Exhibit Identification Index
NORTH GUALALA HEARING

Participant **North Gualala Water Company**

Exhibit No.	Description	Status of Evidence Introduced	Accepted	By Official Notice
NGWC-1	Curriculum Vitae of John T. Phillips			
NGWC-2	Testimony of John T. Phillips			
NGWC-3	Resume of Patrick B. Cawood			
NGWC-4	Testimony of Patrick B. Cawood			
NGWC-5	Map of North Fork Gualala River and Vicinity			
NGWC-6	Resume of Joseph C. Scalmanini			
NGWC-7	Testimony of Joseph C. Scalmanini			
NGWC-8	Luhdorff & Scalmanini Consulting Engineers: "Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie" (January 1998)			
NGWC-9	Geologic Map of North Gualala River Watershed			
NGWC-10	USGS 7.5' McGuire Ridge, California Quadrangle Topographic Map			
NGWC-11	USGS 7.5' Gualala, California Quadrangle Topographic Map			
NGWC-12	U.S. Dept. of the Interior, U.S. Geological Survey, "Topographic Map Symbols"			

CURRICULUM VITAE

John T. Phillips
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SUMMARY

Currently I maintain active membership in the California Bar, and provide legal assistance as an Attorney, on a contract basis, on land use issues. As a licensed geologist, I have conducted countless technical investigations and developed the requisite hazards mitigation and project development design criteria. Generally my technical services are directed toward regulatory compliance matters, assisting clients with local, State, and Federal permit acquisition, and assistance in administrative law proceedings. My professional experience is directly applicable to many legal issues relative to land use and/or environmental law. My experience includes over 3 years minerals and energy exploration, 9 years as a Senior Geologist and Project Manager for several prominent consulting engineering firms, and for the last 8 years providing a broad spectrum of geologic consultation for numerous clients.

My experience includes detailed, site-specific geologic mapping, regional bedrock and structural mapping, mapping of surface geologic deposits, geologic studies for mineral resource management, energy exploration and production, and geotechnical design. Those studies include landslide identification, rock slope stability evaluation, tunnel support demands, dam foundations, active fault studies, seismic hazards assessment, and ground water, aggregate resources assessment, and permit acquisition for major subdivision development. Typically I perform as Project Manager and supervise technical and support personnel. Necessarily, I maintain certifications from EPA approved Health & Safety courses to access contaminated or hazardous waste sites, and to perform investigations of hazardous discharge as required by 29 CFR 1910.120.

Presently, I am providing technical design and remediation to mitigate several active landslides that threaten residential development. Subsequent to a recent site evaluation, I provided litigation support and expert witness testimony at trial in regard to the risk associated with an active landslide. Additionally, I provided conceptual design recommendations for a retaining wall structure for landslide mitigation, and provided cost estimates for slope stabilization. Recently, I completed several consulting projects, including a site-specific investigation of the Talmage segment of the zoned Maacama fault in Mendocino County. Through detailed subsurface trenching, I was able to locate the fault and determine, with a high degree of confidence, that the fault is "active" within the definition established by the Alquist-Priolo Act.

PROFESSIONAL EXPERIENCE

1989 - Present	*Independent CONSULTING GEOLOGIST: Western States.* Consultation on geology, geotechnical, and environmental matters. Advise clients on project development related geologic hazards, including landslides, faults, ground water resources, and regulatory and environmental compliance issues. Conduct investigations of hazardous waste discharge.
1997 - 1998	*ATTORNEY: Rawles, Hinkle, Carter, Behnke & Oglesby; Ukiah, California.* Provide legal assistance in land use matters on a contract basis.
1992 - 1994	*FORENSIC CONSULTING EXPERT: Garrett Engineers, Inc.; San Francisco, California.* Provide site investigation and hazard evaluation for foundation risk due to geologic and/or soils problems. Provide expert documentation for litigation and insurance claims disputes.

EXHIBIT NGWC-1

1984 - 1989 *HARDING LAWSON & ASSOCIATES, Novato California.* **Senior Geologist & Project Manager.** Provide extensive technical support and project management services for detailed geologic site investigations for project development, facilities design, hazards mitigation and permit acquisition. Provide design recommendations for large-scale power installations, co-generation power plant development, injection well design, open-pit mine site development, and coastline development. Conducted numerous rock slope evaluations for highway design, mine development and tunnel excavation, and related tunnel support demands. Additionally, performed numerous investigations for commercial/residential subdivisions, providing foundation design, surface and subsurface drainage recommendations, road alignment design, and landslide repair programs. My duties included the implementation of studies for mine waste classification and discharge, and site characterization of solid waste landfill projects. Maintained certifications for access to hazardous sites and investigated contaminated ground water.

1981 - 1984 *INDEPENDENT CONSULTING* ***GEOLOGIST,*** *Santa Rosa, California.* Provided geologic consultation services for geothermal development and production. Conducted landslide investigations and performed field studies for the design and construction of a large-scale hydroelectric development in the central Sierra Nevada Mountains.

1979 -1981 *COOPER & CLARK, Novato, California.* **Senior Geologist.** Geologic investigations for geothermal development, including well site design and landslide investigations. Geologic studies for residential subdivisions, including landslide repairs, ground water issues, roadway alignments, and foundation recommendations. Additionally, provided extensive geologic and environmental studies for project feasibility and permitting. All studies included earthquake hazards evaluation and seismic design.

1977 - 1979 *THERMOGENICS, INC., Santa Rosa, California.* **Senior Geologist.** Performed geologic exploration for hydrothermal resources and conducted extensive geotechnical support for the placement of drilling sites on hillside terrain. Provided technical support in the design and placement of drilling fluid containment facilities (hazardous waste ponds).

1976 - 1977 *GEOTHERMAL SERVICES, INC., San Diego, California.* **Project Geologist.** Conducted geothermal exploration; geophysical surveys, down-hole surveys, temperature surveys and heat-flow analysis on numerous *Geothermal Resources Areas* in all of the western United States.

CREDENTIALS

ATTORNEY AT LAW, SBN 181803, admitted to the California Bar, March, 1996

REGISTERED GEOLOGIST,	*RG 3718, California*	*(since 1982)*
	G851, Oregon	*(since 1982)*
	18434, Arizona	*(since 1985)*

CERTIFIED ENGINEERING GEOLOGIST,	*EG 1482, California*	*(since 1990)*
	E 851, Oregon	*(since 1990)*

EDUCATION

Juris Doctor (JD)	*Empire College School of Law,* 1993
Bachelor of Science (BS), Geology	*San Diego State University,* 1975
Associate of Arts (AA), Physical Science	*Pasadena City College,* 1973

ADDENDUM: Representative Projects

- **New Irrigation Dam,** Potter Valley, California. Conducted geologic mapping and field investigation for the design and construction of a 25 foot high, earthfill dam embankment and associated reservoir. Supervised the excavation of several soil test pits and numerous test soil borings and logged the material encountered. Performed data analysis and made alternative foundation recommendations based on adverse soil/geologic parameters.
- **Mine Reclamation,** Lake County, California. Completed a rock mechanics evaluation for a proposed 180 foot high cut slope to be excavated at a slope ratio of 1 foot horizontal to 1 foot vertical for an open-pit, hard rock quarry site. My conclusions and recommendations were part of the permit application and mine reclamation plan mandated for surface mining practice under California Public Resources Code Section 2700 et seq.
- **Expert Witness,** Laytonville, Mendocino County, California. Performed geologic reconnaissance and slope stability evaluation of an improperly designed and constructed hillside excavation. Provided testimony for plaintiff at trial; settled for plaintiff.
- **Expert Witness,** Ukiah, Mendocino County, California. Performed geologic investigation and subsurface data acquisition of a large earthfill slope placed over a naturally occurring, active landslide. Provided expert consultation for defendant; case settled.
- **Expert Witness,** Gualala, Mendocino County, California. Performed geologic reconnaissance and data evaluation for an ocean bluff residence subject to landsliding. Provided expert witness support for defendant; case pending.
- **Ground Water Investigations,** Redwood Valley, Anderson Valley, Robertson Creek, and Tomki Rd., Mendocino County, California. Conducted stereoscopic analysis of selected aerial photographs and geologic reconnaissance of moutain property underlain by Franciscan bedrock for siting drill locations for residential use water wells. Production results were successful for each site and pump tests indicated flow rates from 5 to 35 gallons per minuet at respective sites. Several of these sites were previously drilled by others who were unsuccessful.
- **Landfill Investigation,** Puente Hills Landfill, Los Angeles County, California. Supervising Geologist for Environ Corp.'s hydrogeologic investigation along subsurface groundwater barriers at the Class III disposal site, in accordance with the Waste Discharge Requirements (WDR) issued by the Regional Water Quality Control Board (RWQCB), Los Angeles Region.
- **Landslide Evaluation,** Ukiah, California. Performed geologic reconnaissance necessary to identify an "active" landslide. Provided mitigation recommendations to minimize damage to an existing residential structure.
- **Fault Study,** Willits, California. Conducted geologic mapping and analysis of a proposed development site along a portion of the zoned Maacama earthquake fault near Willits. Provided recommendations for minor subdivision and residential development.
- **Fault Study and Preliminary Geotechnical Evaluation,** West Fork Subdivision, Ukiah, California. Conducted geologic mapping and performed detailed subsurface investigation of a proposed major residential subdivision. Developed cross-section and subsurface trench profiles depicting soils and bedrock conditions along a portion of the "zoned" Maacama fault near Ukiah. Presented design level seismic criteria, construction setbacks from the active fault, and presented preliminary foundation design parameters. Presented expert testimony for permit acquisition at Planning hearing and for the Board of Supervisors hearing. This report withstood extensive scrunity by peer review and by review of the State Division of Mines and Geology
- **Fault Study,** Konocti Bay, Lake County, California. Performed detailed site evaluation along a portion of the Konocti Bay Special Studies Zone. Conducted subsurface trenching and geologic mapping. Provided residential development setback zone and seismic design criteria.
- **Towsely Canyon Landfill,** Los Angeles County, California. Supervising Geologist for the investigation phase for a major proposed landfill site. Conducted geologic evaluation and supervised field crew and subsurface drilling operations, water sampling, ground water monitoring, and data collection.

ADDENDUM: Representative Projects

- **Palos Verdes Landfill,** Los Angeles County, California. Supervising Geologist for the investigation phase of a solid waste landfill closure program. Conducted geologic evaluation, water sampling, ground water monitoring, and subsurface data collection. Managed field crew and drilling operator for a Class I landfill. Implemented the field work, which required level B/C safety equipment to protect field personnel from potential contamination.
- **Louisiana-Pacific Lumber Mill,** Cloverdale, California. Served as Project Manager to investigate subsurface for predesign of a ground water clean-up of a wood preserving facility. Included seismic refraction, geologic mapping, drilling and sampling, and *in situ* bedrock permeability test.
- **Texas Hill Mine,** Mariposa, California. Geotechnical evaluation of existing gold heap leach pads at the Mt. Gaines Mine. Performed slope stability analysis of several unstable mine tailings heaps that contained over 150,000 cubic yards of cyanide saturated unconsolidated soil. Provided remedial slope repair recommendations to protect adjacent streams from discharge of cyanide soil and pond fluid.
- **French Creek Hydroelectric Project,** Feather River, Sierra Range, California. Project Manager for detailed geotechnical investigation and design of a diversion dam, low-flow water transmission tunnel, penstock, and power plant site.
- **Waste Classification,** Blue Moon Mine, Mariposa County, California. Conducted and managed all aspects of the mine waste classification under local, state, and federal regulations for the discharge of mining waste and tailings onto land. Project included surface installations and underground excavations in the volcanogenic, massive sulfide belt along the Melones fault. Study results were part of the application for operation permits, waste discharge permits, and NPDES permits.
- **Spill Prevention and Containment Plan,** Geysers, Northern California. Provided technical evaluation of facilities design and installation as per CFR 40, Section 112 for the Santa Fe Geothermal Power Plant (in association with RES environmental services, Santa Rosa, CA.)
- **New Castle Hot Springs Road,** New Waddell Dam, Central Arizona Project, Arizona. Conducted site-specific, engineering geologic mapping program and drilling, as well as pump-in water pressure testing study for the planned expansion on an existing dam and associated facilities.
- **Foothill Oaks Subdivision,** Windsor, California. Lead Geologist for geotechnical studies for the design and development of a major subdivision, including fault studies, soils investigations, detailed geology and geophysical studies.
- **La Porte Channel Gold Mine,** Sierra Range, California. Conducted placer gold exploration and mine site evaluation of ground water conditions for an open-pit gold production mine. Designed and implemented detailed drilling and sampling program for ore reserve production and mine reclamation.
- **Austin Gold Venture Mine,** Austin, Nevada. Conducted engineering geology and geologic hazards studies for the gold mine development and permitting.
- **Klamath National Forest,** Northern California. Project Manager for geologic resources and hazards investigation. Assessed slope stability, performed geomorphic mapping and interpreted photogeologic data of a 64 square mile portion of the National Forest.
- **Sherwin Bowl Ski Area,** Mammoth Lakes, California. Prepared all geology related technical sections of the *Environmental Impact Statement* for the proposed new ski area. The project included the assessment of site and regional geology, soils, avalanche and geology hazards, ground water, and economic geology.
- **State Lands Parcels No. 7, 8, & 9,** The Geysers, Northern California. Performed environmental geologic assessment and landslide/bedrock mapping for geologic hazards section of the *Environmental Impact Report.*

ADDENDUM: Representative Projects

- **The Geysers Known Geothermal Resources Area,** The Geysers, California. Project Geologist for the exploration, development, and production of geothermal resources for a major operator (PG&E Unit 15), southeast Geysers, Sonoma and Lake Counties. Performed large-scale, detailed bedrock mapping and structural mapping of most of the resource area. Additional responsibilities included Geologist-in-Charge of drilling several 10,000-foot production wells.
- **Warm Springs Dam,** Sonoma County, California. Staff geologist working under the Army Corp of Engineers responsible for geologic mapping of the core foundation of the dam and discharge tunnel facilities.
- **Rock Creek No. 2 Hydroelectric Project,** Feather River Canyon, Sierra Range, California. Conducted detailed geotechnical investigation of proposed dam site and power plant location, including low-flow tunnel and penstock alignment. Conceived design recommendations for dam foundation, tunnel and rock wall excavation, tunnel support and lining requirements, and rock-bolt program for fractured rock. Analyzed and evaluated geologic and rock properties data.
- **Pinetree Project,** Mariposa County, California. Project manager for the design and implementation of various investigative assignments for the planned development of a 3,200-acre, 240 million-ton, open-pit gold mine. Assignments ranged from conducting detailed engineering geologic mapping and geomorphic analysis to performing geochemical studies for mine waste classification. Provided technical support necessary to design subsurface investigation for acquisition of oriented rock core for rock mechanics analysis and conduct analysis to provide opinions regarding potential slope stability of proposed 1000-feet deep open-pit gold mine.
- **Water Resource,** Potter Valley, California. Conducted stereoscopic aerial photograph analysis and geologic reconnaissance to ascertain structural and lithologic conditions to make a determination as to the likelihood of encountering ground water at this remote hillside property. Site is underlain by alternating deposits of sandstone and shale of Great Valley sequence (miogeosynclinal facies).
- **Bull Creek Flat Landslide,** Humboldt County, California. Conducted geologic reconnaissance of a large, complex slump block and debris flow landslide that shows evidence of ancient, historic, and recent movement.
- **Wild Horse Quarry,** Ferndale, Humboldt County, California. Conducted geologic reconnaissance and slope stability evaluation of an abandoned sand quarry and provided mine reclamation recommendations for mine closure.
- **Big Nickel Ranch,** Bakersfield, Kern County, California. Conducted detailed surface and subsurface geologic investigation for the design and construction of a 25 foot high concrete, gravity dam and hydro-power generating plant on the Kern River. The dam facilities were utilized as a diversion structure for collection of river flow to supply hydrolic power to generate 10 mega Watts of power. Performed the supervision of field crew and drilling operation, and assisted on the geophysical investigation. Studies included technical analysis and development of design criteria. Site was subject to active faulting.

Testimony of John T. Phillips

SUMMARY STATEMENT

This testimony provides a brief discussion of the significance of the Franciscan formation with regard to its:

1. potential as a water-bearing formation,
2. potential to support production water wells, and
3. potential to provide a natural source for base flows in river systems.

The short answers to these questions are:

1. Portions of the Franciscan bedrock can contain locally highly significant water-bearing strata and thus, can be classified as aquifers.
2. Countless producing water wells exist within the Franciscan formation.
3. Streams and rivers that drain through Franciscan terrain acquire their late summer base flows from discharges of ground water from adjacent bedrock aquifers.

These opinions are based on my professional knowledge of geology, my extensive professional experience with the Franciscan formation, my extensive supervision of drilled wells, my evaluation of bedrock source spring discharges, and my deep hole hydrothermal exploration and production background.

INTRODUCTION

My curriculum vitae (exhibit NGWC-1) accurately and correctly describes my educational background, professional experience, and my professional license and registration data. The information presented below is based on my geologic expertise. My education and experience as an attorney are not pertinent to this testimony.

The principal questions addressed in this testimony concern the physical capacity of the Franciscan formation to collect, store, and discharge ground water. Fundamentally, the question is whether Franciscan formation geologic units can be classified as aquifers. It is my opinion that, locally, geologic units within the Franciscan formation can be classified as aquifers.

The following discussion first addresses my background and professional experience with individual rock units within the Franciscan formation, as well as the overall formation. Next, a brief discussion of the nature of the Franciscan formation is presented. My opinions regarding ground water, water well production capacity, and stream base flow then are presented. Limited water well pump test data (performed by others based on my recommendations) also are presented as Table 1, Table 2, and Table 3. An illustration showing the relative lateral extent of the Franciscan formation is attached as Figure 1. Figure 1 also shows the approximate locations of many producing water wells that have been drilled based on my recommendations. The small cross marks in Figure 1 indicate producing water wells. The larger cross marks with circles indicate water wells that have the potential to produce more than 50 gallons of water per minute. Each of these water wells were drilled into, and are producing water solely from bedrock units of the Franciscan formation.

PROFESSIONAL EXPERIENCE - FRANCISCAN FORMATION

As a professional Registered Geologist and Certified Engineering Geologist, I have had the unique opportunity to perform extensive exploration and study of the Franciscan formation. In 1977 and 1978, I performed geologic exploration within the Geysers Geothermal Resource Area, which is situated within the Franciscan formation, approximately 20 miles southeast of Hopland, California. In that program, I supervised the drilling of countless intermediate depth bore holes into Franciscan bedrock. Subsequently, I performed detailed geologic evaluations of the materials encountered within each boring. The results of my investigation were instrumental in decisions to submit lease applications and future energy production.

My next assignment was with a geothermal operator and energy producer. My technical duties ranged from working on energy production and development concerns to providing technical input for exploration for additional geothermal resources within the Geysers. Of specific concern to geothermal production is the permeability and porosity of the Franciscan formation. This is because steam production is a function of naturally occurring very high temperatures and ground water movement. For this reason, there are many similarities between a shallow ground water aquifer in the Franciscan formation and a producing steam well. Although, steam production is likely to be encountered from 8,000 to 12,000 feet deep while producing ground water wells generally are less than 1,000 feet deep. During that period of my career, I personally mapped tens of square miles of Franciscan terrain at map scales of one inch equals 500 feet, or one inch equals 1,000 feet. That scale of mapping allows for a very detailed evaluation of the geology. To produce those maps, I traversed the ground, as opposed to relying solely on aerial photographs. The goal of my study of the Franciscan formation was to produce an understanding of its very deep subsurface conditions. That experience was invaluable in the development of my current understanding of the Franciscan formation.

After my work for the geothermal operator, I had the opportunity under the auspices of the U.S. Army Corps of Engineers to be part of a select team of geologists who mapped the core bedrock foundation of Warm Springs Dam, which is located approximately 10 miles northwest of Healdsburg, California. Mapping of that foundation was performed at a scale of one inch equals five feet. Warm Springs Dam is situated in Sonoma County within the Franciscan formation.

Next, I was associated with geotechnical engineering firms. The geologic tasks that I performed related to the detailed evaluation of rock strengths, physical properties, landslides, and other related geologic hazards that occur within Franciscan geology. During the early 1980's, I performed countless site-specific, detailed geologic evaluations for geothermal well sites in the Franciscan formation. Those studies formed the technical basis for the placement of deep hole drilling platforms and hazardous waste containment facilities throughout the Geysers hillside terrain. Additionally, I personally mapped large tracts of Franciscan geology and produced the geologic hazards portions of numerous environmental impact reports (EIR) for Geysers steam field and power plant development and permitting.

Through the late 1980's, I continued to work on geologic problems within the Franciscan formation. Typically, those geologic issues related to civil engineering concerns. My projects included road construction, large excavation and fill placement, hillside drainage, landslide identification and mitigation, and subdivision development and permitting. Additionally, I have personal geologic experience with timber harvest engineering related issues, including landslides, road construction, drainage, and erosion mitigation.

Since the late 1980's, I have repeatedly been asked to locate new ground water well sites for people who, before consulting with me, were unsuccessful in finding ground water within the Franciscan formation. Through the years, my geologic experience and extensive investigation of the Franciscan formation has proven invaluable in my exploration for ground water. My deep hole geothermal background, coupled with my very detailed near-surface engineering geology experience, has aided my success in finding ground water in the complex geologic features found in the Franciscan terrain. My estimate is that I have been successful in finding usable ground water in the Franciscan formation in more than 80% of the wells that I have recommended drilling. That success rate provides evidence of the fact that individual geologic units within the Franciscan formation contain usable ground water and are, therefore, aquifers.

FRANCISCAN FORMATION

The Franciscan formation is a structurally complex, yet mappable assemblage of sandstone, shale, altered volcanic rocks, chert, and minor percentages of high grade metamorphic rocks and limestone. This is a generalized description, modified from the California Division of Mines and Geology (CDMG), Bulletin 183, authored by E. H. Bailey, et al, 1964. From that publication, geologists consider that the bulk (90%) of the Franciscan is composed of clastic sedimentary rocks. Sandstone comprises the majority of the sedimentary rocks. The Franciscan sandstone (commonly called "graywacke", based on an older classification of sedimentary rocks) may have a total volume of over 350,000 cubic miles. This sandstone is composed of small (sand size) grains of other rock, with the spaces between the grains of sand filled with silts and clays. Because the spaces between the grains of sand are filled with fine materials, the rock essentially possesses no primary permeability.

Commonly, the Franciscan sandstone is interbedded with shale. This shale is composed of very fine-grained silts and clays. Because of its fine grained texture, the shale has no primary permeability (permeability is discussed below). Additionally, the Franciscan formation contains a mappable geologic unit referred to as melange. The melange is typically a mixture of any rock type of the Franciscan formation. Individual rock inclusions are separated by a matrix of highly deformed and sheared shale-like material. The occurrence of the included rock bodies is random and chaotic in nature. The melange typically has neither primary nor secondary permeability.

The altered volcanic rocks, cherts, and remaining units of the Franciscan formation are typically less significant and are not included in this discussion. They can, however, form local bedrock aquifers or permeable conduits for the movement of ground water. The Franciscan formation is highly susceptible to landslides. Water contained within a landslide mass can be significant. Those types of geologic features are not discussed here.

Porosity is defined as the voids or open spaces within a rock unit that can be filled with water. Permeability is based on the interconnections of void spaces and indicates a geologic unit's ability to transmit water. Porosity and permeability are critical physical properties that affect a geologic unit's potential to collect, store, and transmit ground water. The State of California Department of Water Resources (CDWR), Bulletin 74-81, published in 1981, defines an aquifer as "a geologic formation, group of formations or part of a formation that is water bearing and which transmits water in sufficient quantity to supply springs and pumping wells."

It is not uncommon for people to consider that the geologic units contained within the Franciscan formation are non-water bearing. This type of determination may be based on the physical nature of the sandstone, shale, and melange, and the abundance of fine grained silt and clay within these units. An abundance of fine grained material could preclude porosity and, therefore, limit the permeability of the unit. The void spaces between the sand grains within the sandstone are filled with silts and clays. The shale displays no potential for void spaces and, therefore, generally is impermeable. Although it may have isolated void spaces, the melange usually does not display any permeability. That is to say, what void spaces in the melange do exist are unlikely to communicate with adjacent void spaces and, therefore, water cannot be transmitted through this unit.

Ground water, however, can occur through any void space that may be contained within a rock unit. In particular, the Franciscan possesses other physical properties that allow for extensive "secondary" permeability. The Franciscan sandstone units are often very hard, very strong, and brittle. These physical properties, coupled with the extensive faulting and mountain building processes that are associated with the development of the Coast Ranges of mountains, result in the Franciscan sandstone being highly fractured. Because the fractured rock is hard and strong, the included fractures can stay open at depth, resulting in a secondary porosity. Where fractures communicate or connect within the sandstone unit, that unit will possess secondary permeability. As such, fractured sandstone aquifers are actually quite common within the Franciscan formation.

Fractured sandstone is a primary geologic target for the identification of potential ground water resources and water well sites. Needless to say, the complexity of the Franciscan formation presents a difficult task to correctly identify a potential ground water resource. Attempts to drill a water well within the Franciscan formation that are based on a superficial understanding of the geologic conditions are unlikely to be successful. Consequently, countless dry holes are encountered when drilled into Franciscan rock.

AQUIFER PRODUCTION CAPACITY / WATER WELL DATA

The California Department of Water Resources, Bulletin 118, dated 1975, states that, "In much of the upland areas of the State, fractures and other spaces in harder rock formations yield small quantities of water . . ." The CDWR report further states that, "Advice of a geologist can greatly decrease the probability of drilling a dry hole in search of water in these rock formations."

These CDWR statements apply directly to the Franciscan formation. Specifically, with proper geologic investigations, wells can be located in the Franciscan formation and produce large quantities of water. Faulted and/or highly fractured sandstone beds can display very high porosity and permeability, and these physical properties can allow production of several hundred gallons of water per minute from a drilled well in the Franciscan formation.

The attached Figure 1 shows the locations of producing water wells that have been drilled in the Franciscan formation based on my recommendations. Several of those wells can produce pumping rates in excess of 50 gallons per minute. Driller pumping estimates of some of those wells exceed 400 gallons per minute. Figure 1 also shows the lateral extent of the Franciscan formation. The base map and geologic data presented in Figure 1 are based on the CDMG, Bulletin 183. The locations of the water wells shown in Figure 1 are based on my personal geologic studies. These wells appear to be randomly spaced and their locations are not limited by geologic factors. The identified production water wells locations only represent property sites that I have been asked to explore and where I have located sites for production wells. Needless to say, there are numerous producing water wells throughout the Franciscan terrain that have been located by others, and are not shown on Figure 1.

Attached as Tables 1, 2, and 3 are several water well pump test records for wells in the Franciscan formation. These attached well test records were provided by Weeks Drilling and Pump of Ukiah, California (to protect individual property rights, the specific locations of each of these water wells are not presented).

Table 1 presents pump test data for a water well drilled in Franciscan rock near Covelo, in Mendocino County. That test was run for approximately 16 hours. Based on project logistics and engineering concerns, it was predetermined that a pump rate of 50 gallons per minute (gpm) would be tested. By the end of the pump test, the water level in the well had dropped about 14 feet (drawdown). This pump test was performed in July, 1999.

Table 2 presents pump test data for a water well drilled in Franciscan rock near Cloverdale, in Sonoma County. That test was run for approximately 6 hours and performed in a manner to determine the individual well capacity. The initial pump rate exceeded 200 gpm, and resulted in significant drawdown. Ultimately, a pump rate of 100 gpm was tested. After several hours of pumping at 100 gpm, the test was concluded with "Full Recovery" to the static water elevation within 15 minutes. This test was performed in February, 2000.

Table 3 presents pump test data for a water well drilled in Franciscan rock near Laytonville, in Mendocino County. That pump test was run for approximately 14 hours; pumping rates exceeded 500 gpm. After the pump was shut off, the ground water elevations within the well recovered about 33 feet within 15 minutes. These data indicate that this well can produce several hundreds of gallons of water per minute. This test was performed in August, 2001.

The pump test data discussed above document the fact that the Franciscan formation contains aquifers that can produce significant amounts of ground water.

SPRING DISCHARGE / BASE FLOW

Although vast areas of the Coast Ranges are underlain by shale and melange, locally faulted and/or fractured Franciscan sandstone units also are present. It is my opinion that the ground water contained within the secondary permeable sections of these fault structures and fractured sandstone units migrates over time. Cyclical and seasonal rainfall infiltrates the fault structures and fractured rock units, thus recharging the aquifers. Under the influence of gravity, the stored ground water moves down gradient and accumulates as a localized aquifer. On hillside terrain, it is not uncommon for ground water to interface with an exposed slope surface. Naturally occurring springs develop where ground water drains from a hillside aquifer. It has been my experience that the Franciscan formation produces long-term, year round "bedrock" source springs. Springs of this nature predictably occur at the same locations for decades, centuries, and likely for millennia. Spring discharge rates can be very high; I have observed sets of springs that have a documented discharge in excess of 600 gallons per minute emanating from fractured Franciscan sandstone. It is my opinion that these long-term, large production bedrock springs play a significant role in maintaining the late summer base flows found in many streams and rivers. Even in the absence of observable spring discharges, ground water contained within hillside terrain of the Franciscan formation can drain down gradient and provide base flow recharge to adjacent river systems.

CONCLUSION

Based on my extensive geologic experience working within the Franciscan formation, it is my opinion that locally, individual units within the Franciscan formation can be significant ground water aquifers. Based on careful observation and adequate knowledge of specific rock types, ground water aquifers can be predictably found within the Franciscan formation. Those aquifers can be utilized by drilled water wells. Additionally, naturally occurring spring discharges and ground water drainages through fractured rock from Franciscan units support base flows in adjacent river systems.

I am currently conducting a detailed, site-specific, geologic evaluation of the area adjacent to the Elk Prairie water wells. At this time, I have completed a bedrock geologic map of a 5 square mile area that includes Elk Prairie, and portions of the North Fork and Little North Fork Gualala Rivers.

During the course of this study, I have identified geologic features that are pertinent to this testimony. Specifically, there are several springs adjacent to Elk Prairie that add to and support the base flows of both the North Fork and Little North Fork Gualala Rivers.

It is my opinion that a set of 5 or 6 springs situated adjacent to the North Fork in the northeast quarter of Section 13, Township 11 North, Range 15 West, M.D.B.& M. are discharging water directly from a bedrock aquifer. The combined flow of these springs drains directly into the river. At least one of these springs has historically been developed and used as a year round source of fresh water.

Additionally, a small tributary that flows from the center of Section 14 in a southwest direction to the Little North Fork contains water that actively flows directly from fractured Franciscan sandstone bedrock. Saturated marsh conditions occur where that tributary empties onto the older alluvial deposits adjacent to the Little North Fork.

Log Cabin Creek in the northeast quarter of Section 10 is currently flowing. It is my understanding that Log Cabin Creek is a perennial stream with year round flow. I have traversed most of that drainage. My observations indicate that bedrock occupies and underlies the channel, generally above 400 feet elevation. It is my opinion that the flow of water in Log Cabin Creek originates from springs and flows from a fault in the Franciscan formation. I have mapped the fault through the headwater of that drainage. Log Cabin Creek drains onto older alluvial deposits adjacent to the Little North Fork River.

Based on my geologic observations, it is apparent that discharge of ground water from springs and seeps emanating from fractured rock aquifers contained within the Franciscan formation surrounding the Elk Prairie site can add significant quantities of surface water flow to the adjacent streams and rivers.

John T. Phillips

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CEG 1482

WESTERN HYDROLOGIC SYSTEMS

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RESUME

Patrick B. Cawood

EDUCATION

Portland State College, B.S. Applied Mathematics, 1962.

