumed to be turbid and will be discharged into the pit or containment receptacle. Subsequent clear discharges from testing and development of a new well (anticipated to be on the order of 25 gallons per minute for a period of up to three to four days) will be discharged in a manner to reduce the potential for erosion and sedimentation of area creeks. The discharges will be diffused by use of barriers (hay bales, boulders and gravel, etc.) to keep the discharge energy sufficiently low to avoid erosion. The quality of the discharged water will be equivalent to spring discharges in the area as the water has the same source. Appropriate management of the site during construction will reduce the potential adverse quality impacts to a level of non-significance.

## Geologic Impacts

Will the proposed well result in or expose people to any of the following geologic problems?

a. Fault rupture? No impact!
b. Seismic shaking No impact!
c. Seismic ground failure including liquefaction? No impact!
d. Seiches, tsunami, or volcanic hazard? No impact!
e. Landslides or mudflows? No impact!
f. Erosion, changes in topography or unstable soil conditions from excavation, grading, or fill? No impact!
g. Subsidence of the land? No impact!
h. Expansive soil? No impact!
i. Unique geologic or physical features? No impact!

Substantiation: The impacts from further development of the area groundwater resources will not result in the exacerbation of geologic hazards. Many of the hazards identified above are related to high groundwater tables. Development of additional groundwater resources at this site will likely result in the reduction of those hazards (i.e. landslides, expansive soils, and liquefaction).

## Development of Production Well Specifications

The information gathered from any drilling, logging, and air-lift testing will be used to develop the specifications for production wells. The potential production zones, relative yield and relative depth will all be factors used to determine the final well depth and screened intervals.

Groundwater production from wells, such as these, in fractured rock are generally very low. Typical production from one of these wells is likely to be on the order of 20 to 25 gallons per minute. Anticipated levels of production are relatively insignificant, given the potential recharge surrounding these sites. Based on this, any adverse impacts to the availability of groundwater are expected to be at a level of non-significance.

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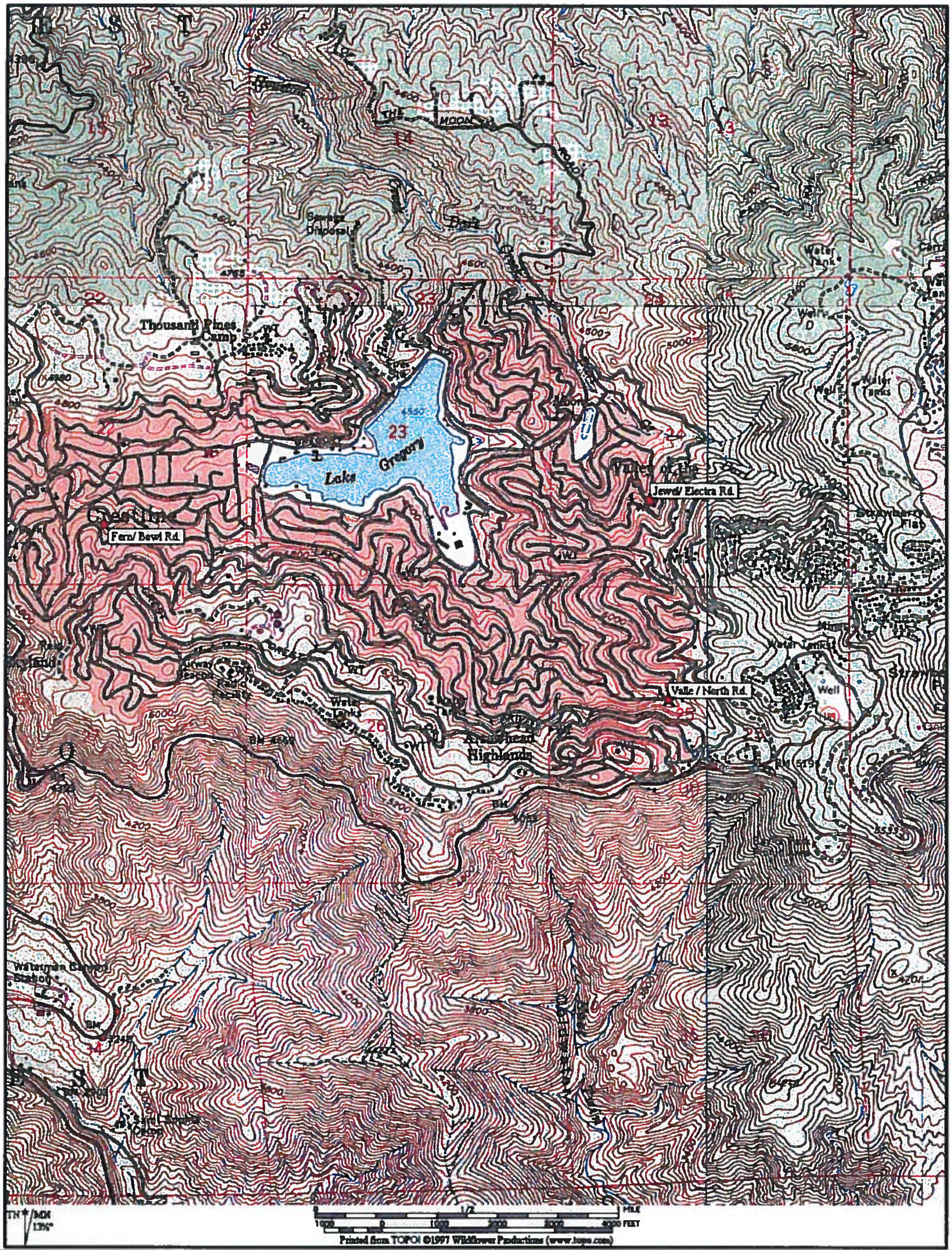