PROFESSIONAL ORGANIZATIONS

American Institute of Hydrology Member since 1983

EMPLOYMENT HISTORY

Western Hydrologic Systems, Auburn, CA, Owner, 1982 - present

Surface water studies, accurate stream gaging work for water rights and conjunctive use projects. Development and marketing of water resources software, in-house hydrologic data processing, computer and hydrologic consulting. Software programs include Computation of Surface Water Records, Computation of Precipitation Records, Hydrologic Plotting Utilities, among others. Writing and editing computer manuals for a European hydrologic software manufacturer.

Surface water records review for various water agencies.

Operation of the Alameda County gaging stations and maintenance of their conjunctive use groundwater program.

City of St. Helena. Construction, operation and computation of records for several gaging stations for the City of St. Helena.

Wagner and Bonsignore Engineers.
Discharge measurement work for North Gualala River study.

EXHIBIT NGWC-3

Brophy Irrigation District.

Canal leakage study using very accurate measuring techniques.

Zone 7, Alameda County Flood Control District

Conducted groundwater recharge studies on the major streams of Livermore Valley, locating the reaches of gain and loss by streamflow measurements to facilitate the development of a conjunctive use program of ground water storage. Purchased water from the SBA is spread through three stream systems, which can recharge depending on several variables. Approximately 1500 discharge maeasurements were made over a period of three years. This is a very successful program and is one the best operated conjunctive use programs in California.

Operated eight gaging stations, cooperating with the USGS Water Resources Division. Instructed and supervised hydrologic technicians and established standards of stream gaging, gaging station management, and computation of surface water records. Current and historical streamflow and water quality records were analyzed and summarized.

James C. Hanson, Engineering

Ongoing water rights flow determination using current meters, portable flumes, and volumetric methods, spillway computations, weir design, etc.

Teaching seminars on U.S.G.S. surface water techniques, field and office, at Tennessee Valley Authority, Idaho Power Company, Southern California Edison Company, State of California DWR, Monterey County Flood Control, Orange County, and many more.

Data Computation and Review for USGS approval: Northern California Power Agency, Zone 7, Alameda County Flood Control and Water Conservation District.

South Florida Water Management District

Review of surface water field and computation methods, surface water and climatological equipment evaluation, and field technique reviews.

Hydrofocus, Inc.

Construction and operation of gaging stations, precipitation gages, and synoptic studies of streamflow gain/loss. Construction, operation, and records computation of several gages on Twitchell Island.

David Ford Consulting Engineers.

Digitized Los Angeles County precipitation charts and produced ASCII files for input to various HEC models. Subcontracted to David Ford Consulting Engineer, Sacramento, CA.

Pacific Gas and Electric

Three year study to compute unimpaired flow estimates at hydro power sites throughout northern California.. This was a unique study that many engineering companies had attempted and failed.

Pearce Hydrology

Computed storm detention pond design using HEC models.

Royal Institute of Technology, Stockholm, 1970 - 1971

Translated the Stanford IV Watershed Model from BALGOL to FORTRAN for the Verka Experimental Basin in northern Sweden.

Freelance computer programming, 1967 - 1979

Applications programming in Denmark, Sweden, Germany, and the U.S. in fields of science and engineering. Computer languages included FORTRAN, ALGOL, PL/I, BASIC, and computer packages such as the BMD statistical programs and the IBM Linear Programming System. Employers included the following:

Resources for Future, Washington, D.C.
Technical University of Copenhagen
Sociology Institute, University of Copenhagen
Royal Agricultural & Veterinary College, Denmark

University of Copenhagen, Denmark, 1971 - 1972

Instructor for Introduction to Computers and FORTRAN Programming.

U.S. Geological Survey, Washington, D.C. 1963 - 1967

Assistant to W. L. Isherwood in Surface Water Branch Computer Section. Aided in design, implementation, and conversion to new computers of basic USGS stream flow computation programs. Special problems such as culvert site computations and tree ring analysis were also programmed for the first time. Other programming involved stochastic generation of stream flow records: generation and testing of random numbers, statistical tests of long records of recorded flows, etc.

U.S. Geological Survey, Oregon and California, 1957 - 1963

Carried out the standard USGS practices of data gathering, computational techniques, and hydrologic studies in Oregon and California. Stream gaging, running levels, station construction and maintenance, computation of discharge records, shifting control, ice-effects, methods of estimating missing record, flood frequency analysis.

PUBLICATIONS

1. *Hydrologic Modeling: An Approach to Digital Simulation*. Royal Institute of Technology, Stockholm, Sweden, 1971.

2. *Om Slaegtsnavne og Hyppigheden af Deres Forekomst.* (*On Last Names and the Frequency of Their Occurrence.*) Senior author Erik Manniche. In Sociologiske Meddelelser, Series 12, Book 2, 1967/68, University of Copenhagen.

3. *Computer Technology in Initial Stages of Project Metropolitan.* In Sociologiske Meddelelser, Series 12, Book 2, 1967/68, University of Copenhagen.

4. *General Marginal Tabulation (GMT) and General Cross Tabulation (GXT) Programs for Sociological Research.* Sociological Institute, University of Copenhagen. In-house publication, 1971.

5. *Nogle Computerprogrammer til Genetiske Undersoegelser af Bovine Blodtype Data.* (*Some Computer Programs for Genetic Analysis of Bovine Blood Group Data.*) Yearbook of the Institute for Sterility Research, Copenhagaen, Denmark, 1970.

6. *Use of Multiple Regression to Predict Stream Recharge Rates.* Zone 7, Alameda County, California, 1981.

7. *The Efficient Use of Portable Flumes.* Water Resources Bulletin, USGS, 1982.

8. *A Method for Estimating Ungaged Local Inflow above the Arroyo de la Laguna Gaging Station.* Zone 7, Alameda County, California, 1982.

9. *A Critique of Trends in Surface Water Monitoring and Computation*, with Susan A. Smith and David R. Dawdy. AMS International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Los Angeles, California, 1985.

10. *Computation of Surface Water Records*, Software Operation Manual, with Susan A. Smith. In-house publication Western Hydrologic Systems, Los Angeles, California, 1983.

11. *Computation of Precipitation Records*, Software Operation Manual, with Susan A. Smith. In-house publication Western Hydrologic Systems, Los Angeles, California, 1983.

12. Various articles for Western Hydro's course work:
Equivalent Mean Gage Height and Subdivision of Gage Heights.
Log Scale Offset.
Fixed Interval Correction to Short Duration Intensity Series.
Design Sizes for Weirs and Flumes.
Determining Critical Flow in the Field.
Some Real World Stage Shift Techniques.

Estimating Periods of Missing Record Using Hydrographic Comparisons. Weighted Mean Gage Height.

13. *Why We Don't Use Statistical Curve Fitting Techniques to Rate Streams.* Alert Transmission, January, 1999.

14. *Some Recent Stream Gaging Foibles.* Alert Transmission, January, 2002.

TESTIMONY OF PATRICK B. CAWOOD

My experience in accurate flow determinations consists of three parts.

My first 11 years of surface water work was spent in several offices of the US Geological Survey.

During three years work for Alameda County Flood Control, I made 1500 measurements and found the gaining and losing reaches of three stream systems of Livermore valley, over dry years and wet years, and throughout the seasons. The results of this work are still in use in the Zone 7 conjunctive use program.

The last 10 years have been spent teaching, studying, writing technical articles, as well as practicing accurate stream gaging and records computation techniques.

A copy of my resume, which accurately describes my education and experience, is exhibit NGWC-3.

I made 6 measurements on the upper No. Fk. Gualala River on 9/12/98. These measurements were measured *synoptically* in the downstream direction. Synoptic masurements are made in the downstream direction to minimize any possible problems due to changes in flow caused by diurnal fluctuations.

Time	Stream	Location (See attached map)	Discharge in CFS
9:40	No. Fk. Gualala River	Point A	4.4
10:45 .	Robinson Creek	D.s. of road crossing	0.4
	Computed total		*4.8*
11:15	No. Fk. Gualala River	Point B.	6.2
12:15	No. Fk. Gualala River	Point C	7.1
13:30	No. Fk. Gualala River	EP1	7.0
14:50	No. Fk. Gualala River	EP2	7.9

A map showing the locations of these measurements is exhibit NGWC- 5. I prepared this map from the appropriate 7.5 minute USGS quadrangle maps.

I measured all creek inflows between points A and EP2. Robinson Creek is mentioned above. I estimated the flow of Hoodoo Creek, which also comes in between points A and B, to be approximately 0.02 cfs. McGann Gulch, which joins the North Fork Gualala River in the vicinity of point A, was wet, but its flow was zero. No other creeks were flowing into the North Fork Gualala River between points A and EP2 on 9/12/98.

Based on my extensive stream gaging experience, I estimate the errors of the discharge measurements listed in the above table to be plus or minus 3 percent or less.

The lower part of No. Fk. Gualala River was measured on 10/14/98 twice: once in the morning and once in the afternoon. These measurements were also made in the downstream direction. The measured flows are listed in the following table.

Stream	Location	Time	Discharge (cfs)	Time	Discharge (cfs)
No. Fk. Gualala River	Point D	9:15	7.6	13:20	7.6
No. Fk. Gualala River	Point E	10:25	7.4	14:15	7.4
No. Fk. Gualala River	Point F	11:15	6.5	15:05	6.4

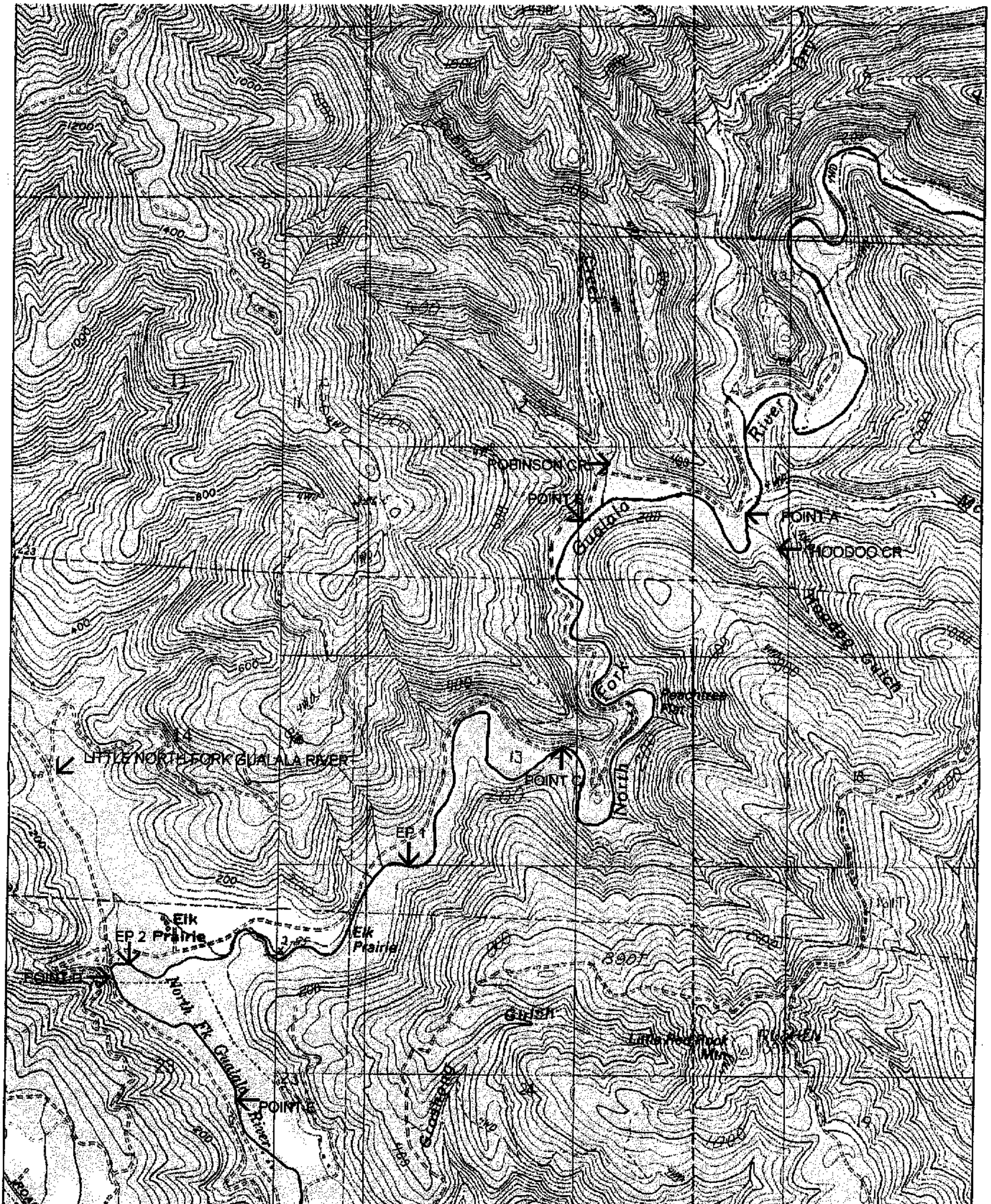

EXHIBIT NGWC-5

RESUME

Joseph C. Scalmanini

Specialization:

Thirty-five years of experience in ground-water development and management, and oil and gas production. Assessments of ground-water resources and implementation of ground-water basin management in various areas of California; ground-water development and management encompassing well design, construction, operation, and maintenance; ground-water monitoring as part of basin management and as part of ground-water contamination investigations; artificial ground-water recharge facilities and practices; injection of industrial waste water; utilization of brackish ground water for industrial water supply and cooling applications. Industrial design, construction and operation of secondary oil recovery systems involving water and steam processing, injection and recovery.

Professional Registration:

Registered Civil Engineer, California, CE 28233

Academic Degrees:

M.E. Civil Engineering, University of California, Davis, CA	1984
B.S. Mechanical Engineering, University of Santa Clara, Santa Clara, CA	1967

Professional Experience:

Luhdorff and Scalmanini, Consulting Engineers, Woodland, CA Partner	1980 to Present
University of California, Davis, Davis, CA Associate Development Engineer	1973 - 1979
Shell Oil Company Mechanical and Facilities Engineer	1967 - 1973

Representative Professional Assignments:

- Consultant to water districts and utilities, municipalities, corporate and individual farming interests, corporate and private industry, and other engineering firms on ground-water development, utilization and management. Consultation with public agencies, corporate and private concerns regarding ground-water contamination, its identification, monitoring, and management. Consultation with legal profession on technical aspects of ground-water development and utilization, including well design and construction and application of pumping equipment.

Representative Professional Assignments (continued):

- Engineering research in ground-water resources, development and management. Coordinated and conducted engineering projects concerning assessment of ground-water resources in various areas of California including mountainous and valley regions; application of principles of design, construction, completion and development of wells, aquifer analyses, design of pumping equipment, optimal and efficient operation of wells and pumps, and well rehabilitation and maintenance; design of artificial ground-water recharge facilities and practices, including surface infiltration and deep-well injection; assessment and development of brackish ground-water for water supply and cooling applications in industrial plants. Provided consultation services to engineering firms, local, state and federal agencies, corporate and private industry and farming interests, and well contractors on the development and management of ground-water resources.

- Project Engineer on water treatment, injection, and recovery systems for secondary oil recovery in Southern California oil fields; project engineer for the design and installation of facilities and utilities in a new oil field development in Central California; design engineer on various pumping and piping applications of water, oil, gas and other compressible fluids.

Professional Affiliations:

American Society of Civil Engineers
  - Ground Water Committee, Irrigation and Drainage Division
  - Water Resources Planning Committee, Water Resources Planning and Management Division
National Ground Water Association
  - Association of Ground Water Scientists and Engineers
American Water Works Association
National Society of Professional Engineers
California Groundwater Association
Groundwater Resources Association of California

Public Service:

- **Yolo County Aggregate Resources Committee (1975-79)**, Alternate delegate, hydrologist - analysis of impacts and development of management plans for extraction of aggregate from Cache Creek basin.

- **California Tenth Biennial Conference on Ground Water (1975)**, Member, Planning Committee

- **Chancellor's Campus (Univ. of Calif., Davis) Water Committee (1976-78)**, Staff Engineer - analysis of water supplies and uses, projection of requirements, development of conservation and management plans.

- **City of Davis Water Planning and Conservation Committee (1977-79)**, Chairman - analysis of water supplies and uses, projection of requirements, consideration of alternative supplies, development of conservation and management plans.

- **Yolo County Water Resources Task Force (1979)**, Member - development of county-wide master water plan.

Public Service (continued):

- **Pacific Gas and Electric Co. ACT^2 Irrigation Pumping Demonstration Project (1992),** Technical Advisor
- **Association of California Water Agencies (1994-1996),** Member - Ground-Water Committee
- **Cache Creek Conservancy, (2000-2002),** Director

Teaching Activities:

Course Coordinator and Instructor University Extension Courses, University of California, Davis:

Concepts of Ground Water Management (1974, 1976, 1978, 1981)
Legal and Policy Considerations in Ground Water Management (1975, 1976, 1980)
Water Supply Wells and Pumps (1977, 1978,1981, 1983, 1985, 1986)

Instructor, University of California, Davis, Water Science 198, Introductory Hydraulics (1977, 1978, 1979)

Lecturer, University of California, Davis, Water Science 2, 140, 160; Ecology 230; Civil Engineering / Geology 175 (1975 - 1979)

Lecturer on Aquifer Characteristics, Well Hydraulics, and Ground-Water Development, in Technical Training Classes at the U.S. Army Corps of Engineers' Hydraulic Engineering Center, Davis, CA.

Publications and Presentations:

Scott, V.H. and J.C. Scalmanini, **Water Wells and Pumps: Their Design, Construction, Operation, and Maintenance**, University of California Division of Agricultural Sciences Bulletin No. 1889, 1977.

Helweg, O.J., Scott, V.H., and J.C. Scalmanini, **Improving Well and Pump Efficiency**, American Water Works Association, 1983.

Scalmanini, J.C., and Scott V.H., **Design and Operational Criteria for Artificial Groundwater Recharge Facilities**, Water Science and Engineering Paper No. 2009, University of California, Davis, 1979.

Scalmanini, J.C., Scott, V.H., and O.J. Helweg, **Energy and Efficiency in Wells and Pumps**, presented at Twelfth Biennial Ground Water Conference, 1979.

Scalmanini, J.C., Johnson Jr., R.M., and E.E. Luhdorff Jr., **Development of a Ground-Water Monitoring Program as a Basis for Coastal Ground-Water Basin Management**, presented at the Fall Conference, American Water Works Association, CA-NV Section, 1983.

Scalmanini, J.C., **3030 Hindsight and 2020 Foresight, Actual Ground-Water Management Experience Over the Last 15 Years, Soquel Creek Water District**, presented at the Association of California Water Agencies' Ground-Water Management Conference, March 1994.

Publications and Presentations (continued):

Scalmanini, J.C., **Legal and Technical Issues Related to Surface Water and Ground-Water Interaction**, presented at the Groundwater Resources Association's California Ground Water & Efficient Usage for the Year 2000 and Beyond, October 1998.

Scalmanini, J.C., A. Schneider, and V. Cahill (panel presentation), **Groundwater Classification: Is the State Water Resources Control Board's Jurisdiction Over Ground Water Changing?**, presented at the Water Education Foundation's 2000 Update on Water Law and Policy, July 2000.

Scalmanini, J.C., **What the Heck's a Sub-Basin? Defining Basins and Sub-Basins**, presented at the Association of California Water Agencies' Ground-Water Management: Will CalFed Help or Hinder Workshop, November 2000.

Testimony of Joseph C. Scalmanini
Regarding Ground Water at the Elk Prairie
North Fork Gualala River, Mendocino County

I am a registered Civil Engineer in California and principal partner in Luhdorff and Scalmanini, Consulting Engineers, which specializes in the geologic, hydrologic and engineering activities associated with the investigation, assessment, development and management of ground-water resources throughout California. I have conducted and directed ground-water assessments and investigations, developed and implemented ground-water monitoring and management programs, and designed ground-water development projects throughout California over the last 30 years. Prior to the founding of Luhdorff and Scalmanini, Consulting Engineers, I was a Development Engineer at the University of California, Davis, where I directed applied research in ground water and taught classes in Hydraulics and Principles of Ground-Water Management. A copy of my resume, which accurately states my education and experience, is Exhibit NGWC-6.

I have prepared the following testimony regarding the occurrence of ground water and the impacts of pumping at the Elk Prairie, which is located adjacent to the North Fork of the Gualala River in Mendocino County as shown in Figure 1, at the request of the North Gualala Water Company (NGWC). My testimony is based in part on a review of published works by others and primarily on my firm’s investigation and analysis of geologic and hydrologic conditions at the Elk Prairie, most of which was conducted in 1996 and 1997. The principal objective of our investigation and analysis was to develop conclusions regarding the occurrence of ground water and the characteristics of the aquifer materials which are developed for water supply at the Elk Prairie. Specifically, we have addressed whether ground water beneath Elk Prairie flows in a known and definite subterranean channel; and we have also addressed whether the pumping of water supply wells at Elk Prairie induces water to infiltrate from the North Fork of the Gualala River, or whether pumping of ground water instead intercepts ground water that is flowing beneath Elk Prairie. Our conclusion, based on the geologic and hydrologic factors discussed below, is that ground water does not flow within a known and definite subterranean channel beneath Elk Prairie, but rather flows toward the surface stream, where it partly discharges to contribute to a gaining reach of the North Fork Gualala River. Our conclusion is also that ground-water pumping at Elk Prairie for municipal water supply, at the levels necessary to supply existing and projected water demands for North Gualala Water Company, will intercept ground water that is flowing toward the River, and will not induce infiltration from the River; in other words, even with this pumping of these wells to meet part of the existing or projected water demand of the North Gualala Water Company, the North Fork Gualala River still will have a gaining reach at Elk Prairie.

Introduction

Our analysis of the occurrence of ground water and the impacts of pumping at Elk Prairie can be divided into three general subject areas: 1) geology and the nature of aquifer materials, including well completions; 2) field investigation, including geophysical investigation, test hole drilling, monitoring well and production well construction, monitoring of stream stages and ground-water levels, aquifer testing, and water quality sampling; and 3) analysis of ground-water levels, well yields and aquifer characteristics to assess the occurrence of ground water and pumping impacts on stream flow under existing and projected water demand conditions. In addition to the preceding, we also reviewed and considered the conclusions reached in a previous analysis of the occurrence of ground water in light of the information developed and interpreted as part of our investigation.

Overall, to respond to questions raised about stream-aquifer conditions and pumping impacts on stream flow, and to establish a basis for defining the occurrence of ground water beneath Elk Prairie, a multi-step investigation of the occurrence of ground water, its relationship to the River, and the direct impacts of pumping on stream flow was developed and conducted in five steps, or phases. This testimony summarizes the multi-step investigation and the resultant conclusions. Each of the phases is briefly described as follows.

Geophysical Investigation - Historical exploration of the Elk Prairie aquifer originally consisted of only one boring, to a depth of 142 feet, when NGWC's Well 4 was constructed in 1989. Consequently, prior to further drilling and construction of monitoring wells and a second production well, surface geophysical exploration was conducted to initially define the horizontal and vertical extent of aquifer materials, and the depth of the basement complex underlying the aquifer materials. The geophysical investigation was intended to partially define the geologic or lithologic stream-aquifer connection, and to illustrate potential well construction depths.

Lithologic Borings and Monitoring Wells - Based on the geophysical findings, a network of test holes was drilled and logged to define geologic and lithologic conditions; all five of the borings were completed into dedicated monitoring wells for short-term observation during well/aquifer testing, and for long-term assessment of ground-water conditions beneath Elk Prairie.

Production Well Construction - A backup water supply well (Well 5) was constructed on Elk

Prairie near Well 4 to protect NGWC's source capacity in the event of maintenance or repair of Well 4. The well was completed in the same aquifer materials as Well 4.

Ground-Water and Stream Monitoring - The time period between production well construction (October-November, 1996) and aquifer testing (September-October, 1997) was used to measure surface and ground-water conditions and to define the relationship between the stream and the aquifer system while Well 4 was used for normal water supply. Biweekly measurements of water levels were made in all monitoring and production wells and in the River as a basis for defining ground-water elevations and flow directions, and stream status (gaining or losing reach) adjacent to Elk Prairie.

Well and Aquifer Testing - A constant-rate aquifer test was conducted in Well 4 in September 1997 at its design pumping capacity. The primary objectives of the test were to determine the characteristics of the aquifer materials in which Wells 4 and 5 are completed and to evaluate the stream-aquifer interaction. Ultimately, due to precipitation and runoff which affected stream stage during an initial test, two tests of Well 4 were conducted, the first for 80 hours and the second for 24 hours. During both tests, water levels were measured in the pumped well, in the other Elk Prairie wells, and at staff gauges in the River near the pumped well. Water-quality samples were collected from both production wells and from the River at the end of the first test.

Ground-Water Occurrence and Pumping Impacts Analysis - Data collected from all the preceding steps were analyzed to determine ground-water flow directions and hydraulic gradients under static conditions; the hydraulic characteristics of the aquifer materials beneath Elk Prairie; and pumping impacts on both the aquifer system and the stream, i.e. whether pumping intercepts ground water discharging toward the stream or induces infiltration from the stream, and the magnitude of such impacts.

The results show that, at Elk Prairie, ground water flows toward the River, at angles that are all closer to perpendicular to the stream, and not close to the direction of the stream. Ground-water flow is not channelized, and does not flow parallel to the direction of the stream. Further, under a long period of normal well operations, there is no local or other reversal of the gradient of ground-water flow toward the River; thus, even under pumping conditions, there remains a flow and discharge of ground water to the River, and there is no inducement of infiltration from the surface flow by the pumping of the production wells. Simulations of the pumping that would be required to meet increased NGWC water demands in the future show that similar conditions can be maintained, i.e. no reversal of gradient, maintenance of ground-water flow toward the River, and no induced infiltration that would reduce stream flow.

Geology and Aquifer Materials

The Elk Prairie is located in the northern Coastal Range geologic province straddling the San Andreas Fault Zone, which is the dominate geologic feature of the region. The northwest-southeast trending fault zone marks the structural boundary between the northward moving Pacific tectonic plate to the west and the North American tectonic plate to the east. The San Andreas Fault creates a weak rock zone which controls the flow direction of the lower reaches of the forks of the Gualala River.

East of the valley formed by the San Andreas Fault, the topography rises in steep slopes to sharp narrow ridge lines up to elevations of 1,400 feet or more. Bedrock consists of Coastal Belt Franciscan Complex of Cretaceous and Paleocene ages. This unit consists of marine sandstones, shales, and conglomerates which have been complexly deformed and folded.

The youngest geologic unit in the area consists of Holocene and possibly Pleistocene age alluvium deposited by streams along the main stream channels and along the floor of the San Andreas fault valley. These deposits consist of unconsolidated sand and gravel, silt, and clay deposits, specifically beneath Elk Prairie adjacent to the North Fork Gualala River, that are the focus of this testimony. All the production and monitoring wells discussed in this testimony are completed in these alluvial deposits at Elk Prairie.

Prior to our investigation of the occurrence of ground water and pumping impacts, the only subsurface information at Elk Prairie was derived from NGWC Well 4. That well was drilled to 142 feet and encountered interbedded sands and gravels and silt or clay beds. In order to evaluate the thickness and extent of the alluvium, a geophysical survey of the area was undertaken using the seismic refraction methods. Based on that geophysical survey, a structure contour map (or subsurface elevation map) of the top of the Franciscan Complex, beneath the alluvium, was prepared based on the evidence of higher seismic velocity in the consolidated Franciscan sandstone. The structure contour map showed a narrow, deep paleo-thalweg (channel) filled with alluvium extending below the valley to depths of about 170 feet.

Subsequent to the geophysical survey, lithologic logs of exploratory boreholes and drillers' logs of production wells were used to prepare three geologic cross sections along and across Elk Prairie at the locations shown on Figure 2. These cross sections are presented on Figures 3 through 5. The surface of the Franciscan Complex shown on the cross sections is based on the geophysical investigation, although the configuration south of the River is noted to be projected, due to a lack of geophysical information and borehole control south of the River. The cross sections show that a fine-grained silt and clay overbank/floodplain deposit occurs at the surface and appears to initially thicken northward and then thin toward the valley margin. Coarser-grained sand and gravel stream channel deposits occur near the present River channel, and extend to depths of at least 140 feet. The sand and gravel appear to be cleaner near the surface, while deeper deposits contain more silts and clays. These deeper deposits appear to interbed with fine-grained beds to the south and may be significantly older. The alluvium appears to be stratigraphically complex and may include interbedded landslide (mudflow) and possibly estuary deposits along with the fluvial (stream) and floodplain deposits. This complexity may be due to various factors which could have affected sediment deposition such as high sediment yield and erosion rates, including landsliding; fault disruption, uplift and downwarping; and base level changes due to sea level fluctuations or faulting.

Based on topographic expression, and surface geologic mapping, alluvium could extend up the North Fork Gualala River at least 7,000 feet east of Elk Prairie. The thickness of the alluvium in the reaches upstream of the Elk Prairie is not known, but both the areal and vertical extent appear to be notably smaller than the alluvium that forms the aquifer system at Elk Prairie. Both geologic mapping, as shown in Exhibit NGWC-9, and field observations show the alluvium east of Elk Prairie to be immediately adjacent to the River, in effect forming the bed of the River channel, and not extending several hundreds of feet from the River as is the case locally at Elk Prairie.

Both the alluvium and the underlying Franciscan Complex in the Elk Prairie area are water bearing, although they have very different properties. The unconsolidated alluvium is dominated by coarse-grain sediments (sand and gravel) and is, therefore, highly permeable. This permeability is both horizontally and vertically heterogenous due in part to the stratigraphic complexity discussed above. The deeper portion of the alluvial formation appears to be somewhat less permeable due to a higher percentage of fine-grain sediments (silts and clays).

The consolidated Franciscan Complex has a much lower permeability but is sufficiently porous to store large volumes of precipitated water which slowly drains to maintain stream base flows throughout the dry season. Water storage is evidenced by perennial seeps and springs, both natural and on manmade cutslopes, and shallow depths to saturated soils and weathered bedrock. The high water content is also seen in the propensity of shallow and deep-seated landsliding occurring on slopes underlain by the Franciscan Complex. The permeability of the Franciscan Complex is highly dependent of fracture density, which tends to be higher near seismically active areas such as Elk Prairie. Ultimately, however, the combination of perennial stream flow in the North Fork Gualala River, supported only by discharge from the Franciscan Complex beneath and east of Elk Prairie after the end of the rainfall/runoff season, and a sustained ground-water gradient nearly perpendicular to the River at Elk Prairie, are evidence of both the water storage and water yielding characteristics of the Franciscan Complex in those local areas.

Monitoring and Production Wells

Key factors in the overall assessment of ground-water occurrence and pumping impacts are ground-water levels, ground-water flow directions and gradients, and stream-aquifer interaction under both static and pumping conditions.

Visual observations of ground-water discharge from beneath Elk Prairie into the North Fork Gualala River during low flow/low stage conditions suggest that ground-water elevations are higher than the adjacent stream stage, at least under some hydrologic conditions. Such observations also suggest that, while there is apparent hydraulic continuity between the aquifer and the stream, pumping may not induce infiltration from the stream, i.e. ground-water elevations may be sufficiently high that pumping may not cause a gradient reversal and create losing stream conditions in the reach adjacent to the pumping well. However, visual observations of ground-water discharge into the River are insufficient, by themselves, to define ground-water gradients, flow directions, and reactions to pumping. Therefore, to further define the aquifer system and to understand the hydraulic relationship between the aquifer and the River, an exploratory drilling program was conducted and a monitoring well network was designed and constructed on the NGWC property at Elk Prairie on the north side of the North Fork Gualala River. The five-well monitoring network, illustrated in Figure 6 (which also includes the locations of the production wells and River staff gauges described below), was laid out in a geometric form capable of determining ground-water flow directions in response to whatever ground-water levels were encountered.

As discussed above, the geophysical exploration of Elk Prairie indicated the presence of a more consolidated formation beneath the unconsolidated alluvial aquifer materials in which Well 4 is completed. As a result, in addition to more completely defining lithology across the NGWC property on Elk Prairie, an objective of the drilling associated with monitoring well construction was to explore to the base of the alluvium in order to verify the seismic geophysical interpretation of the alluvium/consolidated material interface. Ultimately, the monitoring wells have been used for ongoing ground-water level measurements which have been compared with stream stage measurements to identify flow directions to or from the River; they have also been used for measuring water level drawdown during aquifer testing, and interpreting whether pumping reversed the natural gradient for ground-water flow toward the River.

Test hole drilling and monitoring well construction were conducted in October 1996 by Taber

Consultants using both auger and direct rotary drilling methods. Two of the boreholes, MW-3 and MW-5 were drilled through the alluvium to confirm its thickness, which is 149 feet and 147 feet, respectively, at those locations. All five of the test holes were completed into two-inch monitoring wells, each with a 20-foot screen section located opposite permeable aquifer materials. All of the monitoring wells are sealed in accordance with County standards. The geologist's lithologic logs and as-built construction details of each of the monitoring wells are included in Exhibit NGWC-8.

As introduced above, the first ground-water exploration and development effort on Elk Prairie was conducted in 1989 when NGWC drilled and constructed its Well 4 as part of an effort to develop an additional source water supply. Well 4 was drilled using the direct rotary method to 142 feet, almost all of which (below the top 21 feet) was lithologically described as sand and gravels. An eight-inch PVC casing assembly was installed in the borehole to a depth of 141 feet; the casing is perforated from 56 to 134 feet. A gravel envelope is installed in the annular space from 50 feet to total depth; the upper annular space is sealed with concrete from 50 feet to the surface. The driller's lithologic log and as-built construction details of Well 4 are included in Exhibit NGWC-8 . Well 4 is equipped with a submersible pump designed to discharge about 260 gallons per minute (about 0.6 cubic feet per second, or cfs) and is an approved water supply source under NGWC's Water Supply Permit issued by the State Department of Health Services.

As part of the investigation of ground-water occurrence and pumping impacts beneath the Elk Prairie, a backup water supply well (Well 5) was constructed about 400 feet east of Well 4. Well 5 was drilled and constructed in November 1996, after the test hole drilling and monitoring well construction on Elk Prairie. Well 5 was drilled using the direct rotary drilling method to 137 feet, most of which was lithologically described as sand and gravel with some thin clay lenses or streaks of clay. An eight-inch PVC casing assembly was installed in the borehole to a depth of 97 feet; the casing is perforated from 55 to 92 feet. A gravel envelope is installed in the annular space from 50 feet to the total depth of the borehole; the upper 50 feet of the annular space is sealed with cement to the surface. The driller's lithologic log and as-built construction details of Well 5 are included in Exhibit NGWC-8. PW-5 is equipped with a submersible pump with a capacity of approximately 260 gpm and has been approved for water supply service as part of the NGWC water supply system by DHS.

As part of the original construction of both Well 4 and Well 5, the drilling contractor conducted step-drawdown tests (pumping tests at a variously increasing capacities) to determine the respective well yields and to serve as a basis for design of pumps to be installed in them. A step-drawdown test was conducted in Well 4 at eight capacities from 168 gpm to more than 850 gpm (the limit of the measurement equipment). The duration of each step ranged from 15 minutes to two hours. The maximum drawdown achieved during step-drawdown testing was 7.4 feet. The yield of Well 4, as measured by its specific capacity (pumping capacity divided by drawdown) was typically about 130 gpm/ft (129-137 gpm/ft).

Step-drawdown testing was also conducted in Well 5 at five capacities from 200 gpm to 700 gpm. The duration of each step ranged from 30 minutes at the lower capacities (200, 300, 400 gpm) to ten hours at 500 gpm and eight hours at 700 gpm. The maximum drawdown achieved during step-drawdown testing was approximately nine feet at 700 gpm. The yield of the well, as measured by its specific capacity during the longest step (500 gpm) was about 90 gpm/ft.

The high specific capacities (small drawdowns experienced at high pumping capacities) in both wells are indicative that the aquifer materials in which the wells are completed have high hydraulic conductivity and transmissivity. They also suggest that pumping at the capacity of permanently installed pumps, e.g. about 260 gpm, may not have a sufficient impact on ground-water levels around the wells to induce infiltration from the River. Ultimately, however, high specific capacities are not sufficient, by themselves, to reach a conclusion about induced infiltration. Consequently, focused testing was conducted and routine operations were monitored to directly address pumping impacts, as discussed below.

Ground-Water and River Stage Monitoring

Regular monitoring of Elk Prairie ground-water elevations and North Fork Gualala River stages began in March 1996. Water levels in Well 4 and River stages at an adjacent location (Staff Gauge 1, or SG-1) were measured on a weekly basis between March 1996 and October 1996. In October and November 1996, the water level monitoring network was expanded to include the second production well and five monitoring wells described above. Two additional surveyed control points for measuring River stage (Staff Gauges SG-2 and 3) were also added to the monitoring network at that time. The completed water level monitoring network at Elk Prairie, as shown on Figure 6, was in place at that time; it remains in place today. Beginning with the completion of the monitoring wells, and continuing through 1997, ground-water levels and River stage were measured biweekly at all the Elk Prairie monitoring locations. A few measurements were subsequently made in summer-fall 1998 and 1999, and a number of measurements were made in late 2001; regular measurements are continuing at present.

Prior to the construction of the monitoring wells, when ground-water and River stage measurements were limited to Well 4 and SG-1, there was a notable positive hydraulic head difference between Well 4 and the River, i.e. the static ground-water elevation at Well 4 was always higher than the stream elevation at SG-1. The head difference between the two points was about 1.4 feet throughout the monitored period beginning in March 1996. This head difference was generally independent of hydraulic conditions: ground-water elevation and stream stage increased together in wet periods, and declined together in dry periods. Those observations indicate that ground water was continuously discharging to the stream in the vicinity of NGWC's only Elk Prairie well at the time, Well 4. Those observations also indicated that ground water discharging to the River was not solely coming from the alluvium beneath Elk Prairie. Once stream stage stabilized in summer-fall, ground-water levels also stabilized and there was no further decline in ground-water levels, which would have had to occur if the discharge to the River was solely from the alluvium.

After installation of the five monitoring wells and Well 5 in late 1996, the regular measurement of water levels in all those wells and at the three stream gauges further delineated the same picture: there was a perennial gradient for ground-water discharge from beneath Elk Prairie to the North Fork Gualala River; those conditions prevailed throughout wet and dry periods, and through regular pumping of Well 4 for water supply, since focused monitoring began in March 1996. The relative elevations of ground water at Well 4 and Monitoring Well 1 and the River stage at SG-1 through 2001 are illustrated in Figure 7. Similar hydrographs of ground-water elevations and stream stage at two other locations on Elk Prairie are illustrated in Figures 8 and 9.

The hydrographs of ground-water elevations and River stages shown on Figures 7-9 have almost identical shapes, which indicates significant hydraulic connection between the aquifer and the River. In 1996, water-level measurements began after the highest water levels in the winter, and levels gradually declined to a seasonal low by August. The gradient between the aquifer and the River is steepest at SG-1; upstream of SG-1, the gradient between the aquifer and River is not as steep. However, although the upstream gradient is flatter, the upstream hydrographs have shapes similar to those at Well 4 - SG-1; there is a year-round pattern of constant head difference (gradient) at various locations, all showing a condition of ground-water discharge to the stream throughout the Elk Prairie area during both wet and dry periods.

To examine ground-water flow directions and gradients, contours of equal ground-water elevations beneath Elk Prairie were mapped for both high and low levels, January and October 1997, (Figures 10 and 11). Under both conditions, the contour maps show that the hydraulic gradient is generally from the northeast to southwest and show ground water discharging to the River along the entire reach adjacent to Elk Prairie.

One of the most significant factors associated with the orientation and elevation of the ground-water contours illustrated in Figures 10 and 11 is that the resultant ground-water flow direction is practically normal (perpendicular) to the surface stream channel at Elk Prairie. There is no channelization of ground-water flow parallel to the River or any subsurface channel that might be described from the extrapolated geophysical exploration or extrapolated lithologic cross sections described above.

Another significant factor associated with the orientation and elevation of ground-water contours, and perhaps more importantly associated with the hydrographs of water levels, is the fact that all the data was collected (and continues to be collected) while NGWC makes regular use of one of the wells at Elk Prairie for water supply (at the design capacity of the pumping equipment, approximately 260 gpm, or about 0.6 cfs). Even with that pumping operation in place, all regular and less frequent measurements have shown no induced gradient for flow from the River to the production well. There continues to be ground-water flow toward the River, at almost constant gradients depending on exact location on Elk Prairie, throughout the wet and dry parts of multiple years and throughout normal pumping cycles for municipal water supply.

A key question in the overall consideration of ground-water occurrence at Elk Prairie is whether ground water is channelized. Obviously, the prevailing gradient and direction of ground-water flow beneath Elk Prairie is not parallel to the River or within any “channel” that might be interpreted from the geophysical exploration and lithologic descriptions derived from drilling at the site. Thus, ground water beneath Elk Prairie is not flowing in a subterranean channel; rather, it is flowing across the alluvium toward the River.

An alternate potential interpretation of the hydrologic picture at Elk Prairie, however, could be that ground-water flow is “channelized” in the alluvium, and is only turned toward the River beneath Elk Prairie because of the damming effect of the San Andreas rift zone immediately west of Elk Prairie. Because of this potential alternate interpretation, special attention has been given in this testimony to whether ground water beneath Elk Prairie is merely the deflected flow of channelized ground water, or is simply ground water flowing in its prevailing direction, across the alluvium and toward the River, in response to ground-water inflow from farther upgradient, i.e. generally north of Elk Prairie.

An essential factor in the overall interpretation of ground-water flow is recognition of the gaining reach conditions at Elk Prairie. As discussed above, ground-water discharge into the River can be visually observed under varying River stage conditions. Such observations were part of the impetus for installation of the extensive well network to measure ground-water gradients and flow directions. In addition, stream gauging was conducted to quantify the magnitude of flow increase upstream of and at Elk Prairie. In separate testimony, Patrick Cawood documents the results of his stream flow measurements which show a flow increase of nearly one cfs along Elk Prairie. Given the essentially constant head differences and gradients measured in ground water at Elk Prairie over various times of year, all as discussed in this testimony, it is reasonable to expect that a generally similar rate of ground-water discharge and related flow increase occurs to the River throughout the year.

Fundamentally, it is not possible for the source of ground water discharging into the River at Elk Prairie to have originated in the River farther upstream. The River cannot augment its own flow in a downstream direction by causing water to flow from the River through porous media (alluvial aquifer materials) for some distance and then re-emerge at a higher flow rate. In order to satisfy the fundamental principle of conservation of mass, there needs to be a supplemental water source to provide the increased surface flow caused by ground water discharging to the River.

In the Elk Prairie setting, there are only two possible sources of water that can contribute to a sustained increase in River flow as a result of ground-water discharge: drainage from the alluvial aquifer materials beneath Elk Prairie, and ground-water inflow into those aquifer materials from the subjacent Franciscan Complex. However, if the alluvial aquifer were draining to support the gaining River reach, then ground-water levels would have to decline relative to the River stage to reflect such drainage. In other words, ground water would have to come out of storage in the alluvium to create discharge to the River; such a storage change would be reflected by continuously declining ground-water levels independent of River stage conditions (whether the River is declining or constant over any given period). Observation of actual ground-water levels at Elk Prairie shows this condition to not be the case. Relative to River stage, ground-water levels remain essentially constant over all times of the year and associated changes in River stage (see, for example, any of Figures 7 to 9). There is no depletion of ground-water storage that is contributing to, and sustaining, ground-water discharge to the river adjacent to Elk Prairie.

The only remaining source of water to sustain the generally constant ground-water gradient for flow toward the River at Elk Prairie is ground-water inflow from the upgradient (generally north) Franciscan Complex. While there are no wells completed in those materials adjacent to Elk Prairie, and hence there are no well yield or water level data on the formation at that location, there are several observations or interpretations that support a ground-water discharge on the order of one cfs. First, where the Franciscan Complex is noted in the literature to have some yield, it is where it is fractured or otherwise caused to have so-called secondary porosity and permeability. The immediate proximity of the San Andreas fault zone to Elk Prairie suggests the possibility to probability of fracturing that would cause secondary porosity and permeability to be present. Second, surface geologic mapping and field observations throughout the watershed above Elk Prairie show the North Fork of the Gualala River, including its narrow alluvial streambed, to be incised in Franciscan Complex. The North Fork of the Gualala River above Elk Prairie and the San Andreas Fault (and in fact even upstream of the extent of alluvium) is a perennial stream, with stream flow continuing throughout the year, for months between the end of each rainy season and the beginning of the next rainy season. In fact, the River progressively increases in flow as it proceeds toward Elk Prairie (see Cawood testimony). The only source of water to sustain, and to increase, stream flow in a downstream direction as far as Elk Prairie is the discharge of ground water from the Franciscan Complex in which the River is incised.

Finally, the water storing and yielding characteristics of the Franciscan Complex are evident by visual observations adjacent to Elk Prairie and for miles upstream along the banks of the North Fork of the Gualala River. Seeps and small springs emanate from the Franciscan along the north perimeter of Elk Prairie, suggesting that additional ground-water flow is discharging from the Franciscan in a downgradient direction toward Elk Prairie. Seeps and springs also emanate from the steep slopes of the Franciscan, which forms the banks of the River channel, for miles above Elk Prairie. Those seeps and springs, a photograph of one of which is enclosed as Figure 12, directly discharge or flow into the River. No attempt has been made to quantify the flows from the evident seeps and springs, and it would be impractical to attempt to do so. It would be even more impractical to attempt to quantify ground-water discharges from the Franciscan to the River or to ground water beneath Elk Prairie, particularly over the extent of the watershed. However, visual identification of ground-water discharges from the Franciscan Complex, such as can be observed at numerous locations adjacent to Elk Prairie (which are depicted in Figure 13), including the one shown in Figure 12, combined with the sustained baseflow in the River as described above, are evidence from locations both adjacent to Elk Prairie and upstream in the watershed that the Franciscan Complex has both water storage and yield capacity. Given that evidence and the lack of any other viable source of water to sustain the ground-water gradient toward the River beneath Elk Prairie, it can be reasonably concluded that there is ground-water flow from the Franciscan Complex to the alluvium beneath Elk Prairie, and that there is no flow boundary at the abutment of alluvium against the Franciscan Complex at that location. In effect, there must be sufficient ground-water flow from the Franciscan Complex, across its boundary with the alluvium beneath Elk Prairie, in approximately the direction as schematically illustrated in Figure 14, to support the ground-water discharge to the River.

Aquifer Characteristics

An aquifer testing program was conducted at Elk Prairie to determine the aquifer characteristics of the alluvial formation, to further investigate the Elk Prairie stream/aquifer relationship, and to determine any direct impacts of pumping from beneath Elk Prairie on the North Fork of the Gualala River. The testing was conducted in the fall of 1997, so that aquifer and River response could be evaluated under low stream flow conditions. Monitoring of ground and surface-water levels in seven wells and three staff gauges was continued prior to and after the aquifer testing, as described elsewhere in this testimony, to document seasonal variations in hydrologic conditions at Elk Prairie.

The aquifer testing at Elk Prairie was conducted using NGWC's Well 4, its only active production well at the time, since it has a similar pumping capacity as Well 5, since it is located a similar distance as Well 5 from the River, and since the use of Well 4 minimized disruptions to NGWC's water supply and facilitated the discharge of pumped water away from the Elk Prairie. Data collection during the aquifer testing was by pressure transducers and data loggers installed in six observation wells (Well 5, MW-1, MW-2, MW-3, MW-4, and MW-5) and in the River at SG-1 to automatically measure and record ground-water levels and River stage. Because of limited access through a small port in the wellhead structure, a transducer could not be installed in PW-4, and water levels were measured manually in this well.

Two aquifer tests were conducted, both at the normal operating capacity of Well 4 (average pumping capacity was 258 gpm in both tests); the first test was extended to 80 hours of continuous, constant rate pumping, while the second was continued for 24 hours. Water level drawdown during pumping, and recovery after pumping, were measured in the pumped well and in all six observation wells (Well 5 and the five monitoring wells) plus SG-1.

Aquifer Characteristics

Based on multiple analytical methods to interpret water level drawdown in response to pumping, the hydraulic characteristics at Elk Prairie were found to include very high transmissivity, with an average value between 318,000 gallons per day per foot (gpd/ft) and 427,000 gpd/ft. Aquifer storativity is about 1.1×10^{-3}, based on averages from all interpretations of both tests; and specific yield is about 0.13.

The preceding values of aquifer transmissivity and storage, including specific yield, strongly suggest minimal drawdown in pumped wells and in the surrounding aquifer, particularly at the relatively low pumping capacities of Wells 4 and 5. This was verified by actual water level drawdown of only 1.9 feet in Well 4 after 80 hours of continuous pumping; it was further verified by drawdown of less than one-half foot (in the range of 1.7 to 5.6 inches) in all the observation wells after 80 hours of pumping.

In fact, even under such an extended pumping test (which far exceeds NGWC's normal operational pumping cycles of a few minutes each hour), there was insufficient drawdown in the aquifer system to create a gradient for flow from the River toward the pumped well.

Boundary Effects (River - Aquifer Interaction)

A key factor in both the consideration of the possibilities of channelized ground-water flow or induced infiltration of stream flow is whether drawdown associated with a pumping well encounters boundary conditions. A true channel boundary would act as a so-called negative boundary (because water could not readily flow across such a boundary) and, if encountered, would tend to steepen the rate of drawdown associated with constant-rate pumping of a well. Conversely, a true recharge boundary would act as a so-called positive boundary (because water from such a recharge source would readily contribute to the well's discharge) and, if encountered, would tend to reduce the rate of drawdown associated with constant-rate pumping of a well. Neither a positive nor a negative boundary condition was encountered during extended aquifer testing at Elk Prairie.

During the aquifer testing at Elk Prairie, focus was on the potential effects of the River because it is the closest boundary (180 feet away from Well 4) and because a primary purpose of the tests was to determine the extent of interaction between the aquifer and the stream. Despite the proximity of the River, however, the aquifer test results indicated that it did not act as a source of recharge to the well during the two aquifer tests.

The S-shaped time-drawdown curves from the aquifer testing are typical of unconfined aquifers, including the flatter slopes observed after 20 minutes of pumping caused by delayed yield from the aquifer rather than by recharge from the River. If a true recharge boundary had been encountered, the flatter slope would have continued for the duration of pumping and would not have steepened at the end of the test. If the stream were to act as a full recharge boundary, the curve would become completely flat and there would be no additional drawdown in the aquifer once the cone of depression reached the stream; at that point, induced infiltration from the River would be contributing all the well's discharge.

All of the ground-water elevation contour maps of static conditions (e.g. Figures 10 and 11) show a steep hydraulic gradient beneath Elk Prairie, with a southwesterly direction of ground-water flow. This steep slope causes a distortion of the cone of depression around the well so that the area of influence becomes elliptical rather than circular as more of the water pumped by the well is derived from the upgradient (northeasterly) portion of the aquifer. Water will not be derived from the downgradient portion of the aquifer until the cone of depression becomes deep enough to cause a gradient reversal in a downgradient direction from the well. Drawdown will still be expected to occur in downgradient monitoring wells such MW-1, however, because the pumping well intercepts water that would otherwise flow to this area. Some drawdown is also expected to occur at the River staff gauges, because water pumped by the well reduces the amount of ground water that is contributing to the gaining River in the reach adjacent to the well. The effect of this reduced gain on stream flow is minor, as was observed in the small amount of stage decline at SG-1 during the well and aquifer testing. Again, emphasis should be added to the fact that "impacts" at the stream are a result of intercepting ground water flowing toward the stream; surface water flows in the River along Elk Prairie still exceed the upstream surface water flows into the vicinity of Elk Prairie.

Ground-water flow directions under pumping conditions are indicated on Figure 15, which shows the ground-water elevation contours during the second test after 12 hours of a continuous pumping. This plot shows that ground water continues to discharge to the River at all locations, including SG-1, under extended pumping conditions as occurred during the aquifer tests (in contrast to the much shorter pumping cycles typical of NGWC's normal operation of the well for water supply). Since there is a ground-water divide between Well 4 and SG-1, with ground water flowing toward the well north of the divide and toward the River south of the divide, even this extended period of pumping does not induce flow from the River into the aquifer.

Water Requirements and Potential Pumping Impacts

Current and Projected NGWC Requirements

In 1996, NGWC's municipal water requirements were about 190 acre-feet per year; the source capacity required to meet that average daily water demand was 119 gpm. Based on the number of service connections in the system (916), the average day demand was 0.13 gpm per service connection. Under 1996 operations, NGWC was able to meet some of its demand from two treated surface-water sources which have a combined average capacity of 78 gpm. With that supply in service, the average demand from Well 4 at Elk Prairie was 41 gpm in 1996. The latter flow rate equates to an average pumping cycle of about ten minutes per hour at Well 4, which is essentially what was observed during monitoring prior to well and aquifer testing at Elk Prairie in 1997.

Future NGWC water requirements can be projected on the basis of historical unit water demands and growth projections for NGWC's service area. For purposes of considering potential pumping scenarios on Elk Prairie, NGWC had previously projected water demand for a 20-year period based on current unit water requirements (average day demand) and Town Plan growth projections (2,242 equivalent meters by 2016). Under those conditions, the average annual demand in 2016 was projected to be about 470 acre-feet per year, or an average day water supply requirement of 292 gpm. With the existing surface-water sources in service, the future average year-round pumping capacity from an Elk Prairie wellfield (one or more wells) would be 214 gpm. Projected future maximum day demand was projected to be about 430 gpm, or about 350 gpm from Elk Prairie with the existing surface-water sources in service.

Recent updating of maximum day demand projections by NGWC suggests that the previous projections were too high. Growth data in the intervening years now suggests that future (2021) maximum day demand will be lower, in the range of 300 to 370 gpm, which suggests that the maximum day demand from Elk Prairie could be as low as about 220 to 300 gpm. Average day demand would be even lower, on the order of 80 to 110 gpm. In that light, the pumping scenarios described in the following testimony, which were based on the previous projections of future NGWC water demand, are based on higher pumping rates than likely to actually occur between now and 2021. Since most of the previously modeled scenarios result in no induced infiltration from the River, pumping to meet a lower demand would have less impact and similarly would not induce any infiltration from the River.

Potential Pumping Impacts

Given the nature of NGWC's water supply sources, the ability to pump additional ground water from the alluvial aquifer beneath Elk Prairie would be a logical source to meet the projected increase in NGWC water demand described above. A logical question, of course, would be whether such increased pumping would continue to just intercept ground water, or whether such pumping would cause induced infiltration from the River. The two well and aquifer scenarios, interception of ground water versus induced infiltration from the River, are schematically illustrated in Figures 16 and 17. In effect, the objective at Elk Prairie would be to pump at capacities and durations that preserve the hydraulic picture in Figure 16, where the net ground-water gradient for flow remains toward the River; the objective would similarly be to limit pump capacities and durations in order to preclude the development of the hydraulic picture in Figure 17, where some component of discharge from the well is derived from induced infiltration from the River. In examining Figures 16 and 17, it is important to recognize that the distance to which the cone of depression extends from a pumped well is dictated by aquifer characteristics and pumping time only. Hence, one objective in trying to avoid induced infiltration from the River is to limit pumping time such that the cone of depression does not extend far enough to reverse the natural gradient for ground-water flow toward the River. Another important factor to recognize in examining Figures 16 and 17 is that pumping capacity directly affects the depth of drawdown within the cone of depression. Hence, a second objective in trying to avoid induced infiltration from the River is to limit pumping capacity such that whatever local gradient forms around the pumped well (within the cone of depression) is relatively flat rather than steep.

In light of data showing that ground water continued to discharge to the river during the aquifer tests discussed above, the most logical approach to meeting increased demand is to increase the duration of pumping cycles in Well 4. However, while that would not be expected to reverse the aquifer-stream gradient, it would result in NGWC's dependence on that one well for an ever increasing portion of total water demand. A major concern with such an approach would be the lack of water supply capacity in the event of any routine or other down-time in what would then be NGWC's largest single source of supply. A more reliable alternative to achieve increased capacity would be to devise a multiple well pumping program which utilizes short pumping cycles (as in the existing use of Well 4) that would meet increased water demand but would not be long enough to allow the cone of pumping depression to reverse the aquifer-stream gradient. NGWC has implemented the beginnings of such an alternative by alternating its current pumping between Wells 4 and 5; the small pumping impacts at Elk Prairie are now diminished by distribution of pumping among two wells rather than just one. In effect, since both wells have similar pumping capacities (260 gpm), each well is pumped about half the time that Well 4 was previously pumped by itself.

In light of the high aquifer transmissivity at Elk Prairie, a number of options were developed and analyzed for increasing water supply at Elk Prairie, generally as follows:

- alternating pumping between Wells 4 and 5
- increasing the duration or frequency of pumping cycles at Well 4
- increasing the capacity of Well 4
- simultaneous pumping of Wells 4 and 5
- construction of additional wells to further distribute pumping, and to retain individual low pumping rates and short pumping cycles.

Potential well sites on NGWC's property are illustrated on Figure 18, which also includes the existing Wells 4 and 5, the existing monitoring wells and stream staff gauges, and a number of additional monitoring sites which were considered in analyzing the potential impacts of using some combination of wells to meet existing and projected NGWC water demand.

Sixteen different scenarios were analyzed to examine the potential impacts of using various combinations of the wells illustrated in Figure 18, at various pumping capacities and pumping times, to meet projected NGWC water demand. Each scenario was examined by use of an analytical model, based on measured aquifer characteristics at Elk Prairie, to compute drawdown impacts around the well(s) and to determine whether or not that drawdown caused the net ground-water gradient to remain toward the River (Figure 16) or to be reversed (Figure 17). The sixteen scenarios included:

- individual pumping of Wells 4 and 5 at rates of 250 and 500 gpm
- simultaneous pumping of Wells 4 and 5 at individual rates of 125 to 375 gpm (375 to 500 gpm combined)
- individual pumping of hypothetical Wells 6 and 7 at 500 gpm
- simultaneous pumping of various pairs of existing (Wells 4 and 5) and hypothetical (Wells 6 and 7) wells at 250 gpm each (500 gpm combined)
- simultaneous pumping of various combinations of three existing and hypothetical wells at 125 and 250 gpm each (625 gpm combined)

! simultaneous pumping of various combinations of two existing and hypothetical wells at 250 and 500 gpm (750 gpm combined)

All the scenarios were configured to meet the projected future demands described above; in other words, pumping times would increase or decrease as a function of pumping capacities in order to meet the same projected water demand.

The detailed results of the 16 scenarios are included in our report entitled **Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie** (January, 1998), which is separately submitted as part of this proceeding as Exhibit NGWC-8. For purposes of this testimony, it can be summarized that 12 of the 16 scenarios would not result in any reversal of gradient and thus no inducement of infiltration from the River as a result of pumping by NGWC to meet existing or projected future water requirements, e.g. the hydraulic picture as schematically illustrated in Figure 16.

In light of all the preceding, NGWC can incrementally increase its pumping from Elk Prairie to meet projected increases in water demand in the future without causing a reversal in aquifer-stream gradient that would induce infiltration from the River. Various options exist for such increases, including: 1) increasing the design capacity of Well 4 up to 500 gpm; 2) pumping Well 5 simultaneously with Well 4 at a combined capacity up to 500 gpm; 3) installing and operating a new Well 6 at a capacity up to 500 gpm; 4) operating Wells 4, 5, and 6 at a combined capacity up to 625 gpm; and 5) installing a new Well 7 with a capacity of 250 gpm and operating it along with Well 6 at a combined capacity of 750 gpm. Since Wells 6 and 7 are potential rather than existing wells, the actual capacities and pumping impacts of these wells would need to be verified by testing if they are constructed as part of an overall strategy to meet water requirements from local ground-water flow without inducing any depletion of the nearby North Fork of the Gualala River.

Ultimately, it would be appropriate to configure an integrated pumping and monitoring program at Elk Prairie to ensure that whatever well field is installed and operated (which of the 12 scenarios is implemented) does not induce infiltration from the River. Conceptually, assuming that the existing Wells 4 and 5 remain in service, it is logical that the existing monitoring network (MW 1-5 plus SG 1-3) would be utilized for regular water level measurements to verify maintenance of ground-water flow toward (and not from) the River. In the event that pumping were to cause a gradient reversal, some combination of pumping rates, well locations, and pumping cycles would have to be adjusted to eliminate such an impact. In general, pumping operations would have to be conducted in such a way that ground-water levels at the monitoring wells between the production wells and the River would be sustained higher than the River elevations measured at the stream stage monitoring locations.

Legal Classification of Ground Water

As discussed in the introduction of this testimony, the scope of our investigation at Elk Prairie was to investigate the occurrence of ground water and to assess pumping impacts on stream flow. The investigation into the occurrence of ground water resulted from the SWRCB staff's assertion in December 1992 that NGWC's Well 4 was pumping ground water flowing in a subterranean stream. The SWRCB staff's assertion was based on its agreement with the conclusions in a November 5, 1992 letter report prepared by Richard C. Slade and Associates. The letter report discussed the legal classification of ground water beneath the Gualala River system, with focus on NGWC's Well 4. According to the SWRCB staff, the Slade investigation was conducted for the Sea Ranch Water Company because of its interest in NGWC's Well 4 as a potential source of water supply for the Sea Ranch, although such an interest is not mentioned in the Slade letter report.

The Slade report states that its hydrogeologic assessment was conducted for the purposes of establishing whether water extracted from NGWC's Well 4 is from ground water flowing in a "subterranean stream" or from "percolating" ground water. Despite Slade's stated purpose of establishing the legal classification of ground water extracted by NGWC's Well 4, his report also discusses NGWC's Wells 1-3 (located westerly across the San Andreas Rift Zone from Well 4) and Sea Ranch Water Company's Well 2 and four test holes near Well 2 (which is apparently one of three Sea Ranch Wells). All of the Sea Ranch wells are located along the South Fork Gualala River. Ultimately, Slade concluded that the entire Gualala River system and, in particular the ground water extracted by NGWC Well 4, conforms with the definition of a "subterranean stream" and therefore is under the water-right permitting jurisdiction of the SWRCB.

At the time of Slade's investigation, the majority of the specific technical data presented and discussed in this testimony, including essentially all of the ground-water elevation data, was not available. Some limited ground-water level data was available from Well 4, but it was apparently not considered by Slade. It would have taken a more detailed investigation than was conducted by Slade to interpret ground-water gradients and flow directions relative to the River. However, simple consideration of the difference between the ground-water level at Well 4 and stream level would have raised questions about the alleged "channelized" flow, had water levels been considered. Well yield information from Well 4 was available but apparently not used or considered by Slade. For example, Slade reported that pumping rates for NGWC Wells 1-4 at the time of their construction were 50 to 60 gpm. Well 4 actually was test pumped at capacities up to 850 gpm when it was constructed, and it has been permanently equipped to pump 260 gpm since it was connected to the NGWC system in 1989. Independent of those details, the majority of Slade's assessment was based on generalized geological descriptions, general values of aquifer characteristics published in the literature, assumed ground-water flow directions, and similarities in surface water and ground-water quality.

The Slade letter report cites four criteria which, according to a personal communication from Julie Laudon, SWRCB staff, delineate a "subterranean stream":

- a channel, well-defined both laterally and vertically;
- shallow alluvium present in the channel;
- geologic contact between the shallow alluvium and underlying bedrock is a flow boundary marked by a sharp permeability (hydraulic conductivity) contrast; and
- similarity in water quality between water extracted from wells located in the alluvium, and surface water runoff in the local stream channel.

Interestingly, there was no mention in the criteria cited by Slade that there be flow in the subterranean channel; presumably as a result of that omission, there is no discussion of ground-water flow in the Slade letter report. Consequently, Slade drew no conclusion about whether ground-water was flowing in, or in any way confined in, the subterranean stream channel which he concluded to be present.