| San Bernardino North 7½ Minute Topographic Quadrangle | GENERAL LOCATION MAP | | FIGURE 1 |
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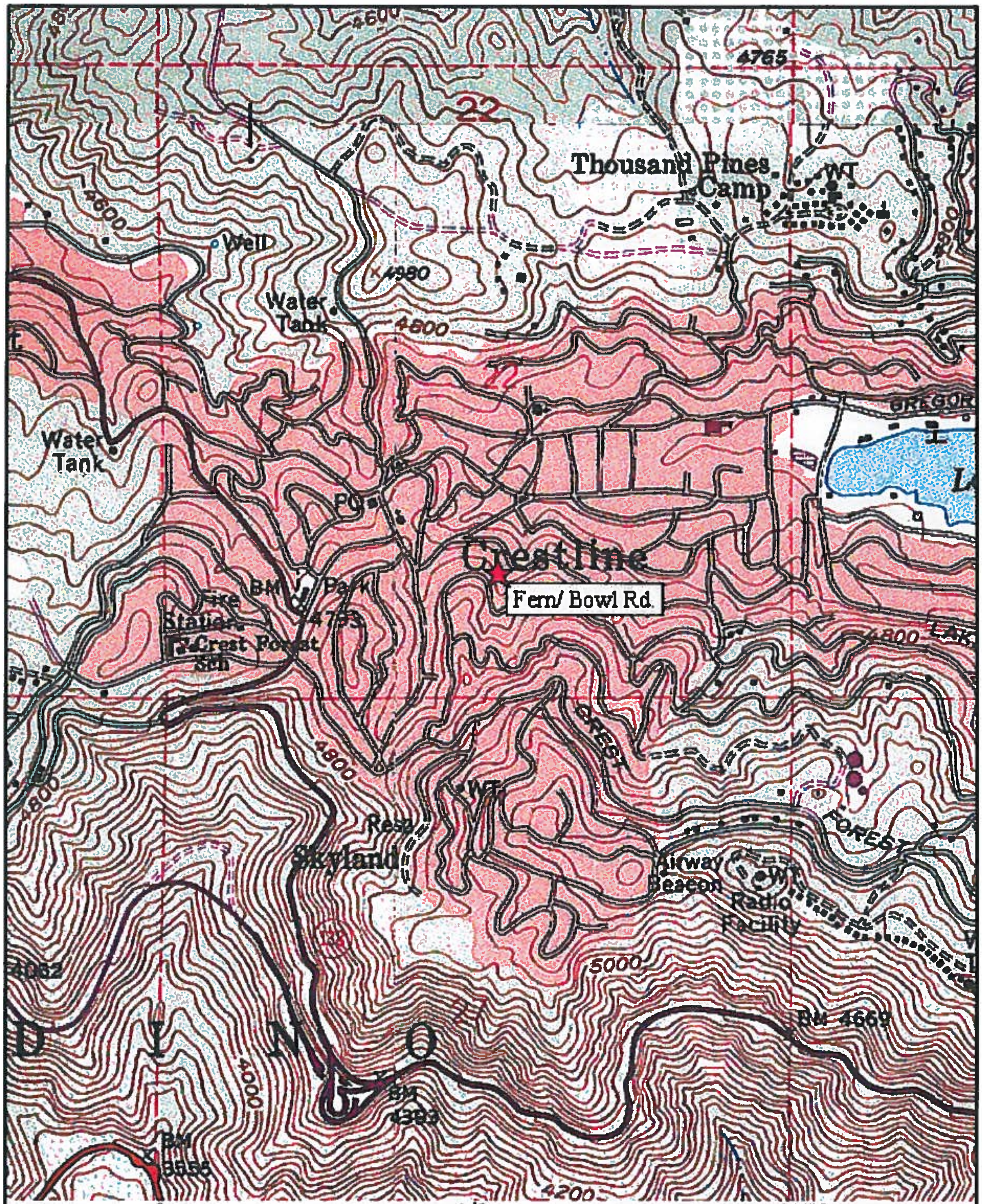