Slade's conclusion regarding a subterranean stream was based on some of the geologic and hydrologic information available at the time, and was organized into several sub-conclusions: 1) the aquifer system is a relatively narrow, confined alluvial stream valley which is underlain by relatively impermeable, consolidated, fractured marine conglomerate, sandstone, and siltstone of the Franciscan Formation; the latter materials were considered by Slade to be non-water bearing; 2) the alluvial aquifer materials are shallow, ranging in depth from 55 to 105 feet; 3) recharge to the alluvial aquifer system is largely from influent seepage of stream flow in the Gualala River; 4) recharge to the alluvial aquifer materials from rainfall and from the underlying bedrock formations appear to be a minor contributing source of water in the alluvium; 5) textbook values of hydraulic conductivity for alluvium are several orders of magnitude higher than textbook values for bedrock; and 6) water quality data indicate that the source of NGWC ground water is from the Gualala River.

As a result of the investigation and analysis undertaken as a basis for this testimony, it is now clear that ground water beneath Elk Prairie is not flowing in a subterranean stream. The bases for this conclusion are summarized as follows.

The geophysical exploration and test hole drilling parts of the 1996-97 investigation show the alluvial aquifer system beneath Elk Prairie to be notably wider (possibly up to 0.5 mile) than the rest of the “relatively narrow” river system described by Slade. It is also substantially deeper (up to about 170 feet) than Slade’s estimate (up to 105 feet).

Water level data from wells and stream stages at Elk Prairie clearly show that recharge to the alluvial aquifer at Elk Prairie is not from influent seepage of stream flow. Instead, ground water perennially discharges to the stream and there is no influent seepage, even under pumping conditions. Water level data also show that recharge from rainfall and/or from the underlying bedrock formations must be contributing sources of water to the alluvium. Ground-water level measurements in wells on Elk Prairie show rapid responses to precipitation; and maintenance of a positive ground-water gradient toward the River (the ground-water flow direction is perpendicular to the stream, not parallel to it, beneath Elk Prairie) without declining ground-water levels and storage throughout the dry part of the year show that there is a subsurface flow from the basement complex to the alluvium, particularly during periods of no precipitation.

The results of pumped well testing show that alluvial aquifer transmissivity is notably higher than what might have been estimated from the data reported by Slade. While that might suggest a greater contrast with the underlying bedrock, the maintenance of ground-water flow nearly perpendicular to the stream, with associated ground-water discharges to the stream, strongly supports the conclusion that the basement materials are not relatively impermeable, probably because the Franciscan Formation bedrock is highly fractured, and more interconnected in its fractures, in the proximity of the San Andreas Fault Zone.

Finally, although there are similarities in surface-water quality and ground-water quality, these water qualities are not identical. For example, the concentrations of total dissolved solids in ground water are 30 to 40 percent higher than in surface water. The hydraulic gradients under all static and pumping conditions clearly show that ground water discharges to the North Fork Gualala River from beneath Elk Prairie. The source of surface water is, in part, ground-water discharge and not the other way around as reported by Slade.

Further consideration of the findings of the investigation on which this testimony is based suggest that, particularly during the dry season when there is no surface runoff, the maintenance of a live stream above Elk Prairie, with a gaining reach adjacent to Elk Prairie results from discharge of ground water either directly from the fractured Franciscan bedrock material or from alluvial materials adjacent to the stream that are, in turn, receiving inflow from subjacent fractured bedrock.

In conclusion, there is a perennial ground-water gradient causing flow in a perpendicular direction toward the North Fork Gualala River and no “channelized” ground-water flow parallel to the River at Elk Prairie. These conditions and the response of the aquifer to precipitation, to pumping, and to dry-season lack of rainfall recharge all show that ground water is not recharged by influent stream seepage and is not flowing in a defined channel. Ground water beneath Elk Prairie is maintained by some combination of deep percolation of precipitation and subsurface flow from the basement complex. Similarities in surface-water quality and ground-water quality are not the result of recharge from the North Fork Gualala River, since ground water is discharging to the River, and not being recharged by it, under both static and pumping conditions. Consequently, ground water beneath Elk Prairie does not occur in a subterranean stream.

Finally, although it has not been alleged by either Slade or SWRCB staff that ground water beneath Elk Prairie is the underflow of the River, it is noteworthy that such is not the case for the same basic reason that ground water is not flowing in a subterranean stream. The perennial ground-water flow direction at large angles to the River, and not parallel to it, is contrary to the requirement that underflow be moving in the same general direction as the surface stream.

Summary and Conclusion

Based on the findings of our investigation of the occurrence of ground water beneath Elk Prairie and its interaction with surface water in the adjacent North Fork of the Gualala River, a number of summary points and conclusions to this testimony can be drawn as follows.

Surface geophysical (seismic refraction) exploration was conducted to initially define the areal and vertical extent of the alluvial aquifer and the location of the basement complex underlying the aquifer. The resultant description of the aquifer system beneath Elk Prairie is a shallow, broad, v-shaped trough or channel generally parallel to the North Fork Gualala River. At its deepest, on the north side of the River near NGWC Wells 4 and 5, the alluvial aquifer is about 170 feet thick and underlain by fractured and slightly-weathered Franciscan Complex.

A network of five test holes was drilled and logged to define geologic and lithologic conditions, and to aid in interpretation of the geophysical exploration work; all of the borings were completed into dedicated monitoring wells. Two of the boreholes were drilled through the alluvium to confirm its thickness, which is 149 and 147 feet at sites MW-3 and 5 respectively. A backup water supply well (Well 5) was constructed on the Elk Prairie approximately 400 feet east of Well 4 to protect NGWC's source capacity in the event of maintenance or repair of Well 4. Well 5 was completed in the same aquifer materials as Well 4, although the completions of the two wells are not identical due to difference in lithology at the respective sites.

Water-level monitoring in Well 4 and a staff gauge in the River (SG-1) began in March 1996, and two additional staff gauges were installed upstream of SG-1 in October 1996. Water levels were measured biweekly at two production wells, five monitoring wells, and three staff gauges through the end of 1997; sporadic observations have been made since then. Hydrographs and ground-water elevation contour plots developed from these data indicate that the reach of the North Fork Gualala River adjacent to Elk Prairie was a gaining reach under all hydrologic conditions that occurred between March 1996 and December 1997, including pumping conditions during Well 4's normal pumping cycles for domestic water supply. Similar conditions have occurred on all occasions when water levels have been measured in 1998 through the present; normal pumping operations have continued throughout that period as well. While there is direct hydraulic continuity between the aquifer system and the River, all measured ground-water levels are above the River; and, as a result, ground water discharges to the stream under all River stages.

In addition to observations of water level responses to day-to-day operations, two constant-rate pumped well and aquifer tests were conducted in Well 4 at a pumping rate of approximately 260 gallons per minute, which is its design capacity. The tests were conducted during low stream flow conditions in September and October 1997 in order to observe “worst case” conditions for possible pumping impacts on stream flow. The tests were also extended well beyond the duration of any existing or projected pumping cycle by NGWC, again to examine “worst case” conditions. During the tests, there were no reversals of gradient, and hence no induced infiltration from the stream to the aquifer. Measurements of ground-water levels and resultant contour mapping of equal ground-water elevations show continuous ground-water discharge toward the River throughout the tests.

Based on interpretation of the well and aquifer testing, the average transmissivity of the aquifer materials beneath Elk Prairie is between 300,000 and 400,000 gpd/ft, and the corresponding hydraulic conductivity is on the order of 4,500 gpd/ft^2. Both are high values, typical of coarse sands and gravels as are present in the aquifer beneath Elk Prairie. It is common that, with such high hydraulic conductivity and aquifer transmissivity, water-level drawdown in pumped wells and in the surrounding aquifer is typically small, as observed during the testing and the regular operation of Well 4.

The ability to pump more ground water from the alluvial aquifer beneath the Elk Prairie would help NGWC meet its projected future water demand. The aquifer test results indicate that more water could be pumped from the aquifer while continuing to maintain a positive gradient for ground-water discharge to the River. Various options available to NGWC to increase pumpage from Elk Prairie include alternating pumpage between Wells 4 and 5, increasing the pumping capacity of Well 4, and constructing additional wells at the site. Simulations using an analytical model based on measured aquifer characteristics at the site indicate that any of 12 different scenarios would not cause a simulated gradient reversal, including one scenario at 375 gpm, six scenarios at 500 gpm, two scenarios at 625 gpm, and one scenario at 750 gpm.

Based on the various components of the Elk Prairie exploration, monitoring, and testing, it can be concluded that NGWC can continue to operate Well 4 at its design capacity, with extended pumping cycles to meet daily and seasonal fluctuations in water demand, and not cause any induced infiltration from the North Fork Gualala River. Similarly, NGWC can operate Well 5 at a similar capacity on intermittent pumping cycles without causing any induced infiltration from the River as long as both wells are not pumped at the same time. However, if Well 5 were equipped with a smaller capacity pump and Well 4 with a larger capacity pump, these wells could be pumped simultaneously at a combined capacity of up to 500 gpm. Finally, as water demand in the system increases in the future, NGWC could install one or two additional production wells at Elk Prairie, located a similar or greater distance from the River and equipped at a similar capacity and operate them in a similar manner without causing any induced infiltration from the River. The addition of that source capacity would provide sufficient supply to meet increased water demand based on the Town's General Plan over the next 20 years. Coincident with the increase in pumping at Elk Prairie to meet increased future water demand, it would be appropriate to implement a monitoring program to ensure that whatever well field is installed and operated does not induce infiltration from the River.

Finally, the results of the overall Elk Prairie ground-water investigation show a perennial gradient for ground-water flow toward, and discharge into, the North Fork Gualala River from beneath Elk Prairie. There is no "channelized" ground-water flow parallel to, or in the same general direction as, the River at Elk Prairie. These conditions and the response of the aquifer to precipitation, to pumping, and to dry season lack of rainfall recharge all show that ground water is not recharged by influent stream seepage. During the dry season, both ground water and stream flow are maintained by subsurface flow from the basement complex. Similarities in surface and ground-water quality are not the result of recharge from the North Fork Gualala River to the aquifer system, because ground water discharges to the River under both static and pumping conditions regardless of stream stage. As a result of all these factors, ground water beneath Elk Prairie does not occur is a subterranean stream, nor does it occur as underflow of the River.

EXHIBIT NGWC-8

Luhdorff & Scalmanini Consulting Engineers: "Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie" (January 1988)

See hard copy of report

EXHIBIT NGWC-9

Geologic Map of North Gualala River Watershed

See hard copy of map

EXHIBIT NGWC-10

USGS 7.5' McGuire Ridge, California Quadrangle Topographic Map

See hard copy of map

EXHIBIT NGWC-11

USGS 7.5' Gualala, California Quadrangle Topographic Map

See hard copy of map

EXHIBIT NGWC-12

U.S. Dept. of the Interior, U.S. Geologic Survey, “Topographic Map Symbols”

See hard copy of map

STATE OF CALIFORNIA-THE RESOURCES AGENCY GRAY DAVIS, *Governor*

DEPARTMENT OF FISH AND GAME
1416 Ninth Street
Sacramento, California 94244-2090
Telephone: (916) 654-3821

May 3, 2002

VIA HAND DELIVERY

Division of Water Rights
State Water Resources Control Board
P. O. Box 2000
Sacramento, California 95812-2000
Attn: Paul Murphey, Associate Engineering Geologist

RE: HEARING REGARDING THE LEGAL CLASSIFICATION OF GROUNDWATER EXTRACTED FROM THE NORTH GUALALA WATER COMPANY'S WELLS 4 AND 5 UNDER PERMIT 14853

Dear Mr. Murphey:

Enclosed please find five copies of the EXHIBIT IDENTIFICATION INDEX, EXHIBITS 1-23, and statement of service for the above-referenced matter.

If you have any questions, please contact me at (916) 657-4091.

Very truly yours,

HARLLEE BRANCH
Staff Counsel

Enclosures

HB/jmw

PROOF OF SERVICE

I hereby declare as follows:

I am employed in the County of Sacramento, State of California. I am eighteen years of age or older and am not a party to the within entitled action. My business address is 1416 Ninth Street, P. O. Box 944209, Sacramento, California 94244-2090. I am familiar with the business practice of the California Department of Fish and Game with regard to the collection and processing of documents for mailing with the United States Postal Service.

On May 3, 2002, I caused to be served the attached LETTER TO PAUL MURPHEY, EXHIBIT IDENTIFICATION INDEX, and EXHIBITS 1-23 **by placing a true copy thereof in the manner set forth below and addressed as follows:**

Via HAND DELIVERY:

Mr. Paul Murphey
Associate Engineering Geologist
State Water Resources Control Board
P. O. Box 2000
Sacramento, California 95812-2000

Via U.S. Mail by Depositing a Copy in a Sealed Envelope Via First Class Mail with the United States Postal Service with Postage Fully Paid Thereon To:

See attached list.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed in Sacramento, California on May 3, 2002.

Jan Wilcox
JAN WILCOX

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EXHIBIT IDENTIFICATION INDEX

HEARING REGARDING THE LEGAL CLASSIFICATION OF GROUNDWATER EXTRACTED FROM THE NORTH GUALALA WATER COMPANY'S WELLS 4 AND 5 UNDER PERMIT 14853

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
1	Written testimony of Kit H. Custis, Certified Engineering Geologist (CEG).			
2	Resume of Kit H. Custis, CEG.			
3	CALWATER 2.2, Interagency California Watershed Mapping Commission, version 2.2. September, 1999.			
4	Fire and Resource Assessment Program, California Department of Forest and Fire Protection, 10-meter DEM prepared by U.S. Geological Survey.			
5	PRIZM, 2001, Climate Maps from Oregon Climate Services, Oregon State University, California, annual precipitation file available at http://www.ocs.orst.edu/prism/prism_new.html			
6	Excerpts from Parfitt, D.G., and Germain, L.F., 1982, Mendocino County Coastal Ground Water Study, California Department of Water Resources, Northern District.			
7	WRCC, Western Regional Climate Center, Climate Data for California, available at : http://wrcc.sage.dri.edu/			
8	California Department of Water Resources, Northern District, Gualala River, Appendix 6: Hydrology, in Gualala River Synthesis Report, California Resources Agency, available at: *http://www.ncwatershed.ca.gov/Public/watersheds/gualala_river/pdfs/appendices/Gualala_River_Appendix_6.pdf*			
9	Fuller, M.S., Haydon, W.D., Purcell, M.G. and Custis, K., Draft Geology and Geomorphic Features Related to Landsliding, Gualala River Watershed, Sonoma and Mendocino Counties, California, Sheet 1, Northern Section, scale 1:24,000.			
9a	Detail of Exhibit 9 with superimposed cross-section locations.			

EXHIBIT IDENTIFICATION INDEX

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
10	Excerpts from Bailey, E.H., Irwin, W.P., and Jones, D.L., Franciscan and Related Rocks, and Their Significance in the Geology of Western California, 1964, California Division of Mines and Geology Bulletin 183.			
11	Excerpts from Grove, K. and Niemi, T., The San Andreas Fault Zone near Point Reyes: Late Quarternary Deposition, Deformation, and Paleoseismology, from Wagner D.L., and Graham, S.A., editors, Geologic Field Trips in Northern California, California Division of Mines and Geology Special Publication 119, 1999.			
12	Merrits, D.J., Prentice, C.S., and Gardner, T.W., editors, Paleoseismicity and Crustal Deformation Along the Northern San Andreas Fault, Fort Ross to Point Arena, California, from Keck Geology Consortium, 13th Symposium in Geology, 2000, available at: http://keck.carleton.edu/symposium/2000/00index.html			
13	Richardson, E, Uplift of Holocene Marine Terraces Along the San Andreas Fault: Fort Ross to Gualala, California, in Merrits, D.J., Prentice, C.S., and Gardner, T.W., editors, Paleoseismicity and Crustal Deformation Along the Northern San Andreas Fault, Fort Ross to Point Arena, California, Keck Geology Consortium, 13th Symposium in Geology, 2000, available at: http://keck.carleton.edu/symposium/2000/00index.html			
14	Excerpts from Luhdorff & Scalmanini, Consulting Engineers, Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie, January, 1998.			
15	Excerpts from Bailey Scientific, Seismic Survey, Elk Prairie, Gualala, California, December, 1996.			
16	Excerpts from Ford, R.S., Evaluation of Ground Water Resources: Sonoma County, Volume 1: Geologic and Hydrologic Data, California Department of Water Resources, Bulletin No. 118-4, 1975.			

EXHIBIT IDENTIFICATION INDEX

Participant: Department of Fish and Game

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
17	Excerpt from Driscoll, F.G., Groundwater and Wells, Second Edition, Johnson Division, St. Paul, Minnesota, 1986.			
18	Excerpt from Ziemer, R.R., Caspar Creek Thornthwaite Potential Evapotranspiration, Water Years 1990-1995, U.S. Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA, 1997.			
19	Excerpts from Keppeler, E., and Brown, D., Subsurface Drainage Processes and Management Impacts, in Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story, Ukiah, CA, May 6, 1998, Robert R. Ziemer, technical coordinator, U.S. Dept. of Agriculture Forest Service Pacific Southwest Research Station, Albany, CA, General Technical Report SW-GTR-168-Web.			
20	1936 Aerial Photo of Elk Prarie area, found at U.C. Berkeley Libraries.			
21	USGS Digital Orthophoto Quadrangle Images of North Fork Gualala River at Elk Prairie, Images 38123g44.tif and 38123g53.tif, taken July 12, 1993.			
22	Monitoring Well Log, Monitoring Well MW-5, Elk Prairie Groundwater Basin, October 16, 1996, excerpted from Appendix B of Luhdorff & Scalmanini, Consulting Engineers, Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie, January, 1998.			
23	Photos of North Fork Gualala River at Elk Prairie and Little North Fork, taken by Kit H. Custis, April 8, 2002.			

DFG EXHIBIT 1

Harllee Branch, Staff Counsel
California Department of Fish and Game
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1416 9th Street, 12th Floor
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STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

In the Matter of: HEARING REGARDING THE LEGAL CLASSIFICATION OF GROUNDWATER EXTRACTED FROM THE NORTH GUALALA WATER COMPANY'S WELLS 4 AND 5 UNDER PERMIT 14853	TESTIMONY OF KIT H. CUSTIS, CERTIFIED ENGINEERING GEOLOGIST (CEG)

TESTIMONY OF KIT CUSTIS

I, Kit Custis, provide the following written testimony under penalty of perjury in relation to the State Water Resources Control Board's Hearing Regarding the Legal Classification of Groundwater Extracted from the North Gualala Water Company's Wells 4 and 5 Under Permit 14853.

Q1: Please state your name and your professional qualifications.

1. I hold Bachelor of Science and Master of Science degrees in Geology from California State University, Northridge, and have over 55 units of graduate credit at UC Davis as part of a PhD program in Hydrological Sciences. I am a California Registered Geologist, RG3942; a Certified Engineering Geologist, EG1219; and a Certified Hydrogeologist, HG254. I have more than twenty-three years of professional experience in engineering geology and hydrology. I am presently employed as a Senior Engineering Geologist with the Department of

Conservation's California Geological Survey (formerly the Division of Mines and Geology) in the North Coast Watershed Assessment Program providing hydrologic and fluvial geomorphic analysis and mapping. Through an interagency contract, I also regularly provide technical analysis for the Department of Fish and Game (DFG) on the effects of pumping wells on surface stream flows.

2. My career as an engineering geologist has included work for both private scientific consulting companies and public agencies. My work for private companies has included the following: 1) hydrogeologic evaluations of groundwater resources and potential for groundwater contamination; 2) oversight of groundwater monitoring programs; 3) hazardous waste site assessments; 4) well design; 5) geotechnical, seismic and landslide hazard investigations and monitoring; and 6) development and design of database and computer mapping applications.

3. Other private projects have included the following: 1) geotechnical and groundwater studies of hillside homes and developments; 2) geologic and seismic hazard assessment for large dams; 3) project geologist at nuclear power plants; and 4) statewide resource surveys.

4. My experience working for public agencies has included the following: 1) statewide manager of investigations to find sources of pollution to public drinking water wells; 2) case officer for over 30 contaminated soil and groundwater cleanup projects; 3) preparation and oversight of WDR's and NPDES permits, Monitoring and Reporting Programs and Cleanup and Abatement Orders; 4) evaluation of geologic hazards for hospitals and schools; 5) evaluation of mined land reclamation plans; 6) evaluation of stability of slopes and erosion controls on mined lands; 7) research for the U.S. Environmental Protection Agency on the application of

geophysical methods to acid mine drainage investigations; 8) preparation of a cleanup plan to abate acid mine drainage from the abandoned Spenceville copper mine through interagency contract with DFG; 9) assistance in implementation of watershed restoration grant projects, also through interagency contract with DFG.

5. My resume has been provided separately as **DFG Exhibit 2**.

Q2: Please begin by providing a brief overview of the general geologic and hydrologic conditions in the North Fork Gualala River watershed, where North Gualala Water Company's Wells 4 and 5 are located.

6. The North Fork Gualala River is a perennial stream that drains an area of approximately 25,400 acres (39.7 square miles) above the North Gualala Water Company's (NGWC) well site (**DFG Exhibit 3**). Approximately 110 miles (177 km) of perennial stream channel exists upstream of the North Fork's confluence with the Little North Fork Gualala based on the 1:24,000 United States Geological Survey (USGS) 7-1/2 minute blue-line streams (**DFG Exhibit 4**). The average annual rainfall in the North Fork Gualala watershed ranges between 39 to 49 inches, with an average of approximately 43 inches (**DFG Exhibit 5**). In the area of Elk Prairie, which is home to NGWC's wells, annual rainfall is approximately 41 inches. Vegetation covering the western portion of the North Fork Gualala watershed, including Elk Prairie, is mostly timber with minor areas of grass and shrubs.

7. A stream gage was installed in 2001 on the North Fork Gualala (USGS station #11467553) just downstream from the confluence with the Little North Fork. However, the period of record for this gage is insufficient to develop a long-term hydrograph. The only long-term record of river flows is from the gage that existed from 1950 to 1971 and 1991 to 1994 (USGS station #11467300) on the South Fork of the Gualala just below the confluence with the Wheatfield Fork of the Gualala River. The upstream watershed for this gage is 161 square miles

-- approximately 4 times that of the North Fork Gualala. The geology and hydrology of the southern Gualala watershed are sufficiently similar to allow this gage to be used to estimate flows in the North Fork watershed.

8. Reports and records of the average precipitation patterns in Mendocino County find that between the months of May and October, little rain falls (**DFG Exhibits 6 and 7**). Therefore, the flow in the Gualala watershed between the months of May and October may be assumed to be baseflow derived primarily from groundwater. At the previous South Fork gage, flows from May to October made up approximately 5 percent of the annual flow (**DFG Exhibit 8**). An average baseflow above the South Fork gage during this time is estimated at approximately 41 cfs. If it is assumed that the baseflows in the North Fork Gualala watershed are proportional by area to the South Fork gage watershed, being of similar geology, hydrology and topography, then an average baseflow of approximately 10 cfs can be estimated for the North Fork during the months of May to October.

9. The North Fork Gualala River lies in an incised bedrock canyon cut into the Triassic/late Cretaceous age Franciscan Formation. **DFG Exhibit 9** is a geologic map of the northern third of the Gualala watershed illustrating alluvium extending up from the confluence of the North and Little North Forks of the Gualala River for approximately 8 miles. The western portion of the watershed is underlain by the sandstones and occasional shale of the Coastal Belt of the Franciscan Formation (**DFG Exhibits 9 and 10**). The eastern portion of the watershed is partially underlain by the mélange of the Central Franciscan. The mélange consists of a variable abundance of hard, resistant blocks of chert, metamorphosed rocks, sandstone, greenstone, serpentinite in a sheared shale and sandstone gouge matrix. Shallow and deep-seated landslides are common in both types of bedrock as shown on **DFG Exhibit 9**.

10. The dominant geologic structure in the Gualala watershed is the San Andreas Fault, which cuts a linear northwest trending valley through the western portion of the watershed. Along with other sub-parallel faults to the east that are today only potentially active, such as the Tombs Creek Fault, the San Andreas has influenced the orientation of stream channels throughout the Gualala watershed. The best example is the orientation of the South Fork Gualala, the Little North Fork Gualala and the North Fork Gualala below the Little North Fork confluence. These rivers are essentially linear channels flowing within the San Andreas Fault Zone. The western edge of the NGWC properties lies at the San Andreas Fault Zone, and wells 1, 2 and 3 are within the zone.

11. The alluvial valley fill at Elk Prairie is approximately 1,200 feet wide. The active channel of the North Fork Gualala River flows approximately 800 feet south of the northern alluvial-bedrock contact. The meanders of the North Fork Gualala's active channel have larger amplitudes and radius of curvatures east and upstream of Elk Prairie. Although the unconsolidated alluvial material that fills the incised channel of the North Fork Gualala are mapped in **DFG Exhibit 9** in yellow and appear to extend only 8 miles upstream of the NGWC's wells, these channel sands and gravels actually extend further upstream. However, the map scale (1 inch = 2,000 feet) precludes mapping these small sediments.

Q3: In your professional opinion, is a subsurface channel present at the location of North Gualala Water Company's Wells 4 and 5?

12. Yes.

Q4: Please describe how you came to this conclusion.

13. **DFG Exhibit 9** shows the alluvium of the North Fork Gualala filling the bottom of an incised sinuous bedrock canyon. The incision of this canyon likely occurred during uplift and inundation of the western Gualala watershed over the last 300,000 years or more to create at

least five marine terraces along the Gualala coast (**DFG Exhibits 11, 12, and 13**). During the marine low stand of the last glacial period 15,000 years ago, the sea level dropped approximately 390 feet below today's elevation -- resulting in the erosion of the North Fork Gualala channel at Elk Prairie to at least 170 feet below today's elevation. Evidence for the depth of this erosion event at the well site is found in Geologic Cross-Sections A-A', B-B', and C-C' in addition to the well logs (see generally pp. 19-24) contained in **DFG Exhibit 14** – a 1998 report by Luhdorff & Scalmanini Consulting Engineers on their subsurface investigation of pumping impacts from the NGWC's production wells PW-4 and PW-5 at Elk Prairie. Similar evidence is also contained on page 7 of the 1996 Bailey Scientific Elk Prairie seismic survey report, which was included as Appendix A of the Luhdorff Scalmanini report (**DFG Exhibit 15, p. 7**). The depth of the North Fork Gualala River channel alluvium at Elk Prairie is consistent with what would be estimated by projecting the slope of the surrounding bedrock into the subsurface. Other estimates of the depth of alluvium at and upstream of Elk Prairie derived by down slope projection of the topography are shown in the chart contained on page 27 of **DFG Exhibit 14**. The approximate location of these profiles is superimposed as cross-sections 1, 2, and 3 on the Elk Prairie detail of **DFG Exhibit 9a**.

14. The Luhdorff & Scalmanini report found that the near-surface deposits at Elk Prairie consist of fine-grain soils, sandy silt to silty clay (**DFG Exhibit 14,** page 7). Below these soils is the coarser-grained alluvial aquifer consisting mostly of sands and gravels with occasional interbeds of fine-grained materials (**DFG Exhibit 14**, page 7; Figures 2-2, 2-3 and 2-4 on pp. 6-8). The thickness of the fine-grained surface soils apparently increases as it extends northward towards the bedrock -- sloping down and away from the active stream channel. The fine-grained surface soils also appear to thicken to the northwest. The top of the coarse-grained

alluvial aquifer is approximately 7 feet below the surface at monitoring well MW-5. The depth to the top of aquifer increases to 17 feet at production well PW-5 and still deeper to 37 feet at monitoring well MW-2, and to 57 feet at MW-4.

15. The lowermost portion of the coarse-grained alluvial aquifer underlying Elk Prairie is bound by bedrock of Coastal Belt Franciscan Formation that consists primarily of greywacke sandstone and minor shale (**DFG Exhibits 9 and 10**). Geologic cross-sections in **DFG Exhibit 14**, Figures 2-2 and 2-3, pp. 6-7, show that the coarse-grained alluvial aquifer overlies a fresh Franciscan sandstone bedrock unit, TKfss. The geophysical investigation of Bailey Scientific (**DFG Exhibit 15**, page 10) concluded that the Elk Prairie alluvium is underlain by 1) local landslide debris, 2) soil and weathered bedrock, and 3) fresh bedrock. In the legend of Bailey Scientific's cross-section A-A' (**DFG Exhibit 15**, last page), the fresh bedrock unit is described as, "[s]lightly weathered, well-fractured Franciscan sandstone with an occasional well-weathered (clayey) zone." Bedrock fractures are described as being "very tight."

16. Although site-specific subsurface information is lacking for the depth of alluvium south of the active North Fork Gualala channel at Elk Prairie, the close agreement between the estimated alluvium depth based on projecting the slopes downward and the site specific drilling data supports the down slope projection of the surface topography to estimate subsurface conditions.

17. Therefore, the presence of the coarse-grained subsurface channel is demonstrated by: 1) the incision of the canyon during the last glacial period to a depth of at least 170 feet greater than today's alluvium surface; 2) the Holocene coarse-grained alluvium filling between the incised bedrock canyon walls through which the North Fork Gualala flows today; and 3) the

bounding of the coarse-grained alluvium by either fine-grained alluvium or fresh Franciscan Formation sandstone bedrock forming a subsurface channel of coarse-grained alluvium.

Q5: In your professional opinion, is groundwater flowing in the subsurface channel you described?

18. Yes.

Q6: Please describe how you arrived at this determination.

19. Groundwater elevation data for Elk Prairie shows that the sand and gravel aquifer of the subterranean channel underlying the North Fork Gualala River in this area is saturated and groundwater is flowing in a generally southwesterly direction (**DFG Exhibit 14,** Figures 4-4 and 4-5, for example). This southwesterly flow results from the fact that groundwater generally flows from high to low elevations (potential). At Elk Prairie, gradient drops in elevation moving generally from east to west.

Q7: In your professional opinion, are the bed and banks of the channel you described relatively impermeable in comparison to the alluvium?

20. Yes.

Q8: Please describe how you arrived at this conclusion.

21. The permeability of the alluvial aquifer is 2.5 to 3 times greater than the surrounding greywacke sandstone bedrock.

22. The Luhdorff & Scalmanini report estimated the permeability of the coarse-grained aquifer beneath Elk Prairie at 4,500 gpd/ft^2 (gallons per day per square foot) (**DFG Exhibit 14**, page 41). The specific capacity of the pumping wells -- the amount of water yielded per foot of drawdown -- ranged from 90 gpm/ft (gallons per minute per foot) for production well PW-5 to 130 gpm/ft for production well PW-4 (**DFG Exhibit 14**, pages 11 and 12). Step-drawdown pump tests demonstrated that NGWC wells PW-4 and PW-5 can yield a respective

maximum pumping rate of 850 and 700 gpm (gallons per minute) with respective drawdowns of 7.4 and 9 feet (**DFG Exhibit 14**, pages 11 and 12).

23. An estimate of the groundwater yield and hydraulic characteristics of the Coastal Belt Franciscan bedrock that surround Elk Prairie can be found in the regional groundwater studies of coastal Mendocino County and Sonoma County. Parfitt and Germain (**DFG Exhibit 6**) placed the Gualala watershed in their Point Arena Subunit. Elk Prairie lies within the inland portion of this subunit and is part of their "Critical Water Resources-bedrock unit," or "CWRbr" (**DFG Exhibit 6**, Figure 3). The CRWbr unit is described as *"groundwater available from usually low yielding bedrock wells."* Parfitt and Germain recommend that for the CRWbr unit the minimum land-use density be 20-acres or larger (**DFG Exhibit 6**, page 18), assuming an average per capital water of 0.2 acre-feet per year (**DFG Exhibit 6**, page 15), unless "proof of water" is demonstrated. From this statement, Parfitt and Germain imply that lots in the Gualala watershed underlain by the Coastal Belt Franciscan have very limited sustained recharge to bedrock to supply domestic water wells. By my calculation, for every inch of deep bedrock recharge, approximately 1.67 acre-feet of groundwater is made available (20 acres x 1/12 feet = 1.67 acre-ft). With a per capita use of 0.2 acre-ft per year, this volume of sustainable recharge can serve up to 8 people.

24. Parfitt and Germain also found that the average specific capacity of wells in the Coastal Belt Franciscan greywacke was 0.265 gpm/ft with well drawdowns averaging approximately 68 feet (**DFG Exhibit 6**, Table 6). Ford (**DFG Exhibit 16**) investigated the occurrence of groundwater in the Sonoma County portion of the Gualala watershed and found similar conditions. Ford found that the yields of wells drilled into the Franciscan bedrock generally are low, ranging from 1 to 3 gpm with an average specific capacity of 0.22 gpm/ft

(**DFG Exhibit 16**, pages 147 and 148). As part of my own Gualala watershed study, I reviewed well logs to evaluate the depth of alluvium and the permeability of bedrock in the Gualala watershed. My review of logs for 17 bedrock wells in the Coastal Belt Franciscan of the Gualala watershed found similar results to Ford, and Parfitt and Germain (**DFG Exhibits 16 and 6**, respectively). I calculated an average bedrock specific capacity of 0.21 gpm/ft, but the data were log-normally distributed with a positive skew. This means that most data are less than the mean value. A better representation for this small, skewed data sets is the median value, or middle value, of specific capacity which was approximately 0.10 gpm/ft for the Coastal Belt Franciscan. I also estimated hydraulic conductivity assuming the conversion of specific capacity to transmissivity proposed by Driscoll for the unsaturated case (**DFG Exhibit 17**, page 1021). I then assumed the thickness of bedrock-yielding water to be the same as the well screen length. As with the specific capacity, the hydraulic conductivity data are log-normally distributed with a positive skew. I calculated a median value of hydraulic conductivity of approximately 1.7 gpd/ft^2. A calculation of the ratio of alluvium-to-bedrock for either the specific capacity or hydraulic conductivity finds that bedrock ranges from 2.5 to 3 orders of magnitude less permeable or water yielding than the subterranean channel alluvium ($Qal_{sc}/bedrock_{sc} = 450$; $Qal_k / bedrock_k = 1800$).

Q9: In your professional opinion, how does water recharge to the subterranean channel alluvium occur at Elk Prairie?

25. There are several possible means by which recharge could occur, including subsurface flow from the subterranean channel alluvium upstream, recharge from surface water through the sand and gravel bed of the stream channel, or a combination of both.

Q10: What is the basis for this determination?

26. The hydrology of the Casper Creek watersheds in the Jackson State Forest near Fort Bragg has been studied since 1963 to evaluate impacts from different types of silvicultural practices on watershed conditions. The studies in Caspar Creek are particularly applicable to the North Fork Gualala because both watersheds have several important characteristics in common: 1) both are underlain by the same Coastal Belt Franciscan bedrock; 2) both are overlain by coastal redwood and Douglas-fir coniferous forests; and 3) both have nearly equivalent annual precipitation -- 43 to 46 inches per year. Findings from studies done in Caspar Creek of the subsurface drainage processes, summer flows, water yield, and water balance can therefore be applied to the North Fork Gualala watershed. Ziemer (**DFG Exhibit 18**) studied the water balance of both basins over a five year period. He estimated the average annual potential evapotranspiration at approximately 50 percent of the annual precipitation. A measurement of the actual runoff from each of the two sub-basins, when compared to the potential runoff, found that 2 to 6 percent of the water was not accounted for. This loss of flow could be due to deep recharge of bedrock. This rate of deep groundwater percolation is similar to that estimated by Parfitt and Germain (**DFG Exhibit 6**). Keppeler and Brown (**DFG Exhibit 19**) studied subsurface drainage process and found that for forested lands such as Caspar Creek and the North Fork Gualala watershed, *"[s]easonal effects of subsurface flows are manifest in the storage properties of forest soils. During the summer, water drains from soils and supports perennial streamflow (baseflow)."* Keppeler and Brown's study also found that much of the streamflow during the winter is from shallow soil pipes that rapidly drain off infiltrating precipitation. Thus, research on north coast forested watersheds suggests that most of the infiltrating precipitation drains to streams through shallow soils and/or weathered bedrock.

27. As discussed above, the only long-term surface water flow gage in the Gualala watershed was on the South Fork (USGS station #11467300). Since the North Fork Gualala is similar to the watershed above this South Fork gage, except being one-quarter of the size, an estimate of 10 cfs average base flow can be used for the months of May through October. This average base flow can be provided through the slow drainage of groundwater in the shallow soils and weathered bedrock. If the average thickness of the channel bank soils is assumed to be at least 1 meter and the hydraulic conductivity and the hydraulic gradient of the shallow soils is similar to that used in the SWRCB's 1999 <u>Garrapata</u> Decision 1639 -- 1 foot/day and 0.25 respectively -- then the banks of the 111.9 miles of blue-line channel in the North Fork Gualala watershed above Elk Prairie can provide the average May-to-October base flow of 10 cfs (110 mi. x 5280 ft./mi. x 2 banks x 1 ft./day x 0.25 ft./ft. x 3 ft./86,400 sec/day = 10.08 cfs).

28. Other information leads me to conclude that groundwater recharge to the Elk Prairie alluvium is derived from the active channel of the North Fork Gualala River. A channel meander in the North Fork Gualala River is located approximately 300 feet east of production well PW-5 and approximately 300 feet southeast of monitoring well MW-4 (**DFG Exhibit 14,** Figure 4-1). This channel meander is a pool that encompasses a point bar, likely composed of sands and gravels similar to the active North Fork Gualala stream channel. **DFG Exhibit 20** is a 1936 aerial photograph of Elk Prairie. The channel meander is visible in the upper right portion of the photograph. The meander is evident as a large (approximately 5 acre) exposure of channel sediment that includes a cutoff chute which suggests a buildup of alluvial sediments. **DFG Exhibit 21** is a portion of a 1993 USGS digital orthophoto of Elk Prairie showing recent North Fork Gualala conditions with riparian vegetation overgrowing the point bar, visible just right of the center of the photograph. Even with vegetation, this point bar will allow surface waters to

infiltrate whenever the river stage exceeds groundwater levels. Typically, point bars will be flooded at least partially each year. Well logs for monitoring well MW-5 indicate that the sands and gravels of the subterranean channel are encountered at a depth of approximately 7 feet below the Elk Prairie floodplain (**DFG Exhibit 22**). This elevation is approximately the same height as the active channel cut bank, visible just off the stream in the upper portion of the top photograph of the North Fork Gualala in **DFG Exhibit 23**. When combined with the depth of the meander pool (several feet is a typical measurement), it appears that the coarse-grained active North Fork Gualala channel deposits are directly interconnected with at least the upper coarse-grained aquifer materials.

29. Although we do not have any data on the stage of the North Fork Gualala at this meander relative to the NGWC wells, there is some data on the elevation of the fiver and well water provided in Table 4 of **DFG Exhibit 14** that shows surface waters likely infiltrated into the groundwater for short periods. For example, on January 24, 1997, the water level measured on the river at staff gage SG-1 (34.33 ft.) was higher than groundwater levels measured in monitoring well MW-3 (33.78 ft.) and production well PW-4 (34.15 ft.). Also for six sampling periods beginning October 31, 1996, and ending November 27, 1996, water levels on the river at SG-3 were consistently higher than groundwater levels in monitoring well MW-5. In both of these instances the direction of the gradient is *out* of the active North Fork Gualala stream channel. These two examples of gradient reversal suggest that for some period of time the river was losing water to the subsurface. The October and November 1996 samples are very interesting since SG-3 is closest to the meander point bar. At the same time, surface water levels in the area of the meander point bar have to be somewhat higher than SG-3 which results in surface water losses to the groundwater aquifer.

30. In summary, I conclude that the bed and banks of the subterranean stream under Elk Prairie are relatively impermeable because 1) the sand and gravel aquifer which NGWC's production wells PW-4 and PW-5 are pumping from is bounded by the slopes of an ancient valley that was cut into fresh greywacke sandstone bedrock that has a measured specific capacity and an estimated hydraulic conductivity 2.5 to 3 times less than the sand and gravel aquifer; 2) estimates of deep recharge to the bedrock are no greater than several inches per year; 3) a mass balance of the watershed indicates that May to October baseflows are likely provided from drainage of shallow soils rather than deep bedrock; 4) a 5-acre sand and gravel point bar and channel meander that can function as a potential aquifer recharge area lies just upstream of the NGWC's wells and is likely flooded during part of the year; and 5) water level data show that at least during part of the year, surface water is being lost to the subsurface aquifer.

Q11: In your opinion, is it possible that water recharge to the subsurface channel alluvium may be occurring through flow from the bedrock base surrounding the channel?

31. No. Although the Luhdorff & Scalmanini report came to this conclusion, I disagree. Luhdorff & Scalmanini concluded as follows:

> "…[T]he results of the overall Elk Prairie ground-water investigation show a perennial gradient for ground-water flow towards, and discharge into, the North Fork Gualala River from beneath Elk Prairie. There is no channelized ground-water flow parallel to the River at Elk Prairie. These conditions and the response of the aquifer to precipitation, to pumping, and to dry season lack of rainfall recharge all show that groundwater is not recharged by influent stream seepage. Groundwater is maintained by some combination of deep percolation of precipitation and subsurface flow from the basement complex. Similarities in surface and ground-water quality are not the result of recharge from the North Fork Gualala River because groundwater discharges to the River under both static and pumping conditions regardless of the stream stage."

(**DFG Exhibit 14**, pp. 42-43) Based on the facts discussed above under Question 8, in my opinion, significant groundwater recharge to the subsurface alluvium through bedrock is unlikely because of the low permeability and low water yielding capacity of the tightly fractured sandstone greywacke bedrock. Data from the Luhdorff & Scalmanini report, as well as other information, leads me to conclude that recharge to the subterranean stream alluvium at Elk Prairie is occurring through other possible pathways. As I stated in my answer to Question 10, these pathways include subsurface flow from the subterranean channel alluvium upstream, recharge from surface water through the sand and gravel bed of the stream channel, or a combination of both.

32. To support its conclusion that recharge is occurring from seepage from the bedrock, the Luhdorff & Scalmanini report presents maps of groundwater contours for both static and pumping conditions at Elk Prairie (**DFG Exhibit 14** -- Figures 4-4, 4-5 and 5-4). However, the subsurface water level measurements for these maps are taken only in the subterranean channel alluvium; no data are presented on bedrock groundwater levels or gradients. Thus, the direction of the groundwater gradient derived from well water levels is only applicable to the relatively small area of the alluvium in the immediate vicinity of NGWC's well field. The direction of flow from the bedrock, if it exists, is unknown.

Q12: In your opinion, is the course of the subsurface channel in Elk Prairie known or capable of being known by reasonable inference?

33. Yes.

Q13: Please describe how you came to this conclusion.

34. The course of the subterranean channel beneath Elk Prairie follows the general meanders of the North Fork Gualala for at least 8 miles upstream. The alluvial materials of both the surface and the subterranean channels lie within a bedrock canyon incised into the Coastal Belt Franciscan formation. Generally, the course of the subterranean channel can be determined simply by projecting the slopes of the canyon to where the sides meet beneath the alluvium. Incision into bedrock at Elk Prairie forms a canyon which slopes to at least 170 feet below

present surface elevation (**DFG Exhibit 14**, page 6). Downstream of Elk Prairie, the course of the subterranean channel likely bends to the south in alignment with the linear valley of the San Andreas Fault. Additional details of the geologic setting for the subterranean channel beneath Elk Prairie are given in my answers to Questions 2, 4 and 8, above.

Q14: In your professional opinion, does the pumping of North Gualala Water Company's Wells 4 and 5 have an impact on the North Fork Gualala River?

35. Yes. Pumped well tests conducted by Luhdorff & Scalmanini on production well PW-4 demonstrated a hydraulic response in the stream at staff gage SG-1 during the aquifer tests and a rebound at the cessation of pumping (**DFG Exhibit 14,** Figures 4-7, 4-8, and Table 4-3). In addition, water levels of the groundwater were lowered during pumping. For example, the 30 foot contour around SG-1 on October 7, 1997 (**DFG Exhibit 14,** Figure 4-5) shifted northward towards production well PW-4 -- as seen in **DFG Exhibit 14**, Figure 5-4. By my calculations, the groundwater level at the apex of the 30 foot contour around SG-1 dropped approximately 0.7 feet (8 inches) during the pumping test. This response demonstrates that the stream and the subterranean channel are hydraulically connected and that pumping of the NGWC wells causes a measurable drop in water table at the surface stream. Although Luhdorff & Scalmanini's report finds that the rapid response of the water table rise in river stage rather was the result of deep groundwater percolation into bedrock, in my opinion, the subterranean channel's direct hydraulic connection with the active stream is a more likely explanation. At the end of summer, when this response was measured, the shallow soils would have been deficient in moisture and early rainfall would likely be absorbed rather than percolate deep into the bedrock.

Q15: In your opinion, are there any areas of North Gualala Water Company's Elk Prairie property which do not have the same geologic and hydrologic characteristics you have described in your testimony above?

36. No. The entire Elk Prairie property overlays the same subterranean channel that I described above. I have no reason to believe and no data illustrating that subsurface geologic and hydrologic conditions have created a distinct and separate alluvial aquifer.

I, Kit H. Custis, declare under penalty of perjury under the laws of the State of California that I have read the foregoing "Testimony of Kit H. Custis" and know its contents. The matters stated in it are true of my own knowledge except as to those matters which are stated based on information and belief, and as to those matters as I believe them to be true.

Executed on May 3, 2002 at Sacramento, California.

By: KIT H. CUSTIS
Certified Engineering Geologist

DFG EXHIBIT 2

Kit H. Custis

Professional Experience

1999- present, Senior Engineering Geologist, DOC-Div. Mines & Geology
1998-1999, Associate Engineering Geologist, Central Valley Regional WQCB
1989-1998, Associate Engineering Geologist, Calif. Department of Conservation
1988-1989, Engineering Geologist, Luhdorff and Scalmanini, Woodland, CA
1988, Hydrogeologist, Herzog Associates, Sacramento, CA
1984-1988, Sr. Engineering Geologist (Supervisory), California State WRCB, Sacramento, CA
1981-1983, Consulting Geologist, Los Angeles, CA
1980-1981, Engineering Geologist, Ertec Western, Inc., Long Beach, CA
1977-1979, Engineering Geologist, Foundation Engineering Co., Tarzana, CA

Education

B.S., Geology, 1977, California State University, Northridge, California
M.S., Geology, 1984, California State University, Northridge, California
Ph.D. program in Hydrologic Sciences, 1990-1997, University of California, Davis

Professional Experience

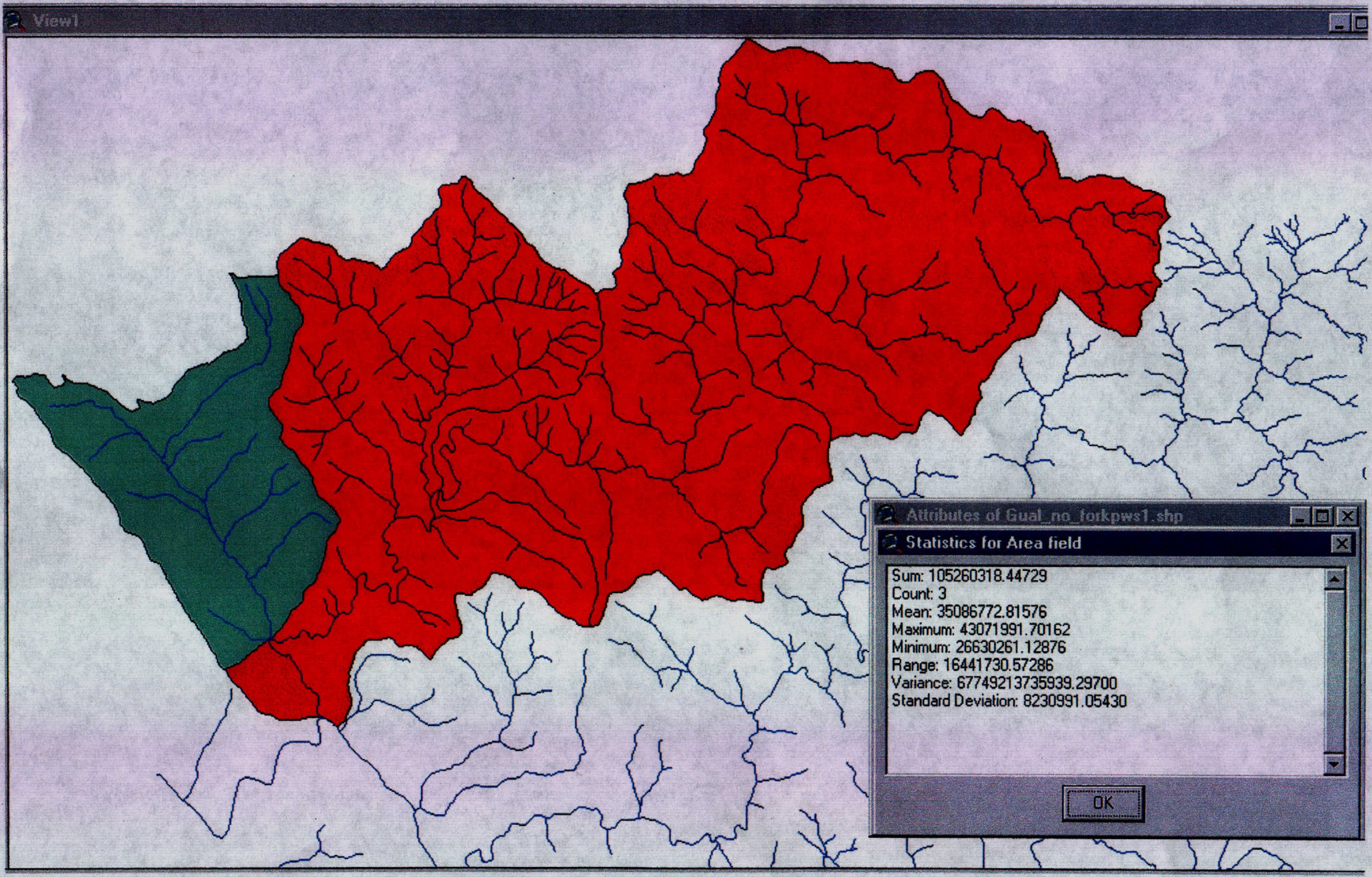
Twenty -three years experience in engineering geology and hydrology, including evaluation of ground water and surface water resource and contaminant problems, geophysical surveys, program management, geologic mapping and sampling, CEQA evaluations, computer application in data management, remote sensing and geologic mapping, regulatory oversight of state hazardous waste programs, investigation of geologic and seismic hazards, and landslide and slope stability analysis, fluvial geomorphic analysis and channel restoration design.

Duties at Foundation Engineering included field mapping and site investigations for geologic and soils engineering studies in Los Angeles Basin. Responsibilities at Ertec Western included field mapping, geomorphic analysis, landslide investigations and report preparation on geologic and seismic hazards for commercial and governmental projects. Served as Senior Engineering Geologist (Supervisory) for California State Water Resources Control Board. Duties included statewide management of AB1803 Follow-Up Program which conducted investigations to find sources of known pollution of public drinking-water wells. Responsibilities included designing and implementing programmatic and technical guidance for over fifty professional staff located throughout the state. Duties at Herzog Associates included conducting hazardous waste site assessments, ground water resource assessments, geotechnical and landslide investigations. Duties at Luhdorff and Scalmanini included hydrogeologic evaluation of ground water resources and potential for ground water contamination, water well design, oversight of Sacramento Area Water Works Association groundwater monitoring program, and development and design of data base and computer mapping applications. Duties at the California Central Valley Regional Water Quality Control Board included overseeing 30 cleanups of contaminated soil and groundwater, preparing and overseeing WDRs and NPDES permits, Monitoring and Reporting Programs and Cleanup and Abatement Orders. Duties with the California Department of Conservation included evaluating geologic hazards for hospitals and schools in compliance with Title 24 regulations, evaluating mined land reclamation plans submitted in compliance with SMARA, evaluating stability of slope and erosion controls on mined lands, researching for the U.S. Environmental Protection Agency the application of geophysical methods to acid mine drainage investigations, preparing a clean-up plan to abate acid mine drainage from the abandoned Spenceville copper mine for the California Department of Fish and Game, preparing a reclamation plan for the abandoned Gambonini mercury mine for San Francisco Bay Regional Water Quality Control Board, researching the application of hydrologic and hydrochemical modeling to identify and assess the risks of mined lands to watersheds using radar and remote sensing imagery. Presently serving as a Senior Engineering Geologist with the Division of Mines and Geology to provide to the Department of Fish and Game (DFG) fluvial geomorphic and channel restoration design review of project submitted for SB 271 grant funds, provide technical oversight for cleanup of Spencville mine, and technical analysis for complaints filed by DFG staff on depletion of stream flows by pumping wells.

Professional Registration

Registered Geologist: California #3942
Certified Engineering Geologist: California #EG1219
Certified Hydrogeologist: California #HG254