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| San Bernardino North 7½ Minute Topographic Quadrangle | Fern/ Bowl Road Site Locations | | FIGURE 2 |
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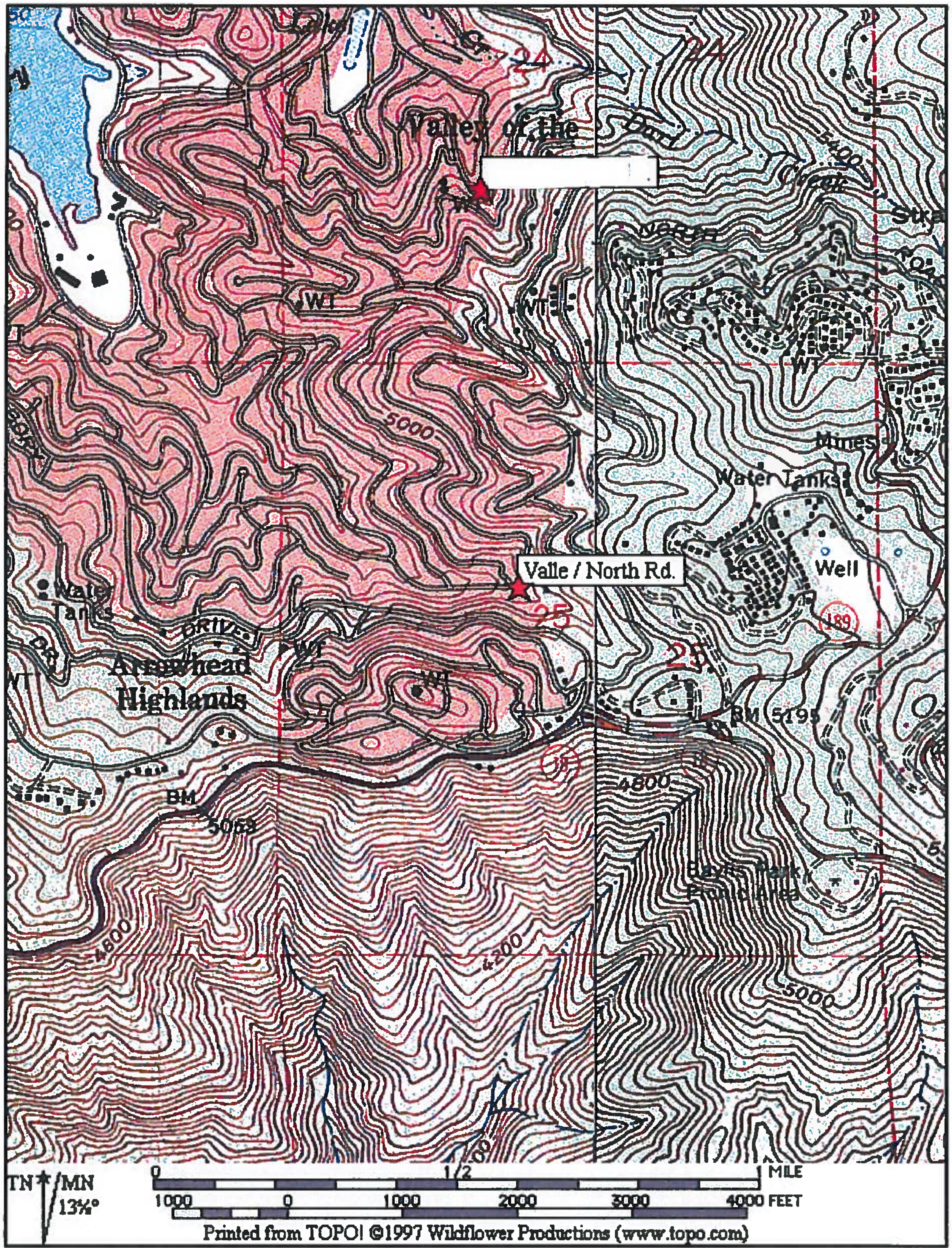
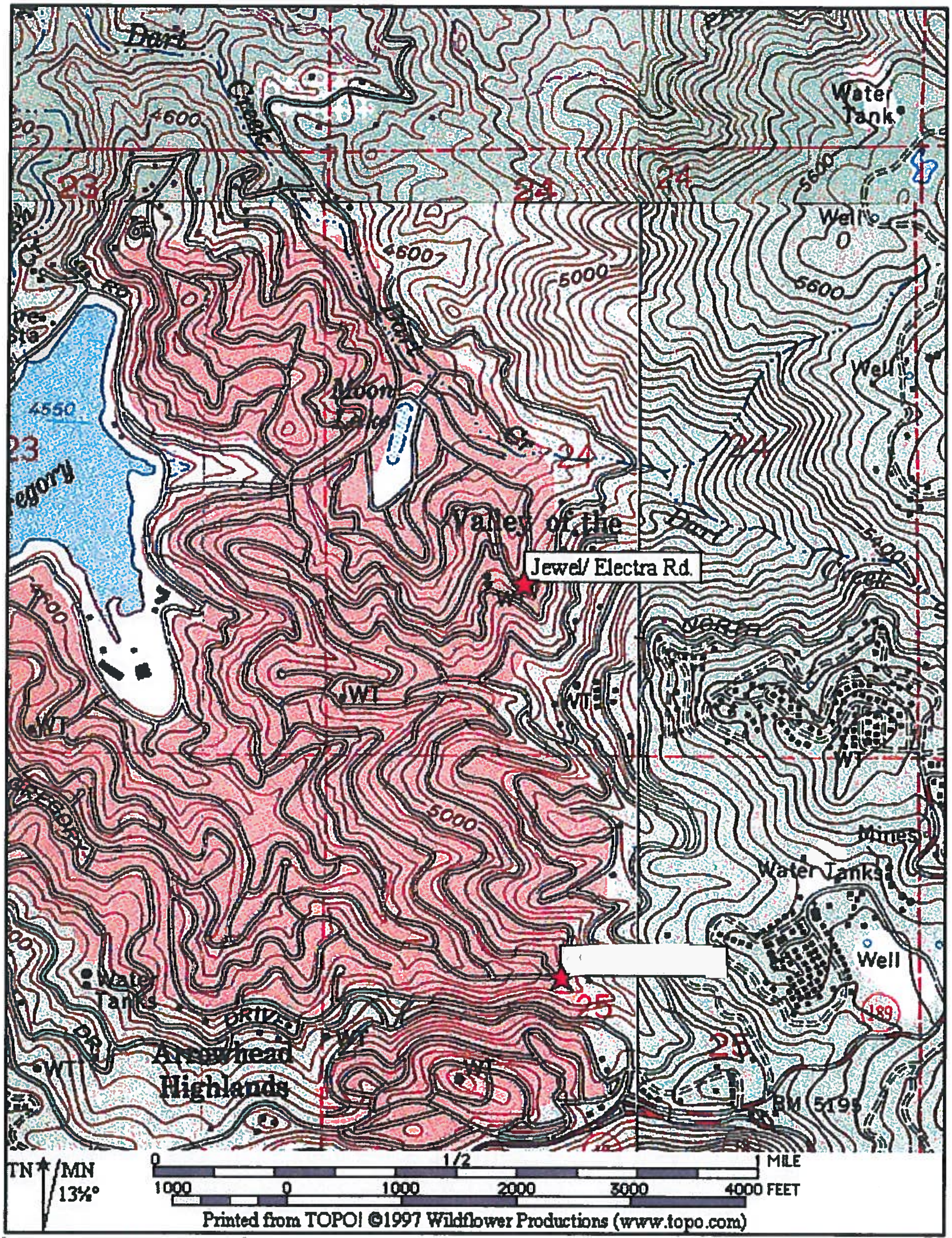



| San Bernardino North 7½ Minute Topographic Quadrangle | Valle/ North Road Site Location | | FIGURE 3 |
|---|---|---|---|

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|---|---|---|
| San Bernardino North 7½ Minute Topographic Quadrangle | Jewel/ Electra Drive Site Locations | FIGURE 4 |