DFG EXHIBIT 3



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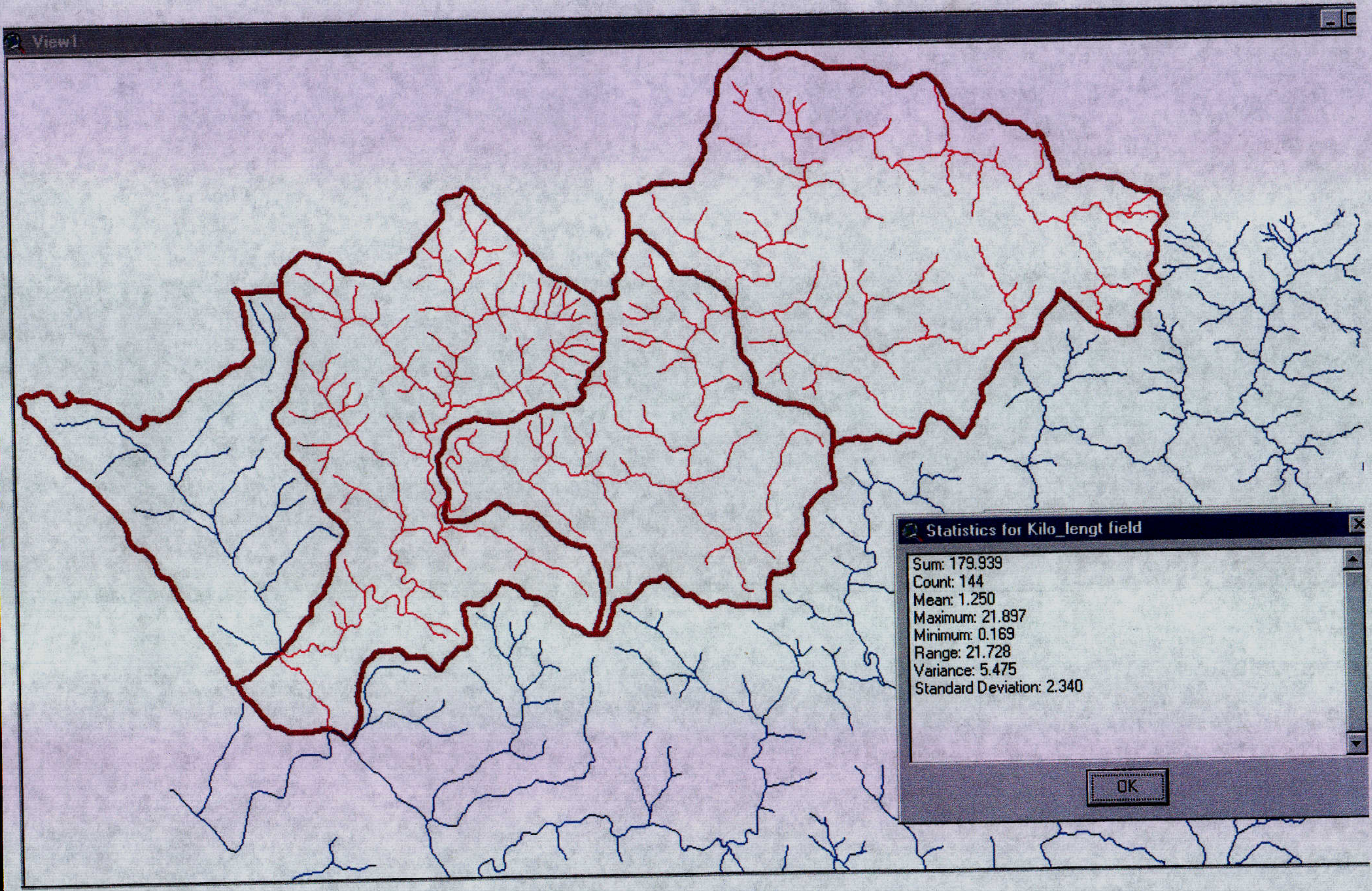
Sum: 105260318.44729
Count: 3
Mean: 35086772.81576
Maximum: 43071991.70162
Minimum: 26630261.12876
Range: 16441730.57286
Variance: 67749213735939.29700
Standard Deviation: 8230991.05430
```

DFG EXHIBIT 4



Statistics for Kilo_lengt field

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Sum: 179.939
Count: 144
Mean: 1.250
Maximum: 21.897
Minimum: 0.169
Range: 21.728
Variance: 5.475
Standard Deviation: 2.340
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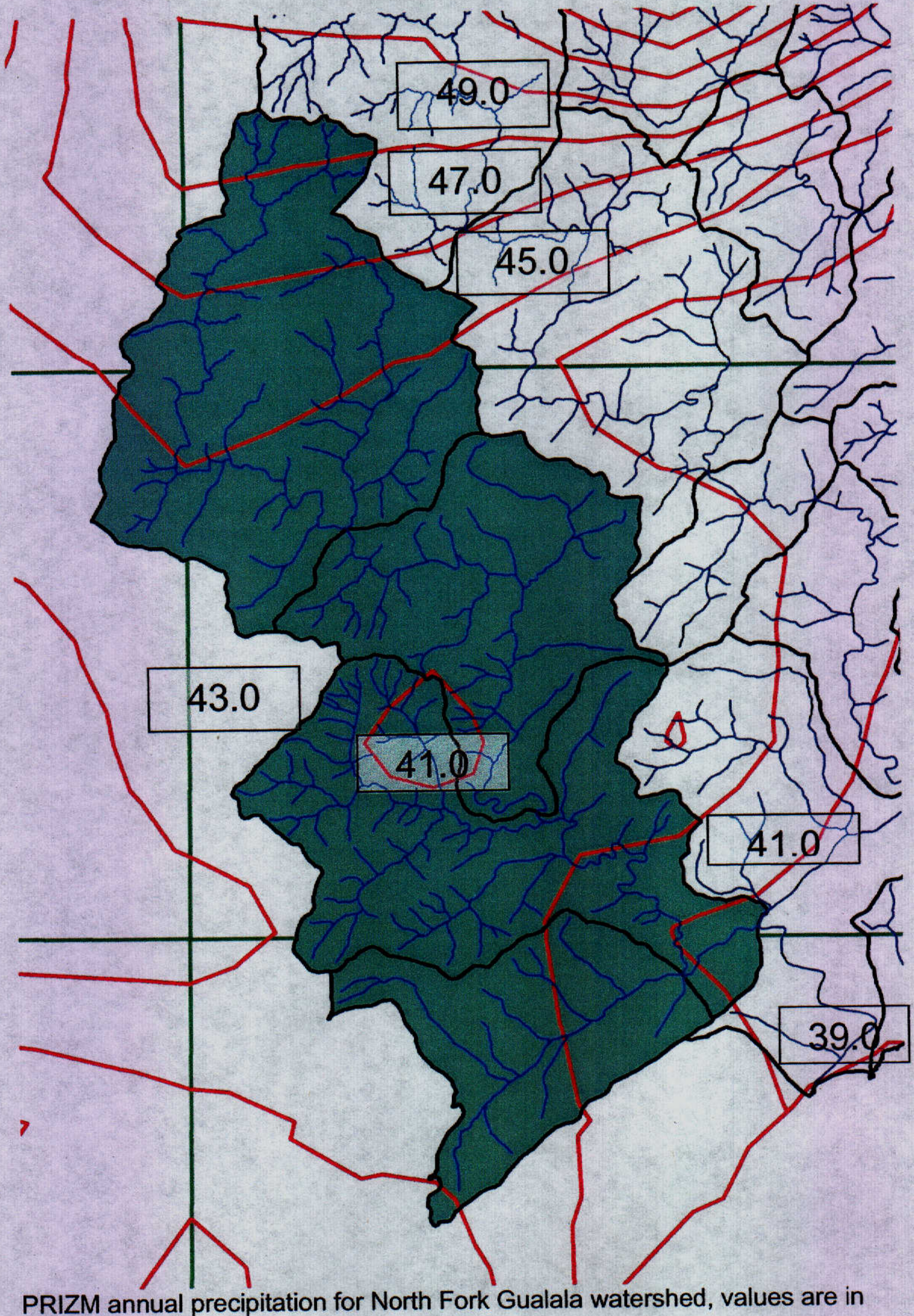
DFG EXHIBIT 5



PRIZM annual precipitation for North Fork Gualala watershed, values are in inches.

DFG EXHIBIT 6

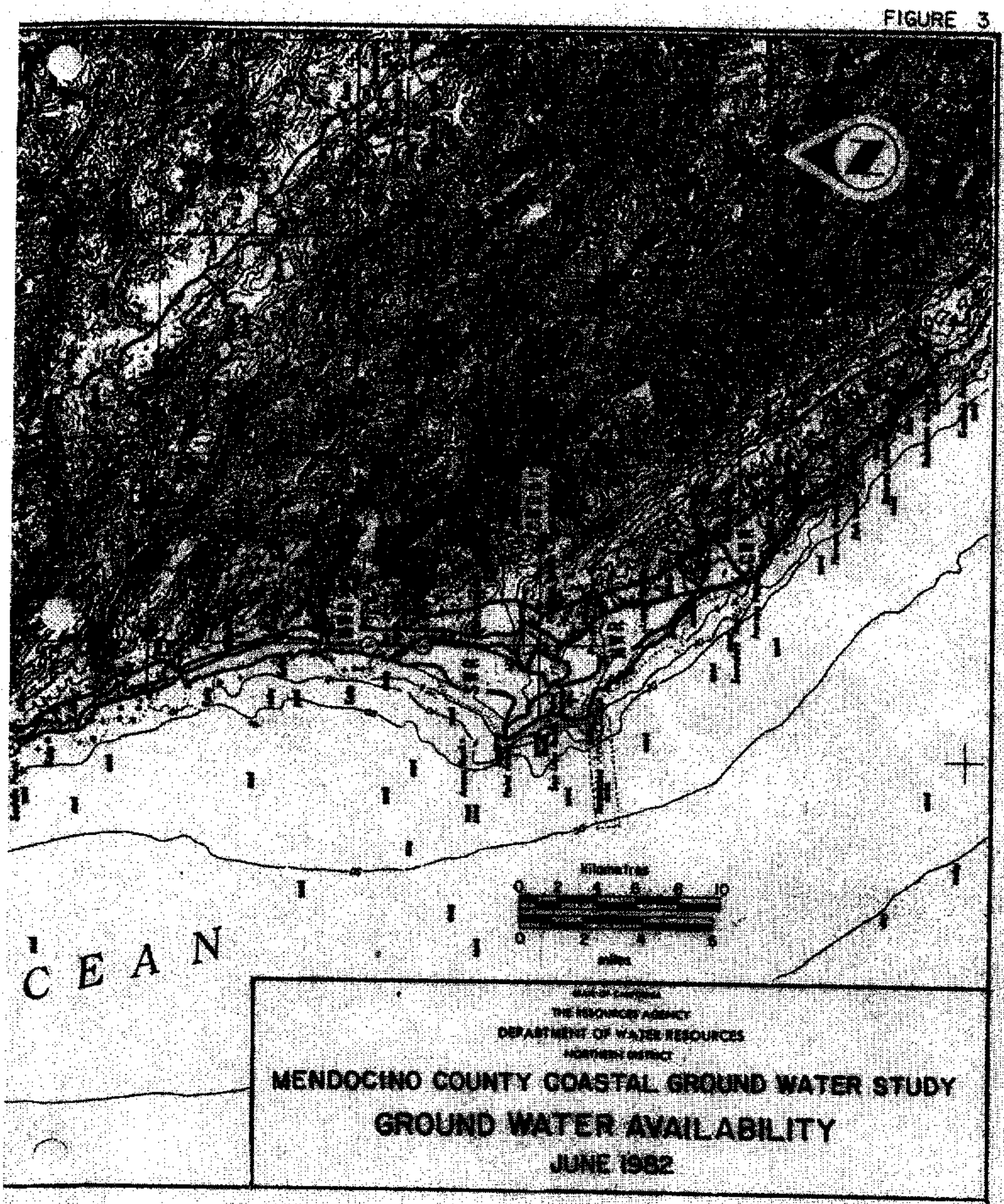
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

MENDOCINO COUNTY COASTAL GROUND WATER STUDY

JUNE 1982

Excerpts from Parfitt, D.G., and Germain, L.F., 1982, Mendocino County Coastal Ground Water Study, DWR, Northern District report, 86 pp. and appendices.

FIGURE 3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Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT
MENDOCINO COUNTY COASTAL GROUND WATER STUDY
GROUND WATER AVAILABILITY
JUNE 1982

RECOMMENDATIONS

It is widely accepted that ground water along the Mendocino County coast is a limited resource that requires conservation and planned development. The following recommendations concern the management of this resource.

Conservation Measures

It is estimated from water-use data for the Fort Bragg and Eureka areas that the average annual per capita water consumption for the Northern California coastal area is 0.25 dam^3/yr (0.2 ac-ft/yr), or 680 L/day (180 gal/day). It is conceivable that implementation of the recommendations in 1 and 2 below could reduce per capita water use by up to 50 percent. Recommendations 3 to 6 are designed to maximize ground water recharge while minimizing runoff.

1. All new development (single family, condominiums, subdivisions, etc.) shall be required to incorporate proven water conservation technology in the planning and construction of the project. These shall include, but not be limited to, low-flush toilets, flow-control inserts on showers, single-control faucets, water-efficient dishwashers and clothes washers, grey-water recycling, and hot-water pipe insulation.
2. Installation of efficient irrigation systems which minimize runoff and evaporation and maximize the water which will reach the plant roots. Drip irrigation, soil moisture sensors and automatic irrigation systems are a few methods of increasing irrigation efficiency.
3. Wherever possible, all new development shall keep rainwater on site in a retention basin to aid in ground water recharge. Where this is not feasible, the development shall be designed to reduce, retard, and disperse runoff. This may be accomplished by mulched and/or terraced slopes to reduce erosion and retain rainfall, porous drain swales and paving materials for infiltration, out-sloped roads to spread runoff evenly down slope, and landscaping

with suitable water-conserving erosion control plants that will protect the soil, facilitate infiltration of rainwater, and reduce runoff.

4. Encouragement of cluster development which can reduce the amount of land being converted to urban use. This will reduce the amount of impervious paving created and thereby aid in ground water recharge.

5. Preserve existing natural drainage areas and encourage the incorporation of natural drainage systems in new developments. This would aid in ground water recharge.

6. Flood plains and aquifer recharge areas which are the best sites for ground water recharge should be preserved as open space.

Development of Water Supplies

1. The "Instructions for Conducting Quantity Testing of Water Wells and Springs for 'Proof of Water'", as presented in "Land Division Requirements", County of Mendocino, Division of Environmental Health, revised January 1, 1982 (Appendix B), shall be amended to reflect the coastal hydrogeology.

   a. The definitions of wells shall be as follows:

      - Shallow wells of the coastal area - wells less than 40 feet deep which obtain their water predominantly from alluvium or terrace deposits, or wells less than 60 feet which obtain their water predominantly from cracks and fissures in bedrock.

      - Deep wells of the coastal area - wells greater than 40 feet deep in alluvium or terrace deposits, or bedrock wells deeper than 60 feet.

   b. The timing of well tests for "proof of water" shall be as follows: For the coastal area, deep wells may be tested any time; shallow well and spring tests shall be conducted during the period of August 20 to November 1.

Land-Use Density

The determination of availability of ground water for a specific development requires professional judgment and interpretation of all available data. This study, though not site specific, has identified coastal areas of differing ground water availability (see Figure 3). From this information, general guidelines can be drawn to aid the planner in reviewing proposed developments.

It is recommended that:

1. Areas designated SWR (Sufficient Water Resources) shall have a minimum lot size of 2 acres (ac); "proof of water" not required. All lots less than 2 ac shall be required to demonstrate "proof of water" (as outlined in Appendix B).
2. Areas designated MWR (Marginal Water Resources) shall have a minimum lot size of 5 ac; "proof of water" not required. All lots less than 5 ac shall be required to demonstrate "proof of water".
3. Areas designated CWR (Critical Water Resources) shall have a minimum lot size of 5 ac and demonstration of "proof of water". All lots less than 5 ac shall demonstrate "proof of water" and may require an environmental impact statement.
4. Areas designated CWRbr (Critical Water Resources, bedrock) should have a minimum lot size of 20 ac. Smaller lots, to a minimum size of 2 ac may be developed with "proof of water" on each lot created.

REGIONAL GEOLOGY

The study area lies within the northern Coast Range geomorphic province. The topography is dominated by high ridges and narrow valleys which trend northwest, paralleling the regional geologic structure. The San Andreas fault, one of the major structural features of California, crosses the southern boundary of the county about 3 km (2 mi) east of Gualala and intersects the coast 3.5 km (2.2 mi) north of Manchester. This northwest-trending fault has strong topographic expression and controls the lower courses of Alder and Brush Creeks and the Garcia and North Fork Gualala Rivers. The fault separates the Jurassic-to-Cretaceous, Franciscan rocks on the east from the Cretaceous and Tertiary, Gualala Block rocks on the west. Superimposed on these older rock units is a series of discontinuous Quaternary marine terrace deposits, alluvial material in the larger stream valleys, and beach and dune deposits along the coast.

Bedrock Geology

Franciscan Complex

Most of the Coast Range of California is underlain by the Franciscan Complex, which is divided into the melange rocks and the Coastal Belt rocks. It has been suggested that the older melange unit was emplaced by thrust faulting on top of, or sliding by gravity onto, the Coastal Belt rocks before uplift of the whole sequence. The emergency from the sea occurred by the Oligocene, 38 million years before the present (mybp). Throughout the Tertiary (3 to 38 mybp) weak to intensive compressive deformation occurred. This included folding, uplifting, tilting and overturning of the Coastal Belt. Numerous faults resulted, trending primarily in a northwest-to-southeast direction. The San Andreas and other high angle faults have existed for at least 25 million years (DPR, 1977).

The Coastal Belt is the youngest part of the Franciscan Complex and is dated from late Cretaceous (70 mybp) to late Eocene (40 mybp). This thick, 10 000-m (32,800-ft) sequence of graywacke sandstone and shale (Kleist, 1974) forms the bedrock base of the coastal zone east of the San Andreas fault.

Compared to the Franciscan melange, the Coastal Belt rocks are relatively undeformed. The beds have a predominantly northwestern strike and homoclinal northeastern dip (Kleist, 1974). Topography of the basement rocks ranges from mountainous terrain to a series of prominent wave-cut benches. Exposures are largely limited to road cuts, ocean cliffs, and stream channels. Surficially, the rock is deeply weathered (exposures and well logs show this) and covered by marine terrace deposits or soil and vegetation (grass, dense brush, and trees).

The sandstone is poorly sorted, with medium-grained, angular fragments of quartz, feldspar, and mafic minerals. It has an overall blue color, imparted during slight metamorphism, but it weathers to brown. Fresh rocks are well indurated and have a variable fracture pattern. They are considered to be non-water bearing, although minor quantities of water occur where deep weathering, shearing, fracturing, and/or jointing have created secondary permeability and porosity.

Gualala Block

The Gualala Block consists of at least 6 100 m (20,000 ft) of marine sediments deposited in quiet water by turbidity currents and biotic activity and appears to have been deformed twice--in response to shear along the San Andreas fault, and in response to northeast-southwest compressive forces (Boyle, 1967). These rocks consist of intensely folded and faulted shale, sandstone, conglomerate, and basalt. They range in age from upper Cretaceous (70 mybp) to Miocene (26 to 7 mybp) (Williams and Bedrossian, 1977) and have been juxtaposed against the Coastal Belt Franciscan rocks as the result of an estimated 240 km (150 mi) of right lateral movement along the San Andreas fault over the past 25 million years (Boyle, 1967).

Charles Weaver (1943) divided the rocks of the Gualala Block into four units, and for simplicity, his schema will be used here. For a more detailed explanation of the Gualala Block geology, the reader is referred to Boyle (1967) and Wentworth (1967, 1968, 1972).

The formations of the Gualala Block include the Gualala series (upper Cretaceous through Eocene age), the Galloway and Schooner Gulch Formations (Miocene age), the Monterey Formation (Miocene age), and Iverson Basalt (Miocene age).

TABLE 6

SUMMARY OF WELL DATA [1]

Formation	Yield		Drawdown		Mean Specific Capacity L/min/m (gpm/ft)	Percent of Wells Yielding 38 L/min (10 gpm) or More
	Average	Range	Average	Range		
Gualala	49 L/min (13 gpm)	1.3 to 190 L/min (0.33 to 50 gpm)	17.4 m (57.2 ft)	0.3 to 46 m (1 to 150 ft)	2.8 (0.23)	34
German Rancho	16 L/min (4.2 gpm)	0.4 to 150 L/min (0.1 to 40 gpm)	23.4 m (77 ft)	1.5 to 52 m (5 to 170 ft)	0.7 (0.06)	6
Schooner Gulch and Galloway	36 L/min (9.5 gpm)	5.7 to 95 L/min (1.5 to 25 gpm)	17.4 m (57 ft)	1.5 to 33 m (5 to 108 ft)	2.1 (0.17)	33
Monterey [2]	63 L/min (16.6 gpm)	2.5 to 114 L/min (0.66 to 30 gpm)	11.7 m (38.5 ft)	6 to 26 m (20 to 85 ft)	4.2 (0.34)	75
Coastal Belt Franciscan	68 L/min (18 gpm)	11 to 136 L/min (3 to 36 gpm)	21 m (68.3 ft)	12 to 27 m (40 go 90 ft)	3.3 (0.265)	50 [3]
Iversen Basalt			NO DATA			
Marine Terrace	100 L/min (26.5 gpm)	7.6 to 284 L/min (2 to 75 gpm)	5.8 m (19 ft)	0.3 to 10.7 m (1 to 35 ft)	18.1 (1.46)	61

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[1] From information in "Water Well Drillers' Reports"

[2] Based on data from 2 bedrock wells and 7 composite wells

[3] Based on limited data from 4 wells

DFG EXHIBIT 7

Summary of monthly precipitation record for Fort Ross 1971 to 2000, from WRCC, 2002.

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FORT ROSS, CALIFORNIA (043191)
Period of Record Monthly Climate Summary
Period of Record : 7/ 1/1948 to 12/31/2000
                                    Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec   Annual
Average Max. Temperature (F)              56.9  58.6  59.3  61.1  62.9  65.7  66.3  67.1  68.3  66.1  61.6  57.5
62.6
Average Min. Temperature (F)              41.4  42.4  42.1  42.4  44.2  46.8  47.8  48.7  48.7  46.9  44.2  41.4
44.7
Average Total Precipitation (in.)          8.26  6.11  5.35  2.64  0.96  0.40  0.10  0.28  0.61  2.47  5.16  6.16
38.52
Average Total SnowFall (in.)               0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0
Average Snow Depth (in.)                     0     0     0     0     0     0     0     0     0     0     0     0
0
Percent of possible observations for period of record.
Max. Temp.: 91.9% Min. Temp.: 91.7% Precipitation: 95.7% Snowfall: 96.4% Snow Depth: 96.3%
Check Station Metadata or Metadata graphics for more detail about data completeness.
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Western Regional Climate Center, wrcc@dri.edu
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DFG EXHIBIT 8

Summary of monthly mean discharge for the period of record for "South Fork Gualala River near Annapolis", USGS station #11467500, from DWR, 2002.

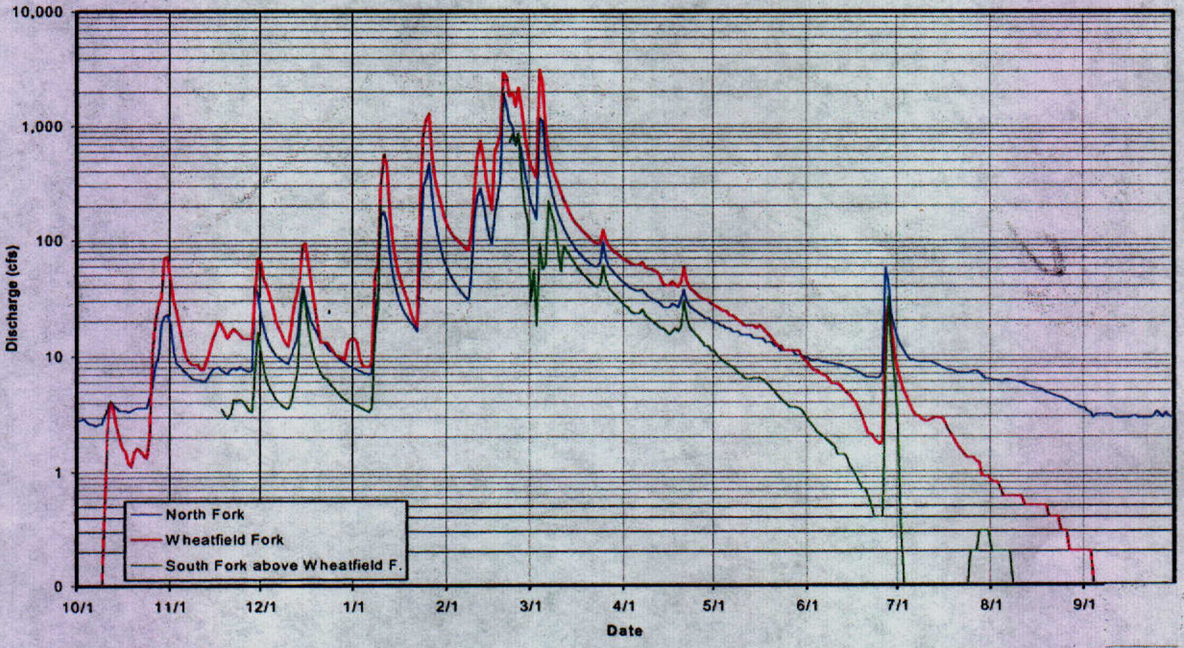
SOUTH FORK GUALALA RIVER NEAR ANNAPOLIS
USGS GAUGE #11467500
MEAN MONTHLY DISCHARGE AND ANNUAL YIELD
WATER YEARS 1951-1971 and 1991-1994

(units in cfs, NR = no record)

Water	Month															WR	Yield
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Min	Max	Avg	Mean	(ac-ft)
1951	NR	NR	1,343	1,420	1,280	747	98	159	28	12	4	2	NR	NR	NR	NR	NR
1952	21	312	2,343	2,111	1,140	905	167	89	34	17	7	4	4	2,343	596	7,150	434,118
1953	4	18	1,847	2,501	135	481	362	163	53	19	9	7	4	2,501	466	5,597	342,446
1954	14	343	270	2,165	863	843	983	109	40	14	25	11	11	2,165	473	5,680	341,394
1955	15	375	782	588	147	83	658	135	33	13	5	4	4	782	237	2,839	171,556
1956	6	88	3,060	2,367	1,650	273	102	78	27	11	5	5	5	3,060	639	7,671	464,709
1957	38	24	15	482	1,039	943	309	660	103	24	9	90	9	1,039	311	3,735	222,413
1958	736	225	577	1,322	4,407	870	1,256	98	61	20	9	6	6	4,407	799	9,587	560,214
1959	7	20	22	1,134	1,533	164	88	33	14	4	3	36	3	1,533	255	3,057	178,536
1960	11	8	13	510	1,713	1,188	188	78	31	13	6	5	5	1,713	314	3,765	224,221
1961	8	87	979	586	1,586	1,034	172	68	30	9	5	4	4	1,586	381	4,569	270,907
1962	6	266	417	260	2,385	1,023	119	52	21	11	5	6	5	2,385	381	4,572	266,079
1963	434	71	560	663	1,144	643	1,401	152	47	21	11	7	7	1,401	430	5,154	307,082
1964	37	879	146	820	150	135	56	32	18	8	4	3	3	879	190	2,285	138,031
1965	22	481	2,276	1,589	273	162	955	118	44	18	10	6	6	2,276	496	5,954	361,541
1966	7	461	544	1,312	906	448	151	51	22	12	6	2	2	1,312	327	3,922	234,512
1967	1	556	1,028	1,909	390	905	866	159	77	21	8	5	1	1,909	494	5,925	359,023
1968	13	36	338	972	1,043	632	124	52	21	9	9	7	7	1,043	271	3,256	195,696
1969	24	61	1,284	2,677	1,798	488	240	66	31	12	5	4	4	2,677	558	6,690	400,006
1970	15	25	1,445	4,152	613	314	73	33	14	3	2	2	2	4,152	558	6,691	407,564
1971	8	395	2,259	1,357	132	858	244	72	29	11	5	4	4	2,259	448	5,375	328,354
1991	NR	NR	NR	NR	NR	NR	NR	NR	12	5	2	1	NR	NR	NR	NR	NR
1992	13	22	NR	183	NR	NR	182	45	20	11	3	2	NR	NR	NR	NR	NR
1993	12	16	NR	NR	NR	NR	337	196	197	42	14	6	NR	NR	NR	NR	NR
1994	5	21	NR	NR	NR	117	61	35	12	NR	NR	NR	NR	NR	NR	NR	NR
Min	1	8	13	183	132	83	56	32	12	3	2	1					
Max	736	879	3,060	4,152	4,407	1,188	1,401	660	197	42	25	90					
Avg	63	208	1,026	1,413	1,159	603	383	114	41	14	7	9					

Daily discharge for the three new stream gauges within the Gualala watershed. Log scale was used to magnify the low flow data, from DWR, 2002..

Gualala River
Daily Discharge, Water Year 2001
(preliminary data)

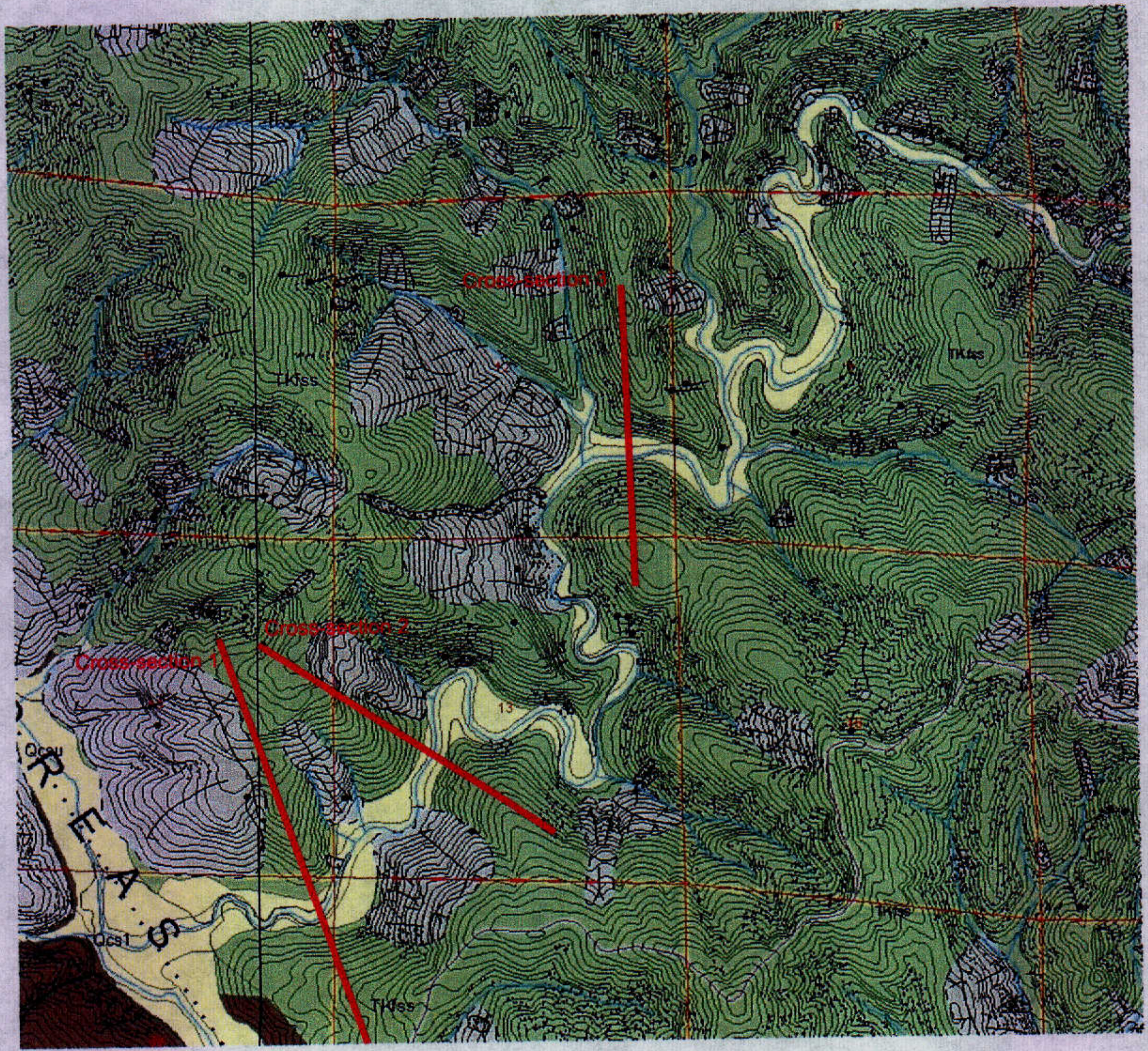


DFG EXHIBIT
9

OVERSIZED
MAPS

DFG EXHIBIT 9a

Excerpt from Geology and landslide map of lower North Fork Gualala river, yellow unit is Quaternary alluvium, section taken from full exhibit map by Fuller, M.S., Haydon, W.D., Purcell,. M.G., and Custis, K., 2002, Draft Geology and Geomorphic Features Related to Landsliding, Gualala River Watershed, Sonoma and Mendocino Counties, California, Sheet 1, Northern Section, scale 1:24,000.



DFG EXHIBIT 10

FRANCISCAN AND RELATED ROCKS, AND THEIR SIGNIFICANCE IN THE GEOLOGY OF WESTERN CALIFORNIA

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1964

BULLETIN 183
CALIFORNIA DIVISION OF MINES AND GEOLOGY
1416 Ninth Street, Sacramento 95814

Abstract

A heterogeneous assemblage of eugeosynclinal rocks found on the San Francisco peninsula has long been variously referred to as the Franciscan Series, Franciscan Group, or Franciscan Formation, and other rocks throughout the Coast Ranges have been correlated with these on the basis of lithologic similarity. The predominant rock is graywacke, but shale, altered mafic volcanic rock (greenstone), chert, and minor limestone are a part of the assemblage. Also included are metamorphic rocks of the zeolite, blueschist (glaucophane schist), and eclogite facies. Ultramafic rocks, largely serpentinites, are an integral part of this eugeosynclinal assemblage, but they are excluded from the Franciscan Formation as they intrude most of the other rocks in it. This assemblage of rocks was deposited in one or more deep marine troughs, probably on a basaltic substratum or peridotite.

This eugeosynclinal assemblage underlies a major part of western California and is prominently exposed in the Coast Ranges. Its known area of outcrop is 15,000 square miles, and its total terrestrial and offshore extent may be 75,000 square miles. Its total thickness cannot be determined by normal stratigraphic methods, but is probably more than 50,000 feet.

The assemblage of rocks grouped together as the Franciscan ranges in age from at least Late Jurassic to Late Cretaceous, but rocks deposited during the entire age span generally are not present in any one area. Although some discrete areas of older or younger Franciscan rocks are recognized, the data available now allow us to describe the characteristics of each prominent kind of rock only in general terms applicable to the entire assemblage. Thus, although some rocks, for example the greenstones, may be consistently different in the older and younger parts of the Franciscan, we are not yet able to discern this, and we must, therefore, describe the variations without attaching age significance to them.

The graywacke is dominantly medium grained and typically is interbedded with minor shale and rarer conglomerate. Bedding is irregular, and the thickness of individual beds ranges from less than an inch to many tens of feet. Current features and graded beds are rare. Most of these sedimentary rocks have more than 10 percent matrix, consisting of chlorite and mica, and varieties classed as arkosic, feldspathic, and lithic graywacke are all widespread. Angular monomineralic grains are predominantly feldspar and quartz; the quartz/feldspar ratio, although widely variable, averages slightly less than 1/1. Sodic plagioclase is the dominant feldspar, and over extensive areas plagioclase is the only feldspar present. In some areas, however, K-feldspar is common and may exceed 15 percent locally. Lithic fragments may comprise over half the rock; generally they are greenstone and chert, but may be shale or schist. Cement is normally a fine-grained paste of micaceous minerals and rock flour, but uncommonly is calcite or silica. The predominant chemical characteristics of the graywacke are: $K_2O/Na_2O < 1$, $Fe_2O_3/FeO < 1$, and combined water (H_2O+)$>$ 2 percent. The physical features indicate rapid deposition of unsorted material, presumably by turbidity or fluxoturbidity currents. The mineralogic and chemical features indicate derivation of the non-K-feldspar-bearing portion from a metamorphic terrane, and the K-feldspar-bearing portion from a granitic and metamorphic terrane, with minimal chemical weathering.

The shale and siltstone accompanying graywacke are dark gray to black in color, and are essentially micrograywacke with only a small amount of clay minerals. Like the graywacke, they have a K_2O/Na_2O ratio close to 1 and a Fe_2O_3/FeO ratio appreciably less than 1.

Conglomerate, although minor, is widespread as small lenses. Nearly all varieties include pebbles and cobbles of extraformational origin, but south of Sebastopol most conglomerates contain abundant pebbles of possible intraformational origin, as well as occasional pebbles of granite. Glaucophane schist pebbles are rare and are regarded as evidence of intraformational origin.

Limestone, largely of chemical origin, occurs sporadically along a narrow belt extending from near Gilroy to Garberville. It is economically important as a source rock for cement and geologically important as the source of diagnostic fossils. A variety colored red by goethite is associated with volcanic rocks and was precipitated in deep water through heating and agitation by submarine eruptions. A thicker white variety is also associated with volcanic rocks, and locally contains abundant pellets, oöliths, and fossil detritus that suggest a shallower environment.

Altered mafic volcanic rocks, termed greenstones, comprise about a tenth of the assemblage and are widespread. Most consist of pillows, tuffs, or breccias resulting from submarine eruptions, but some massive units may be intrusive. The volcanic accumulations range in size from a few feet to many thousands of feet in thickness and 20 miles in extent. Plagioclase and augite are the chief minerals, and olivine is rare. Altered mafic glass is a nearly ubiquitous component. Plagioclase ranges from bytownite or labradorite to albite; pyroxenes are augite, subcalcic augite, pigeonite, or titanaugite. Some pillow lavas contain pumpellyite. The least hydrous massive varieties, which are the least altered, are chemically similar to tholeiitic basalt, but with soda intermediate between spilite and tholeiite. However, most greenstones are abnormally hydrous, and their composition has been altered through reaction with sea water. As pillows and matrices provide samples of a single magma that have had different opportunities for sea water reaction, analyses of the core, rim, and matrix for two pillows were obtained. If magnesia is regarded as a constant, these analyses show from the center outward large losses in silica, alumina, lime, and soda, and smaller losses of iron; only potash was enriched in the shell or matrix. Pillow structure probably results from jet eruptions beneath the ocean, with the pillows forming by solidification of a shell around large drops of magma that result from the breaking up of the jet of magma. The concentration of soda in the core and potash in the rim may be due to reciprocal alkali transfer resulting from unusually steep thermal gradients caused by marginal cooling. After accumulation on the sea floor, reheating of the chilled borders of the pillows, due to equalization of heat in the pile of pillows, gives rise to characteristic plumose and variolitic textures by promoting crystallization in the glass.

Keratophyre, or quartz-keratophyre, occurs in several areas mapped as Franciscan. However, because they everywhere occur either as intrusions into Franciscan rocks or along tectonic zones between Franciscan and younger rocks, their inclusion as a part of the Franciscan may not be warranted.

Chert and a distinctive shale occurring with it are quantitatively minor; however, as they are believed to be chemical precipitates formed by the reaction of magma and sea water under considerable hydrostatic pressure, they are important as indicators of the oceanic depth in which part of the Franciscan was deposited. Rhythmically interlayered red or green chert and shale form lenses less than 50 feet thick and less than a mile in extent, generally with and above greenstones. The thin beds of chert within each chert-shale lens are discontinuous and terminate abruptly; they have a fairly constant thickness of an inch or two regardless of their position in the lenses. Individual beds of chert or colored shale are not interdigitated with Franciscan graywacke or the black shale that accompanies it. The chert consists of quartz or chalcedonic quartz colored by goethite or hematite and contains no clastic grains of quartz or feldspar. Radiolaria may be abundant or virtually absent. The silica content ranges from 93 to 97 percent, and the impurities are alumina or ferric iron, representing an admixture of the material of the shale parting layers. These layers consist of goethite, or locally hematite, mica, and quartz, but shreds of volcanic glass may also be present. The shale accompanying chert differs from the normal Franciscan black shale in having a K_2O/Na_2O ratio of about 10 instead of 1, and both more iron and a larger Fe_2O_3/FeO ratio. It differs from deep sea "red clay" in that the K_2O/Na_2O ratio is much larger.

The association of chert-shale lenses with greenstone suggests a genetic relation. The lenses may represent silica, alumina, and iron released by submarine volcanic rocks at the time of volcanic eruption, the eruption occurring at a depth great enough for sea water at the reactive interface to be heated to a temperature of about 350°C without boiling. At this temperature and at a pressure equal to that of oceanic depths of 13,000 feet, water can dissolve over 1,000 ppm of silica. Such heated, silica-enriched water would rise, be cooled, and quickly become oversaturated with respect to silica. Silica would then be polymerized and precipitated as a gel, apparently along with aluminum and ferrous hydroxide, and it would rain down onto the sea floor forming a mass of impure silica gel. Subsequently, by a process of diffusion and crystallization, layers that superficially resemble normal sedimentary beds would form. Similar though smaller layers were formed experimentally by Davis using sodium silicate and powdered Franciscan shale. This postulated origin for the chert-shale lenses seems to be the only one compatible with all their unusual structural and chemical features, and it implies that deposition of some Franciscan rocks must have been at a depth nearly equivalent to or greater than the average of the Pacific Ocean.

Ultramafic rock, chiefly serpentinite, constitutes a widespread part of the eugeosynclinal assemblage, and it is of economic importance as the host rock for deposits of chromite, magnesite, and asbestos, and for many mercury deposits; but this rock also causes serious engineering problems because some kinds of it are weak and subject to sliding. Most masses are tabular parallel to the general bedding of the rocks they intrude, though this does not imply intrusion when the beds were horizontal. The largest sill-like mass is 70 miles long and has an outcrop width of several miles; it generally separates Franciscan rocks in the northern Coast Ranges from miogeosynclinal rocks of the Great Valley. The highly sheared condition and lack of peripheral metamorphism suggests that the sills were emplaced as serpentine, rather than as ultramafic magma. Several pluglike masses also intrude the Franciscan rocks and these differ from the tabular masses in being less serpentinized and by including considerable dunite in contrast to a preponderance of peridotite in the tabular masses. Chemical analyses of fresh and serpentinized ultramafic rocks, and of chromite from them, indicate they belong to the alpine type.

The assemblage of Franciscan rocks, though dominantly unmetamorphosed, includes metamorphic rocks of the zeolite, blueschist, and eclogite facies, and rarer rocks altered by metasomatism. Laumontite is the typical new mineral in zeolite facies rocks. Glaucophane, lawsonite, jadeite, stilpnomelane, pumpellyite, aragonite, and other minerals less diagnostic of the metamorphic environment occur in the blueschists. In spite of the prevalence of Na-minerals, most blueschists are neither soda-rich nor enriched in soda. The blueschists have three principal modes of occurrence. In one mode metamorphic rocks with either glaucophane or jadeite occur in small isolated patches within, and grade into, unaltered graywacke, shale, or greenstone. Some of these metamorphosed rocks are in contact with serpentine, but many others are not. In a second mode of occurrence, clearly unrelated to serpentine, similar metamorphic rocks occupy areas that are several miles wide and tens of miles long, locally indicating a limited form of regional or load metamorphism. The third mode of occurrence, which is both the most curious and widespread, is as isolated rounded masses of schist ranging from a few feet to a few hundred feet in diameter and generally surrounded by nonmetamorphosed rock. Although all the kinds of metamorphic rocks occur as isolated masses, the most common are eclogites and glaucophane-eclogites, which are known only in this latter type of occurrence. Such blocks occur in serpentine, in shear zones, and amid unaltered Franciscan rocks; they probably are tectonic inclusions.

Considerations of the probable pressure-temperature field of formation of the blueschists indicate that pressures were abnormally high (>5Kb) relative to the temperature ($<300°$C). If the metamorphism of the broader areas is due to load, the rocks must have reached a depth of about 70,000 feet, through downwarping and accumulation, so rapidly that a normal thermal gradient was not established. In addition they must have been uplifted soon after their depression and metamorphism, so as to prohibit the establishment of a normal thermal gradient that would have raised the temperature sufficiently to convert the blueschists to greenschist or a higher grade facies.

Fossils are rare in rocks of Franciscan lithology, but at least 25 localities have yielded fossils diagnostic of age. These indicate a span in age from Late Jurassic (Tithonian) to at least Late Cretaceous (Turonian). Most of the older fossils are from rocks east of the Hayward fault, or an extension of this fault drawn from Berkeley to Eureka, and all of the Late Cretaceous fossils are from areas west of this line.

The fossil evidence indicates the Franciscan rocks are, at least in part, age equivalents of a better known miogeosynclinal assemblage which we refer to as the Great Valley sequence as it is best exposed on the west edge of the valley, although it also extends farther west into the Coast Ranges. The Great Valley sequence, which is at least 40,000 feet thick, includes units known as Knoxville (Upper Jurassic), Paskenta and Horsetown (Lower Cretaceous), and Chico (Upper Cretaceous), and many other names have been applied locally. The miogeosynclinal Great Valley sequence differs from the eugeosynclinal Franciscan by having: no greenstone or chert, except in its basal part; a higher proportion of mudstone and shale; more uniform and thinly bedded sandstone beds; a greater percentage of conglomerate; many more fossils; and much less structural deformity.

The K-feldspar content of graywacke of both the Franciscan and Great Valley assemblages was studied. The median K-feldspar content of units of the Great Valley sequence is: Upper Jurassic (Knoxville), 0.5 percent; Lower Cretaceous, 1.1 percent; and Upper Cretaceous, 13 percent. The median values for different areas of Franciscan rocks are: east of the San Andreas and Hayward (extended) faults, 0 percent; Bay area, west of the Hayward fault and north to Cazadero, 0 percent; coastal belt, west of the extended Hayward fault and north of Cazadero, 4.5 percent; and west of the Nacimiento fault, nearly 0 percent but with many more high values than for the first two areas listed.

The increase of K-feldspar with decrease in age reflects progressive unroofing of the Late Jurassic to mid-Cretaceous Klamath Mountain and Sierra Nevada batholiths in the major source area, and thus the content of K-feldspar provides an indication of approximate age. However, because of the possibility of other sources for the sediments, the absence of K-feldspar is not an infallible indication of a pre-Late Jurassic age in the Coast Range rocks.

The specific gravity of the Franciscan graywacke differs from that of the units of the Great Valley sequence. The median values for these units are: Upper Jurassic (Knoxville), 2.59; Lower Cretaceous, 2.57; and Upper Cretaceous, 2.55. The median values for different areas of Franciscan rocks are: east of the San Andreas fault and the Hayward fault (extended), 2.65; Bay area, west of the Hayward fault and north to Cazadero, 2.65; coastal belt, west of the extended Hayward fault and north of Cazadero, 2.60; and west of the Nacimiento fault, 2.62. Values greater than 2.68 were obtained only in Franciscan rocks, and values greater than 2.70 were obtained only from graywackes that were found to be metamorphosed.

The Franciscan rocks east of the San Andreas and Hayward (extended) faults are known from fossils to include rocks equivalent in age to the Knoxville Formation (Tithonian) and Lower Cretaceous strata of the Great Valley, but they also probably include pre-Knoxville rocks of post-Galice or Mariposa (Kimmeridgian) age. This is indicated by the structural position of the Franciscan beneath the Knoxville. Also the Franciscan unit is likely to represent the large amount of debris stripped from the Klamath Mountains and Sierra Nevada during the earliest part of the Nevadan orogeny. The Franciscan rocks between the San Andreas and Hayward faults in the Bay area are of Cretaceous age, and their low content of K-feldspar suggests they were derived dominantly from pre-existing Franciscan rocks.

The basement for the Franciscan is not exposed, but as the inclusions brought up in the ultramafic masses are all Franciscan rock types, the Franciscan probably was deposited directly on a basaltic crust or on peridotite. The problem of the basement of the Franciscan has not been clarified by geophysical work.

Although the Franciscan is pervasively deformed by folds and faults, the structures within it cannot generally be ascertained because of its persistent heterogeneity and lack of key beds. Most folds trend northwest, but arcuate map patterns around plunging folds are rarely obtained, probably because of widespread faulting along, and parallel to, the axial parts of the folds. The major faults, which have a similar trend, are shear zones that in places are as much as a mile wide. These contain large blocks of more resistant Franciscan rocks in a sheared matrix, and include tectonic inclusions of schist and sheared masses of serpentine. Because of their physical properties, the recognition of shear zones is of utmost importance in planning for construction projects.

The larger structural features of the Coast Ranges, which determine the distribution of the major lithic units, include other rocks in addition to the Franciscan Formation and, consequently, are better known than structures within the Franciscan. Two types of structural terranes are recognized: one has a crystalline basement like the metamorphic and plutonic rocks of the Klamath Mountains and Sierra Nevada; the other, which includes all the Franciscan rocks, rests on a basement that is unknown but that probably is basaltic substratum or peridotite. On the crystalline basement the sedimentary strata are relatively thin, broadly folded, and cut by few faults; on the other basement the sedimentary rocks are thick, more highly deformed, and more faulted. The terranes with these two different basements are, so far as known, separated by major faults.

The fault that separates the Franciscan rocks of the northern Coast Ranges from the crystalline rocks of the Klamath Mountains and Sierra Nevada extends south from the Oregon border to the northern end of the serpentine mass that lies between the Franciscan rocks and the miogeosynclinal rocks of the Great Valley. South of this point the separation between the crystalline basement and unknown basement continues, beneath the miogeosynclinal cover, along the great magnetic high that trends the length of the Great Valley.

The western limit of this area of rocks with unknown basement is the San Andreas fault, which trends northward through the Coast Ranges and joins the Mendocino Escarpment fault zone. West of the San Andreas fault zone is a crystalline block with granitic plutons and with no known sedimentary strata of Late Jurassic to Late Cretaceous (pre-Campanian) age. This block, which is only 40 miles wide but 300 miles long, is bounded on the west by the Nacimiento fault. To the west of the Nacimiento fault is another terrane of rocks with unknown basement in which the eugeosynclinal Franciscan rocks are largely covered by younger rocks or by the Pacific Ocean.

Other major structures pertinent to an understanding of the distribution of the Franciscan rocks are within the terrane lying east of the San Andreas fault. The Hayward fault, which diverges eastward from the San Andreas fault, is more important than has hitherto been recognized. In a general way, it divides the Franciscan into two parts, with the Franciscan rocks to the east being Late Jurassic to Early Cretaceous in age and those to the west being younger and including rocks that are Late Cretaceous in age. Also, it sharply separates Late Cretaceous Franciscan rocks on the west from Late Cretaceous strata of the Great Valley sequence on the east.

East of the Hayward fault the rocks appear to be broadly arched to form the Diablo antiform. In the Diablo Range the axial portion of the antiform is unmistakable, as it is the site of several piercements; north of San Francisco Bay the antiform is less well defined, and north of Clear Lake its position is uncertain.

The recognition of: (1) the post-Knoxville age for part of the Franciscan rocks, (2) the Late Cretaceous age for the granite between the San Andreas and Nacimiento faults, and (3) the significance of the K-feldspar content in the graywackes, clearly defines many problems pertaining to the distribution of the Franciscan rocks and coeval strata of the Great Valley sequence. Previous considerations of Franciscan rocks grading upward to Knoxville rocks or grading laterally into Knoxville or other strata of the Great Valley sequence must be modified, and apparently the modification must include major tectonic dislocation. Several mechanisms that might account for the major dislocations are large strike-slip movement, rifting and westward drifting of the entire Coast Ranges, and thrust faulting or gravity sliding. However, none of the mechanisms discussed will alone completely explain the data now available, although some combination of these dislocations may provide a satisfactory solution.

cept is theoretically appealing, but sufficient data were not available to demonstrate the nature of the facies transition. A further outgrowth of Irwin's reconnaissance study of the northern Coast Ranges was the recognition (Bailey and Irwin, 1959) that the K-feldspar content of much of the Franciscan of northern California differed markedly from the Late Jurassic Knoxville and the Cretaceous rocks of the Sacramento Valley sequence. The Knoxville was found to average about 0.5 percent K-feldspar, the Lower Cretaceous rocks about 2.8 percent, and the Upper Cretaceous rocks about 10.6 percent. The Franciscan rocks immediately west of the Sacramento Valley rocks in northern California, on the other hand, was found to contain generally no K-feldspar, and this striking difference between rocks of similar age seems to preclude a simple facies change. Bailey and Irwin also found that a belt of dominantly sedimentary rocks, lying west of U.S. Highway 101, had a high K-feldspar content, and they suggested excluding this belt, which they termed the "coastal belt," from the Franciscan Formation.

DISTRIBUTION OF THE FRANCISCAN

The assemblage of Franciscan rocks extends along the western margin of North America for most of the length of the State of California. By customary usage, the northern boundary of the Franciscan is the California-Oregon border, where it is exposed only in a narrow band between the Pacific Ocean and the older rocks of the Klamath Mountains province. Southward, the eastern limit is the major fault that forms the western and southern boundary of the Klamath Mountains province and extends for over 150 miles to the Great Valley of California. South of this junction, the eastern limit of Franciscan exposures follows the western border of the Great Valley to its southern end, where Franciscan rocks are largely covered by the younger rocks of the Santa Ynez Mountains of the Transverse Ranges. A more easterly extension of the Franciscan rocks beneath the mantle of miogeosynclinal sedimentary rocks in the Great Valley has been postulated chiefly on the basis of rocks recovered from a few deep drill holes. However, because the older rocks of the western Sierra Nevada Foothills are somewhat similar to the Franciscan rocks, the assignment of these cores to the Franciscan unit can be questioned.

The western margin of Franciscan exposures north of the Transverse Ranges is the Pacific shore, but, within much of the southern and part of the northern Coast Ranges, the Franciscan is strangely absent in a long corridor of metamorphic and granitic rocks that lies between the San Andreas and Nacimiento faults (see fig. 3). West and south of the Nacimiento fault, the Franciscan rocks on the mainland are covered by a mantle of younger sedimentary rocks over extensive areas, and doubtless the coastal waters of the Pacific Ocean also conceal considerable Franciscan rock.

South of the Transverse Ranges, metamorp rocks underlying the Palos Verdes Hills on the ma land (Woodring and others, 1946) and on Santa Ca lina Island (Bailey, 1941) have been described a possible continuation of the Franciscan. According Woodford (1960, p. 408), the widespread presence glaucophane schist in the San Onofre Breccia of M cene age suggests an offshore southeastern extension the schist for at least 65 miles. Glaucophane-bear rocks, thought to be part of the Franciscan, w sampled in place on the Sixtymile, Fortymile, a Thirtymile Banks offshore from San Diego (Eme 1960, p. 66). Further southward, rocks that may correlative with the Franciscan have been descri (Hanna, 1925, 1927; Beal, 1948; van West, 1958) several places, chiefly on islands along the south half of the west coast of Baja California.

In southern Oregon, the extension of rocks mapp as Franciscan in California was assigned by Wells a Peck (1961) to the Dothan Formation of Late Ju sic age. Near Roseburg, Oregon, the part of Myrtle Formation of Diller (1898) that was describ as the Dillard Series by Louderback (1905) also see likely to be correlative with the Franciscan (Irw 1960). Farther north in Washington, Canada, a Alaska are other similar rocks, some of which mig be correlated with the Franciscan, as it forms only small part of a great circum-Pacific belt of thi Mesozoic eugeosynclinal deposits. This belt also characterized by the coincidence of serpentine intr sions (Hess, 1955), low-grade metamorphic rocks the zeolite (Coombs, 1960), blueschist (Schurman 1951), and greenschist facies, and by modern ocea troughs, volcanism, and seismic activity.

In summary, the Franciscan, as restricted to Cal fornia, is distributed over an area of as much as 75,0 square miles, if one includes its total terrestrial and of shore extent, although the total area of outcrop is little less than 15,000 square miles. The total area deposition of Franciscan and other correlative euge synclinal rocks, however, extended not only throug the length of California, a distance of 750 miles, bu also for hundreds of miles beyond the State boundari and over a width of a little more than 100 miles.

THICKNESS OF THE FRANCISCAN

The thickness of the Franciscan doubtless is great but this cannot be ascertained by conventional strat graphic methods because of the intensity of deforma tion, the lack of reasonably continuous exposures, an the absence of recognizable horizons or sequences tha might be used to tie partial sections together. Reason able estimates of a minimum thickness can be made by several methods, but even speculations on the maxi mum thickness are ruled out because the base is no known. Several features suggest the Franciscan mus be very thick, but none of these leads to a close esti mate of thickness. The occurrence of highly deformed

Franciscan rocks in belts, having a width of several tens of miles across the tectonic grain, but with no exposures of a basement and few inliers of younger rocks, leads to the assumption that the Franciscan is tens of thousands of feet thick. Similarily, the fact that in several places volcanic accumulations many thousands of feet thick are enclosed in still thicker sedimentary rocks suggests thicknesses in excess of 10,000 feet. In contrast, we find that the more reliable statements of thickness made by geologists, who studied a dozen different areas, range from 2,700 to 20,000 feet, with thicknesses in the 5,000- to 10,000-foot interval being the most common. These thicknesses apparently were thought to be partial sections measured on reasonably cohesive blocks of Franciscan rocks, rather than the total thickness to be found in each area. No one has been able to construct a composite total section by tying together partial sections by means of matching key horizons or sequences.

The problem of thickness is further complicated by the fact that the eugeosynclinal assemblage probably consists of more than one sequence of rocks that are similar lithologically but separate in time, with some of the younger part seemingly formed by cannibalism of the older. If some of the older sequence is locally eroded to provide the debris to form a younger sequence, how is this taken into account in a meaningful statement of the total thickness of the Franciscan? It is obvious that the thickness of the Franciscan where overlain by the Knoxville, of Late Jurassic age, bears no relation to the thickness where the Franciscan is of mid-Cretaceous age.

An approximation as to the minimum total thickness might be made by adding together minimum total thicknesses of sections thought to have been deposited at different times. McKee (1958a) reports a measurable thickness in the Pacheco Pass area of 4 miles, with an additional 2 miles of rocks believed also to be present. These rocks are probably pre-Knoxville in age, as they seem to be overlain by Knoxville sedimentary rocks, are in part regionally metamorphosed, and contain no K-feldspar (see pp. 139). To this Jurassic section of about 30,000 feet, we might add a section of mid-Cretaceous age exposed in the southern part of Marin County, which, according to J. Schlocker (oral communication, 1960), is about 9,000 feet thick. The age of this section is based on the presence of small amounts of K-feldspar in some of the graywacke and on sparse fossil data. In addition, rocks of very early Cretaceous age are known to be included in the Franciscan, but we know of no estimate of their thickness. If we assume that they are as thick as the mid-Cretaceous sequence, we arrive at an approximation of about 50,000 feet for the entire eugosynclinal assemblage. This estimate of thickness, while very large, seems reasonable when it is compared with the 40,000 or more feet of contemporaneous miogeosynclinal sedimentary rocks present in the bordering Great Valley.

A consideration of the significance of the metamorphic grade of regionally metamorphosed parts of the Franciscan gives an independent clue to its total thickness. As is discussed in further detail in the section on metamorphic rocks (see pp. 111), the blueschists, and especially the aragonite found in them, indicate that these parts of the Franciscan were subjected to a load equivalent to at least 50,000 feet of overlying rock. Further, for the metamorphic assemblages to have persisted, the rocks must have been uplifted and eroded quickly after their deposition, thereby indicating that the 50,000 feet is a measure of the thickness of the Franciscan rocks and not an indication of the quantity of rocks deposited on it in some younger period.

CLASTIC SEDIMENTARY ROCKS

Clastic sedimentary rocks form nearly 90 percent of the assemblage of Franciscan rocks and probably nearly 90 percent of these are dirty, unsorted sandstone or graywacke, with the remainder being mainly siltstone or shale. Conglomerate, although locally prominent, is quantitatively unimportant. The clastic sedimentary rocks, except for the conglomerate, are characterized physically, by being composed of angular and poorly sorted grains; mineralogically, by a high content of feldspar and rock fragments; and chemically, by an abnormally high ratio of soda to potash. Sandstones are dominantly feldspathic and lithic graywackes, which locally grade to tuffs, but some have so little matrix that they might be classed as arenites. Siltstones and shales are apparently quite similar to the graywackes though finer grained; they could be termed micrograywackes, since they contain an abnormally large amount of minute mineral grains and a small amount of clay minerals.

Graywacke

By far the most abundant rock of the Franciscan is graywacke, which has a truly astonishing volume. Even if the average thickness of the Franciscan is regarded as only 25,000 feet, and the depositional area in California and offshore is about 75,000 square miles, the total volume of the Franciscan graywacke is more than 350,000 cubic miles. To make this large figure more meaningful we might point out that this is sufficient sand to cover the State of California to a depth of 10,000 feet or the entire conterminous United States to a depth of 600 feet. As might be expected in a unit of this great bulk and areal extent, the Franciscan graywacke is not everywhere the same, nor has it been studied sufficiently to permit definition of the limits of its variation. Systematic changes, either spatially or temporally, have not been identified, except for K-feldspar content in some areas.

Much of the available data regarding the Franciscan graywacke deals only with a specific area studied as a basis for a thesis, and few geologists have attempted a study of regional variation, provenance, or source. The conclusions of those who have considered the broader problems are repeated briefly here, prior to descriptions of the rock, so that the reader will have a better appreciation of the conflicting views that have been expressed and the difficulty of synthesizing the data.

Davis (1918b), summarizing what was then known of the "Franciscan sandstone," included admirable descriptions of some of the unusual sedimentary features shown by the rocks in the San Francisco Bay area, general statements of mineral content, and information on the more common heavy minerals. He concluded that most of the graywacke was a continental deposit laid down by streams in a region sufficiently arid that decay of rock minerals was very slight.

Taliaferro (1943a) presented considerably more factual data, including some heavy mineral and chemical analyses of graywackes, and he suggested that the graywackes show a southerly increase in quartz, sphene, epidote, tourmaline, and biotite, which increase he attributed to a difference in source rocks. Taliaferro (1943a, p. 139) believed that the Franciscan graywacke

> "* * * was derived from a high, rugged, recently uplifted land mass under rigorous climatic conditions, high rainfall, and possibly a cold climate in the highlands with well-wooded lower slopes. The rivers from this area were large and of high gradient and brought down great floods of unaltered detritus into a shallow sinking basin. The land mass from which the greater part of the Franciscan detritus was derived was made up of granodiorite, crystalline schists, quartzites, recrystallized black cherts, and numerous intrusions of quartz and feldspar porphyries."

Soliman (1958) made a detailed study of the graywacke in the Isabel-Eylar area, east of Mount Hamilton, and compared these rocks with a few specimens from areas north of San Francisco and as far south as the San Benito quadrangle. As a result of the examination of several hundred thin sections, 135 of which were point counted to determine mineral percentages, and 30 heavy mineral analyses, he concluded that the graywackes in northern California have less maturity and contain a greater percentage of rock fragments and less quartz and feldspar than do graywackes in the Diablo Range. He found that epidote decreased from north to south and also from west to east. Soliman concluded that the Franciscan sediments were deposited in a great trough that was filled chiefly from the north, with some additions from the sides. Variations in graywacke were attributed primarily to a north-to-south change in relief of a landmass lying east of the trough, and secondarily to the distance from the major source to the north. An unusual abundance of pink sphene, hypersthene, diopsidic augite, pink garnet, and hyacinth zircon in the Diablo Range was attributed to local derivation of those minerals from a landmass of pre-Mesozoic metamorphic and igneous rocks lying to the west.

Bailey and Irwin (1959) studied the regional variation in K-feldspar content of graywacke in both the northern Coast Ranges and the western border of the Great Valley. In successively younger Mesozoic rocks of the Great Valley, they found a systematic increase in the quantity of K-feldspar, with the average ranging from half a percent in rocks of Late Jurassic age to more than 10 percent in rocks of Late Cretaceous age. Graywackes in the northern Coast Ranges were divided into two units on the basis of their K-feldspar content. One unit, lying generally in the western half of the Coast Ranges and at least in part of mid-Cretaceous age, was found to have an average K-feldspar content of about 8 percent; it was referred to as the "rocks of the coastal belt" and excluded from the Franciscan Formation. The other unit, comprising a central belt in which most of the samples contained little or no K-feldspar, was assigned to the Franciscan; and graywackes in the same area with anomalously high content of K-feldspar were thought to be explained by infolding or infaulting of younger rocks.

Occurrence and megascopic features. Exposures of Franciscan graywacke are in most places poor and discontinuous. Areas of Franciscan sedimentary rocks usually are mantled by at least a few feet of light-colored soil, through which protrude small knobs of the underlying rock. The best and most continuous outcrops occur in the main stream canyons, but even here rocks generally crop out only over the width of the stream at flood stage. In some areas, however, especially where more recent uplift is particularly pronounced, as in parts of the northern Coast Range and in diapiric plugs like those of Mount Diablo and New Idria, massive graywacke forms well-exposed cliffs a few hundred feet high. Excellent artificial exposures have been provided in recent years by cuts being made by highways, roads, quarries, or large buildings. In most areas, however, the fragmentary nature of the exposures permits observation of only small-scale details of sedimentary structures or bedding and does not allow tracing of a specific bed for more than a short distance. Thus, little is known about the continuity or lenticularity of individual beds.

Bedding of the Franciscan graywacke is best characterized by both the irregularity in thickness of the beds and the unusually great thickness of some of them. Single units, as defined by the distances between shale partings or interbeds, have thicknesses ranging from half an inch up to at least tens, and perhaps hundreds, of feet. Although there is an apparent tendency for beds in some areas to be unusually thick or unusually thin, no rhythmic pattern to the variation in thickness has been detected. Commonly a well-exposed section will show a variation in bed thicknesses from an inch up to perhaps as must as 10 feet, with all intermediate thicknesses represented and distributed through the section at random. The quantity of shale present as parting layers between graywacke beds is generally small, amounting to less than a fifth of the

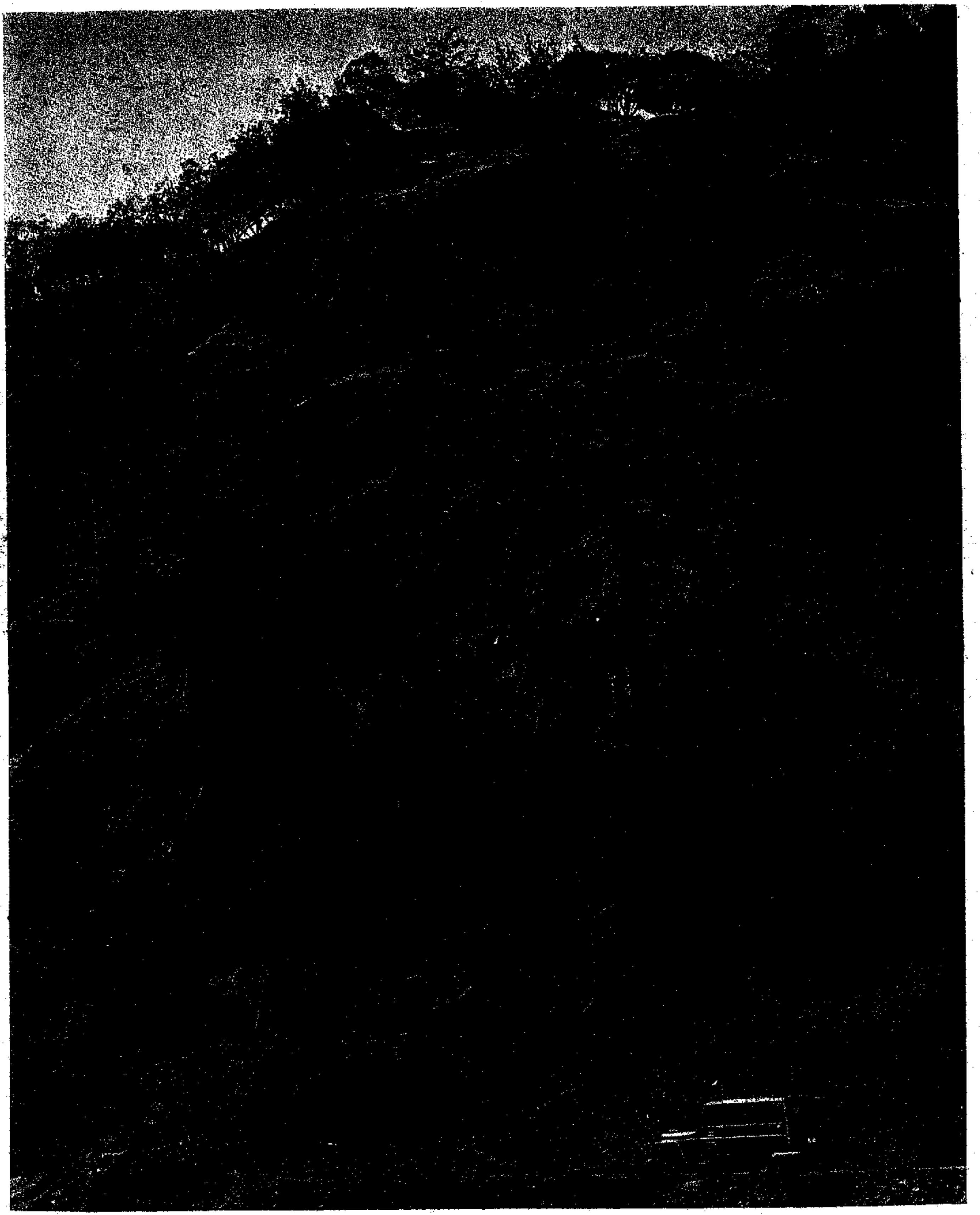


Photo 7. Massive Franciscan graywacke; no bedding apparent in lower 40 feet of exposure. Big Austin Creek, Skaggs quadrangle.

Photo 8. Tightly folded Franciscan (Coastal belt) graywacke and shale. On Highway between Fort Bragg and Willits, east side of Glenblair quadrangle. Note hammer left of center for scale.

graywacke-shale sequence, but no relation between the quantity of shale and the thickness of the graywacke beds has been noted.

Sedimentary structures of the Franciscan graywacke have not been studied in detail, but our observations indicate that most of the graywacke beds are nongraded and possess little internal structure other than a vague platy lamination which is due to alignment of flat shale chips and bits of carbonaceous matter. Sole markings, ripple marks, crossbedding, and graded bedding have been seen only in a few areas. Locally in the Franciscan outcrop belt, the usual thick graywacke beds are replaced by thin graywacke beds alternating with siltstone or by a sequence in which shale and siltstone predominate. In some of these finer grained sequences sedimentary structures are unusually abundant.

The area about Mount Hamilton, in the Diablo Range, is one in which rhythmically alternating beds of graywacke and siltstone or shale form a large part of the total sedimentary sequence. In this area the graywacke generally shows well-developed graded bedding, with beds ranging in thickness from less than an inch to several feet. The upper shaly portion of many of these graded beds is finely laminated and may exhibit small-scale crossbedding. Large-scale crossbedding has not been observed in the graywacke here or elsewhere, and convolute bedding is uncommon. The contact between successive graded units generally is sharp. Sole markings, including both groove casts and flute casts, have been observed at the base of some beds, but these markings rarely can be seen owing both to the lack of adequate exposures of the undersides of beds, and, at least to some extent, to obliteration of sole markings by shearing along bedding planes. In this area carbonaceous material is abundant, particularly in the upper parts of graded beds and in the overlying fine-grained siltstone and shale. Most of this material consists of degraded, shredded bits of charcoal which in places retains cellular structure.

In many places where graywacke beds are thin, they can be seen to be lenticular, but much of this lenticularity is a secondary feature resulting from development of shear planes that intersect bedding planes at low angles. Where shear planes are closely spaced, their intersection with bedding planes forms well-developed boudinage, but more commonly the combination of irregular thickness of beds and irregular spacing of shear planes results in a chaotic jumble of short bed segments and lenticles. Not uncommonly during deformation, shale has been injected plastically into fractures in the graywacke, thus forming planar surfaces between massive graywacke and shale that can be easily mistaken for normal bedding planes. However, the bedding of otherwise massive graywacke can, in some places, be determined by the orientation of mica, shale flakes, or bits of carbonaceous material. This method provides a means of checking whether a thin shale parting is a bed or is material that has been plastically injected along a fracture.

The appearance of fresh Franciscan graywacke varies with differences in grain size, proportions of the component minerals and rock grains, and the amount of pressure it has undergone. All varieties, however, are well indurated, poorly sorted, dirty sandstones containing abundant quartz, feldspar, and some rock fragments. The predominant color of fresh specimens is gray, but may range from light to dark gray to

Photo 9 (below). Thick-bedded Franciscan graywacke, with minor beds of black shale. Road cut in sea cliff about five miles southeast of Crescent City, Del Norte County. Note hammer below center for scale. *(Photo by Salem Rice.)*

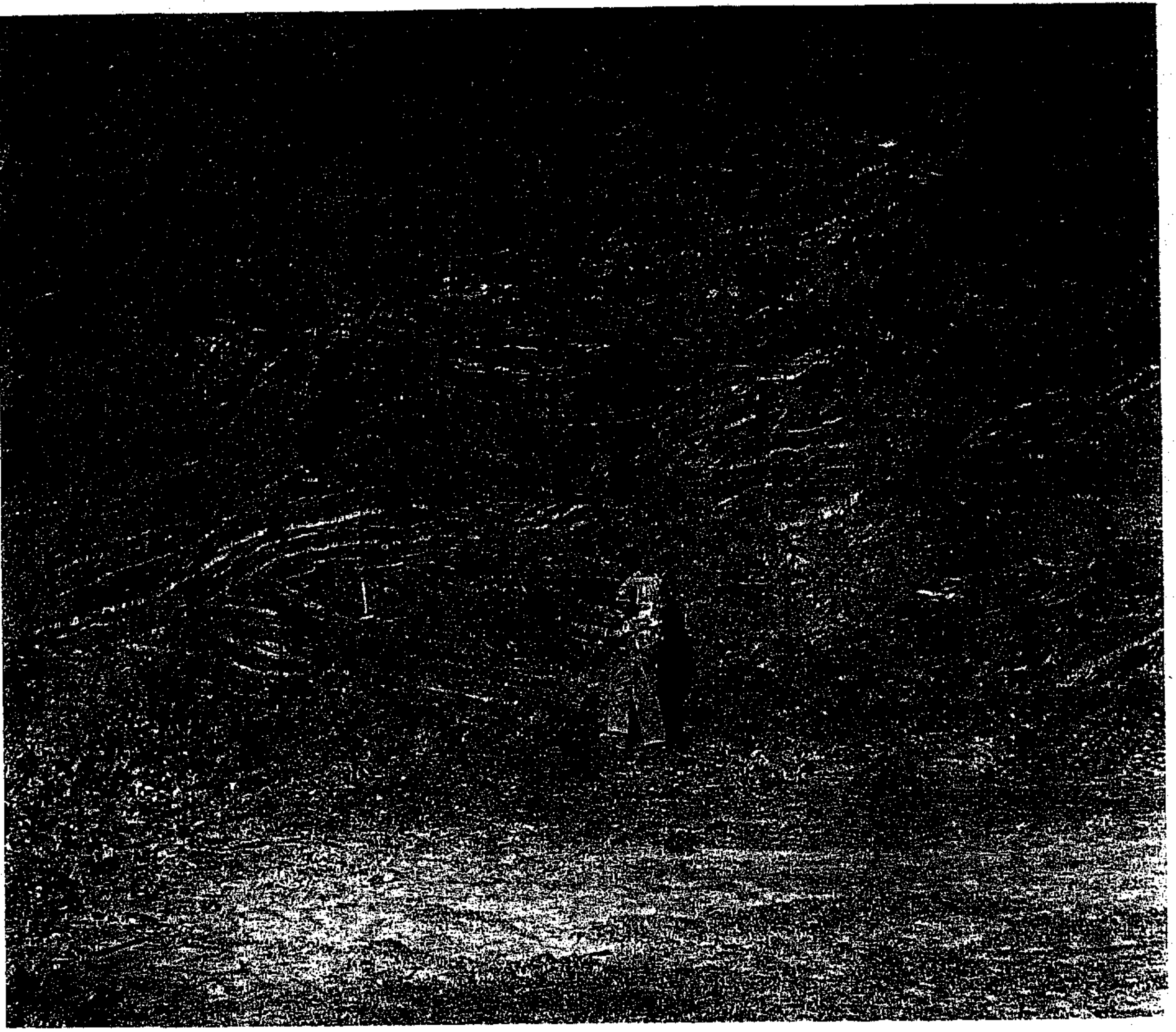


Photo 10. Tightly folded and faulted Franciscan(?) shale and thin-bedded graywacke in quarry one mile south of Novato. Several specimens of *Inoceramus schmidti* of Campanian age have been found in these beds.

bluish or greenish gray. Upon weathering, the color changes first to lighter gray and then to tan. Hydrothermal alteration may change the color to nearly white.

Most of the graywacke appears on cursory inspection to have an average grain size of about half a millimeter, but this appearance is somewhat misleading as the rock is poorly sorted and one tends to overestimate the average grain size when disregarding the finer grains. The grains range in shape from dominantly angular to subangular and, more rarely, subrounded. Typical specimens, especially if not entirely fresh, have a "salt and pepper" aspect, owing to the prominence of white feldspars and black grains of shale, mafic rocks, or carbonaceous material. In addition, many contain larger flakes of shale and shiny flakes of mica, either muscovite or biotite. Much of the graywacke appears merely very well compacted, but in some areas it has been so compressed that the shale and mafic rock fragments have been flattened and impart a slight schistosity to the rock, forming what is sometimes referred to as a semischist. The graywacke is dense and virtually nonporous. In many specimens it is difficult to distinguish with a hand lens any material that would be called matrix. Although the graywacke is generally well indurated and hard, many beds are cut by innumerable invisible cracks and are so shattered that it is difficult to collect a piece the size of a hand specimen. Veining by quartz or calcite is widespread, and locally veins of adularia, albite, or laumontite are found.

Microscopic features. Thin-section study reveals wide diversity among rocks that are now grouped together as Franciscan graywacke, but quantitative data on the components generally are difficult to ob-

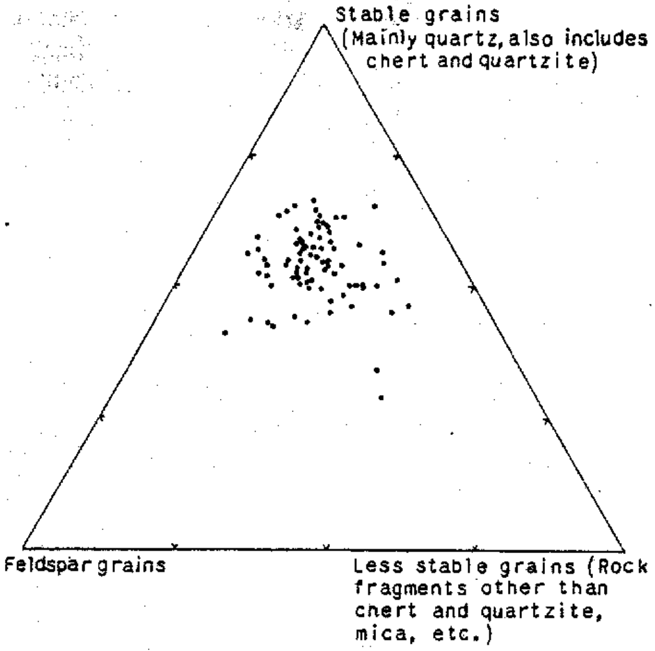


Figure 4. Ternary diagram showing proportions of stable grains, less stable grains, and feldspar grains in 80 Franciscan graywackes (54 northern California, 26 central California). Matrix not included. From Soliman (1958).

tain. This difficulty is chiefly because many of the feldspars are fresh and untwinned, and thus they are not easily distinguished from quartz, and much of the plagioclase is albite that is scarcely distinguishable from K-feldspar. The finest grained material of the matrix is generally unresolvable, and measurement of even the quantity of matrix is difficult, because in many of the rocks there is a gradation rather than a sharp break in size between clasts and matrix. Some of the difficulties of measurement might be overcome by the application of preferential stains to the plagioclase and K-feldspar (Bailey and Stevens, 1960), but because these methods have not yet been applied to thin sections of these rocks, the available data on quartz/feldspar or plagioclase/K-feldspar ratios obtained from thin sections cannot be considered as entirely reliable. Grain counts made following a separation of light and heavy fractions are probably little better because of the same inherent difficulties, and, in addition, the graywacke is so indurated that treatment drastic enough to separate individual grains also will shatter or dissolve some of the components. Thin sections, however, do reveal features not discernable with a hand lens, and the estimates that have been made of component percentages give a general idea of the variability found among the graywackes even though these estimates do not permit one to place rigid limits on the variations or to be confident of any regional variation.

The predominant features seen in thin section are the general lack of abrasion and the lack of sorting of the grains of the rock. Most of the grains are angular, and this is especially true for the monomineralic grains. Rock fragments tend to be subangular or subrounded, but in many sections the compaction of the rock has led to a modification of the shape of the softer composite rock fragments by their yielding to fit between the monomineralic grains. The monomineralic grains are chiefly feldspar and quartz, but most sections contain a few grains of epidote-group minerals, apatite, and zircon. The quantity of rock fragments ranges from near zero to as much as three-fourths of the rock. In many sections the predominant rock fragments are mafic lava, apparently quite like the greenstone in the assemblage of Franciscan rocks, and all gradations between such volcanic-rich graywackes and tuffs are known. Other lithic graywackes contain very few mafic rock fragments but instead contain clasts of shale, chert, quartzite, or quartz-sericite schist.

Most of the Franciscan graywacke has a matrix content of at least 10 percent and thus would fall into the "wacke" classification of Gilbert (Williams and others, 1954, p. 292). Of 80 specimens point counted by Soliman (1958), about 42 percent would fall into the arkosic wacke subdivision, 23 percent into the feldspathic wacke subdivision, and 35 percent into the lithic wacke subdivision (fig. 4).

Quartz grains make up from 10 to 50 percent of most of the Franciscan graywackes, with the average of available measurements being about 30 percent. The average value of normative quartz in the 21 chemical analyses of Franciscan graywacke included with this report is 31.5 percent. Extreme values for quartz grains of 5 to 60 percent based on point counts of thin sections are recorded by Soliman (1958), and his range for "stable grains," shown in figure 4 is from 23 to 62 percent. Soliman's values for quartz and "stable grains" are high as compared with measurements made by others, and with chemical analyses. The quartz grains are generally angular to subangular, but rare rounded or even euhedral grains are present. Most quartz grains are clear, and many contain minute liquid- and gas-filled cavities. Many show undulatory extinction, and some grains are composite, consisting of several crystal units separated by sutured boundaries.

Feldspar generally is the dominant mineral in the graywackes and, in some specimens, probably amounts to as much as 60 percent of the rock. Feldspar occurs most abundantly as monomineralic grains, but it is also a prominent constituent of many of the rock fragments. The percent of clastic feldspar grains in 80 graywacke specimens from northern and central California was determined by point counts by Soliman (1958). Figure 4, taken from his report, indicates feldspar amounts to from 9 to 46 percent of the clastic grains, with more than half the specimens containing

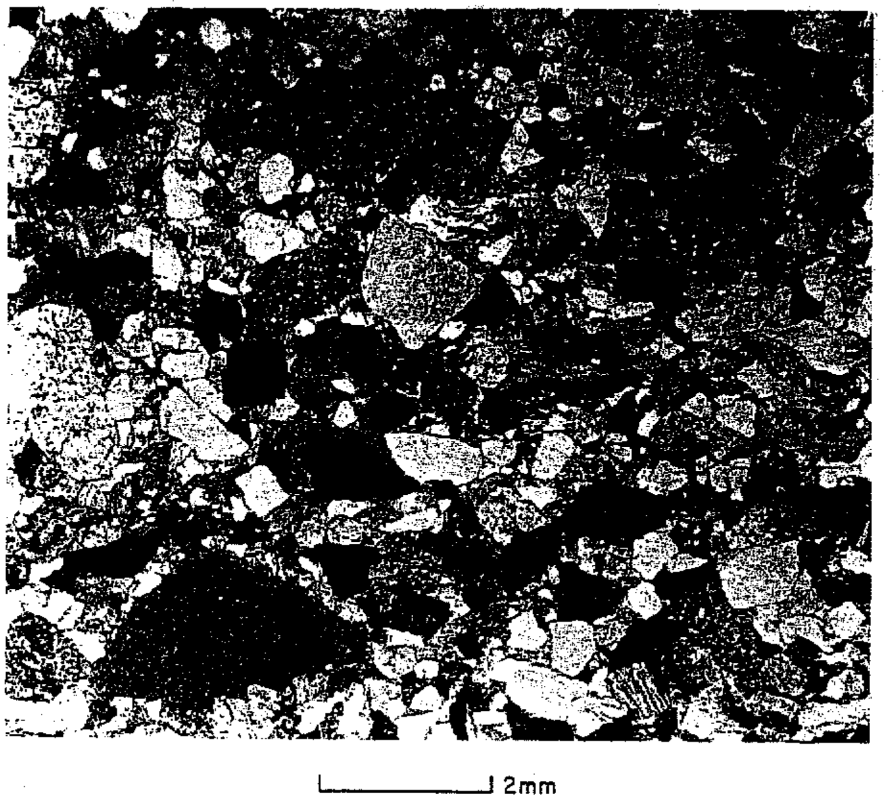


Photo 11 (left). Lithic graywacke with clasts of greenstone, altered mafic glass, shale, chert, quartz, orthoclase, plagioclase, epidote, biotite, and myrmekite: Tombs Creek quadrangle. (Coastal belt unit) (58-274).

Photo 12 (right). Feldspathic graywacke with clasts of quartz, albite, muscovite, biotite, chlorite, mafic volcanic rocks and glass, and shale. Pillsbury Lake quadrangle (B-35).

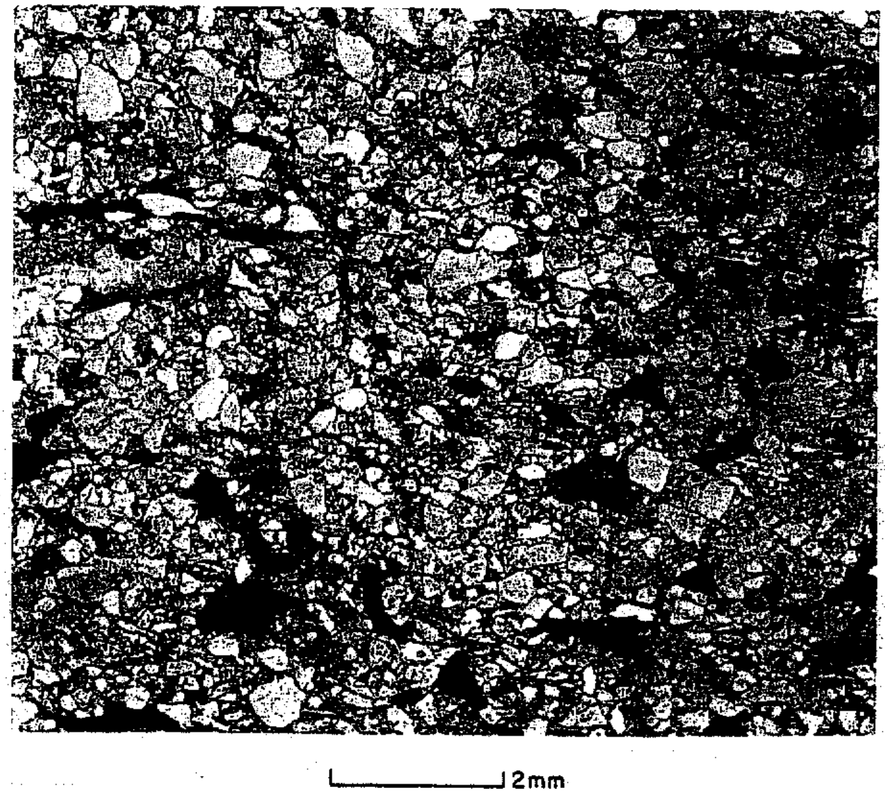
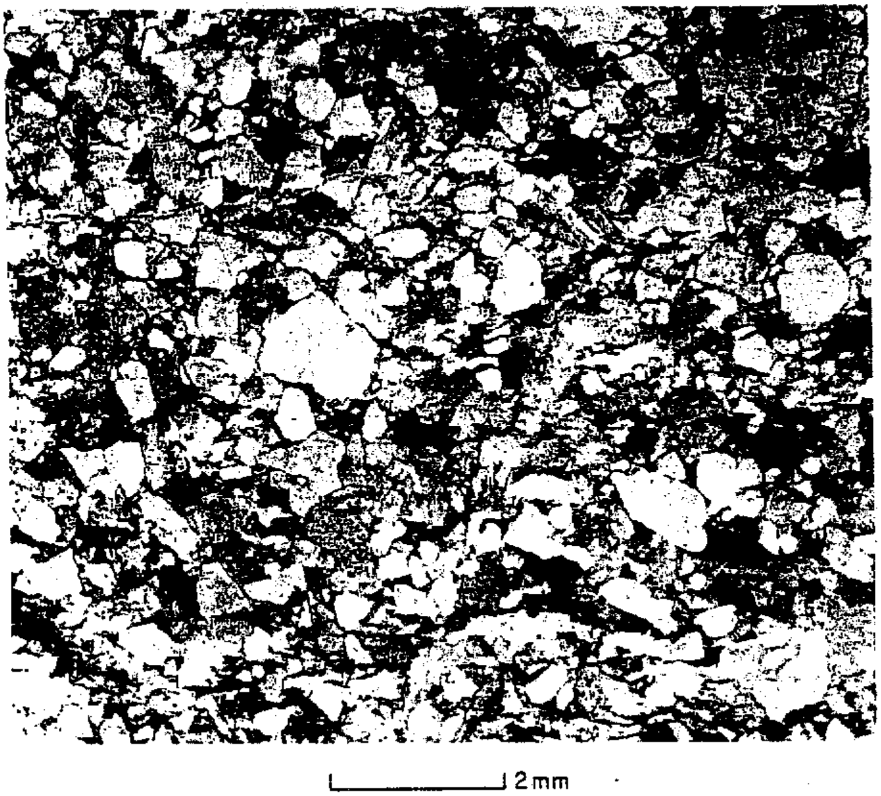


Photo 13 (right). Feldspathic graywacke with quartz, plagioclase, orthoclase, muscovite, biotite, epidote, mafic volcanic rocks, and shale, Fort Ross quadrangle. (Coastal belt unit) (60-305).



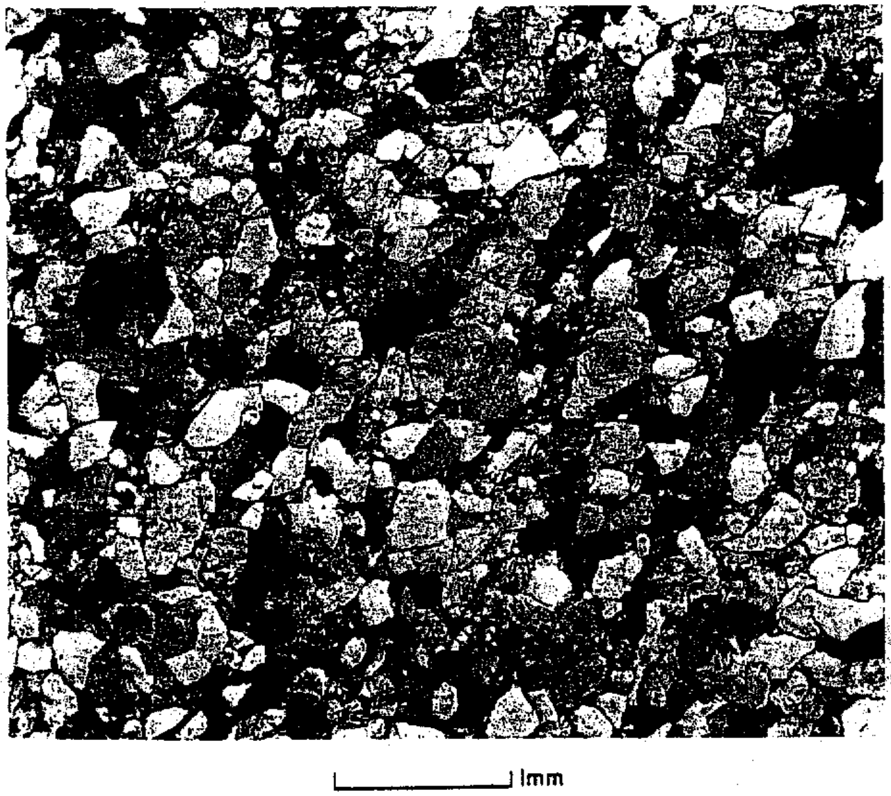


Photo 14 (left). Feldspathic graywacke with quartz, plagioclase, orthoclase, biotite, epidote, mafic volcanic rocks, and shale. Very little matrix. Fort Ross quadrangle (58-191).

between 20 and 30 percent. The average value of normative feldspar in 21 analyses of Franciscan graywackes is 43.5 percent. Grain counts or point counts reported by Soliman and others are probably all low with respect to total feldspar, because the grain counts are made on a light fraction that does not include the mafic feldspar-bearing rock fragments and point counts normally include only the monomineralic grains. The minimum and maximum for feldspar content is the 5 to 55 percent reported for the Pacheco Pass area by McKee (1958a), and the average of all of the measurements and estimates we found in the literature is about 35 percent. Normative feldspar calculated from the available chemical analyses averages about 45 percent.

Over wide areas plagioclase is the only feldspar present as grains in the Franciscan graywacke; in some areas, however, orthoclase is also present. The plagioclase is highly sodic, and most investigators have reported it as either albite or oligoclase. Our thin-section studies indicate albite is most common, oligoclase less so, and andesine comparatively minor. Soliman (1958) reports that labradorite and bytownite also occur in minor amounts. Normative plagioclase calculated from analyses ranges from An$_{01}$ to An$_{32}$ and averages An$_{15}$. As the abundance of K-feldspar can apparently be used to separate otherwise indistinguishable sequences of graywacke, and also has genetic implications as to possible source areas, it is discussed elsewhere in the report in considerable detail (see pp. 139 et seq.).

The feldspar grains, though tending to be more nearly square or rectangular, are comparable in size and angularity to the quartz grains. Many show no twinning, but in some sections they can be distinguished from quartz because they are more cloudy and more susceptible to incipient alteration. Some are composite and appear to have been replaced by groups of smaller crystals of a different kind of plagioclase.

The quartz/feldspar ratio has been measured by various means or estimated by at least two dozen geologists, who report figures ranging from 1:2 to 10:1. The point counts of Soliman (1958) indicate a ratio of siliceous grains, including chert, to feldspar of 2:1 (see fig. 4), but his values for the siliceous grains seem to be high. The average of all of the data available is very close to 1:1. Norms calculated from chemical analyses of 21 graywackes indicate an average ratio of 3 quartz to 4 feldspar, but it should be recognized that some of the normative quartz is present as chert or quartzite, and some of the normative feldspar represents material occurring in rock fragments. We have no data indicating a difference in quartz/feldspar ratios between the graywackes with K-feldspar and those without, but a significant difference may exist.

Rock fragments are the next most abundant component of the graywackes, but they have received little study. Reported percentages of rock clasts range from a minimum of 2 to a maximum of 55, but as the volcanic graywackes apparently grade into tuffs with an increase in volcanic fragments and an elimination of nearly all of the quartz, the reported maximum of 55 percent is rather arbitrary. Even less information is available on the proportions of the various kinds of rock fragments, and nothing has been noted regarding the relation of the total quantity to kind of rock fragment.

The most abundant rock clasts are various kinds of fine-grained mafic volcanic rocks, apparently like the greenstone flows, tuffs, and breccias that are interlayered with the sedimentary rocks. Altered mafic glass fragments are very common, and minute fragments of altered glassy material seem to provide the major part of the matrix for many of the more lithic graywackes. Chert fragments also are common, and some of these that are red and contain radiolaria resemble those found in rhythmically layered sequences of the Franciscan Formation. Other chert fragments, which are common in some of the graywackes, are black and carbonaceous; they seem to be unlike any found as beds in the Franciscan. Recrystallized cherts, many of which contain shreds of mica, are also common. Shale fragments are a ubiquitous component, but pieces of fine-grained graywacke are rare. McKee (1958a) reports that in the Pacheco Pass area detrital grains of quartz diorite are prominent in the part of the Franciscan that he believes to be the oldest exposed. Fragments of quartz-mica schists are not uncommon, but clastic grains of glaucophane schist or

Figure 5. Ternary diagram showing proportions of stable grains, unstable grains, and matrix in 79 Franciscan graywackes (51 northern California, 28 central California). From Soliman (1958).

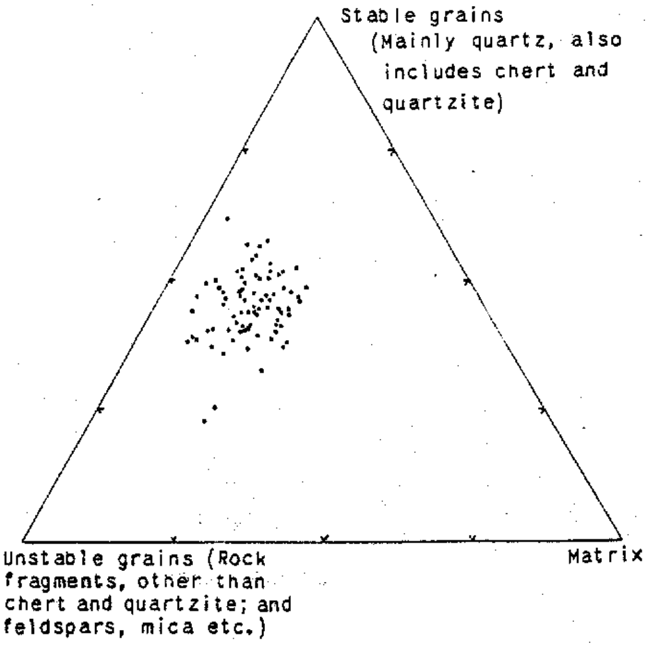


Figure 6. Heavy minerals in Franciscan graywackes.

Quadrangle	Actinolite	Allanite	Andalusite	Apatite	Augite	Biotite	Brookite	Calcite	Cassiterite	Chlorite	Chromite	Clinozoisite	Epidote	Garnet	Gahnite	Glaucophane	Hematite	Hornblende	Hypersthene	Idocrase	Kyanite	Ilmenite	Lawsonite	Leucoxene	Magnetite	Monazite	Muscovite	Oxyhornblende	Piedmontite	Picotite	Pumpellyite	Pyrite	Rutile	Sphene	Tourmaline	Tremolite	Zircon	Zoisite
1. Blue Lake		X		▨		▨	X			▨			▨					▨							▨										▨			
2. Ferndale-Fortuna				X			X					X	▨					▨																X	X		X	X
3. Blocksburg	X						▨			▨			X	X			X	X	X		X			▨	X			X					▨	X	X		X	
4. Leggett			X	▨									▨	▨				X						X		X							X	▨			X	X
5. Covello										▨				X								▨		▨			▨						X	X			X	
6. Anthony Peak						X		X		▨																						▨		X			X	
7. Branscomb				X	▨					▨		X	▨	▨				X				▨	X	▨		X								X			▨	
8. Willits				X		X						X	▨	▨				X						▨	▨									X			▨	
9. Lower Lake						▨						▨	▨																					▨				
10. Sebastopol				D	X	X				X		X	X	X				X				▨			X		X					X	X	X	X		▨	
11. Sebastopol				▨						▨		▨	▨				▨					▨			▨							▨	X	▨			▨	
12. San Francisco North			X	X	X	▨	X		X	▨		X	X	X	X			X	X		X	X		X		X	X			X	X	X		X	X	X	X	X
13. San Francisco South				X		▨		▨		▨			X	X					X			X			X		▨							X	X	X	X	
14. San Jose-Mount Hamilton				X		▨				▨		X	X					X			X			▨	▨					X				▨	X		X	X
15. Isabel-Eylar	X			▨	X	X				▨	X		▨	X	X	X		X	X			X	X	X	X				X					▨	X	X	X	
16. Mount Boardman						▨				▨		▨	▨												▨		▨							▨				
17. Quien Sabe				▨									▨												▨													
18. Ortigalita Peak										▨		▨	▨												▨		▨							▨				
19. San Simeon				D		X				X			▨	X				X				▨			X							X		▨	X		▨	
20. Adelaida				D						X		X	▨	▨				X				▨			X							X		▨	X		▨	
21. Adelaida				D		X				X			▨	X				X				X			▨							X		▨	X		X	X
22. Santa Maria				▨	X					X		▨	▨					X	X	X				X	X							▨	X				▨	

1. Manning, G. A., and Ogle, B. A. (1950, p. 19)
2. Ogle, B. A. (1953, p. 14)
3-8,22. Stanford University students under G. A. Thompson, 1956
9. Brice, J. C. (1953, p. 13) Thin-section studies only.
10. Johnson, F. A. (1934)
11. Travis, R. B. (1952, p. 13) Thin-section studies only.
12-13. Schlocker, Julius (oral communication, 1960)
14. Crittenden, M. D., Jr. (1951, p. 18)
15. Soliman, S. M. (1958)
16. Maddock, M.E. (1955)
17. Leith, C. J. (1949, p. 14) Thin-section studies only.
18. Briggs, L. I. (1953a, p. 14) Thin-section studies only.
19-20. Dosch, E. F. (1932)
21. Goudy, C. L. (1936)

▨ = >5 percent of heavies, or "common"
X = <5 percent of heavies, or "rare"
D = Destroyed by treatment, if present

jadeitized rocks have been reported only by McKee (1958a). The shapes of the rock fragments are variable. In many graywackes, the fragments of relatively weak rocks, such as the mafic volcanics, have been bent to fit between the harder grains, while the harder rocks, such as the cherts, are undeformed.

Estimates of the quantity of matrix in these graywackes range from 8 percent to as much as 50 percent, but probably these have been made on different bases by different geologists. In many of the graywackes there is no clearly discernible break in grain size between the coarsest clasts and the finest matrix material, and, as a result, the distinction between clasts and matrix is arbitrary. The problem is further compounded if slight metamorphism has resulted in the growth of new crystalline aggregates, some of which are larger than the smallest of the original clasts. In general, however, geologists include under the term "matrix" the dark-colored and nearly unidentifiable paste, which probably has a grain size of less than 0.02 mm. In spite of the difficulty of measuring the quantity of matrix, it is obvious that the quantity varies considerably; in some graywackes the clasts appear largely separated by matrix, while in the majority the grains appear closely packed with only narrow films of matrix between them. Figure 5 shows that the quantity of matrix, as determined by Soliman (1958) by point counts on 80 Franciscan graywackes, is generally between 5 and 25 percent.

The nature of the matrix material is largely indeterminate in thin section, but much of it appears to be sericitic or chloritic. An X-ray study of the finest fraction obtained from crushed graywacke of the San Francisco Bay area by J. Schlocker (oral communication, 1963) indicates mica is more abundant than chlorite, except in some volcanic-rich wackes, and there is little, if any, kaolinite. Both the mica and chlorite are fairly well ordered but some contain a low percentage of expandable layers. Calculations of norms also indicate chlorite is generally more abundant than kaolinite and may exceed muscovite, but this would include components in rock grains as well as in the matrix. In some graywacke the original matrix is sufficiently recrystallized to permit one to identify new quartz, sericite, chlorite, and albite; however, most Franciscan graywackes are recrystallized so little that the margins of the clastic grains have not been rendered fuzzy by the growth of new minerals.

The cement for these hard tough rocks is generally just the paste or matrix. Recrystallized quartz is sometimes visible in the matrix of the more feldspathic graywackes, suggesting that their matrix is more siliceous than the average, and a higher proportion of chlorite is present in the matrix of graywackes with abundant mafic rock fragments. Occasionally one finds specimens with a true calcite cement, but, more commonly, calcite cement occurs in small irregular patches that suggest a selective replacement of the more normal matrix. Quartz also locally replaces most or all of the matrix, especially in areas in which all the graywackes show incipient metamorphism.

Other constituents of the graywackes are heavy detrital grains which are readily separated by the use of heavy liquids. More than 50 separations have been reported, and these are summarized in figure 6. In this table an attempt has been made to indicate abundance, even though not all of the data are comparable because of difference in both the treatment and reporting of results. The minerals most investigators find to be abundant are biotite, chlorite, minerals of the epidote group, sphene, and zircon; other apparently widespread minerals present in smaller amounts are apatite, garnet, hornblende, ilmenite, leucoxene, magnetite, pyrite, and tourmaline. More uncommon minerals include brookite, gahnite, kyanite, lawsonite, piedmontite, pumpellyite, and rutile. Chromite or picotite, which would be indicative of derivation from ultramafic rocks, are rarely reported even though several geologists have reported serpentine as one of the common lithic fragments in the graywacke. Much of the reported serpentine may be chloritized mafic glass, with which it is easily confused. Glaucophane, which is so readily recognized that it could scarcely be overlooked, was found as clastic grains in heavy concentrates only by Soliman (1958). Staurolite, which occurs in upper Mesozoic sedimentary rocks of the Great Valley (Briggs, 1953b), has not been found. Among the common heavy minerals are several (such as apatite, biotite, chlorite, and hornblende) that are relatively unstable and readily destroyed by weathering and abrasion. Andalusite, kyanite, piedmontite, and probably also lawsonite and pumpellyite, though not abundant, indicate that at least part of the source rocks were regionally metamorphosed.

Chemical features. The chemical composition of 21 representative graywackes is given in table 1, and the distribution of the sample localities is shown in figure 7. A comparison of the average of these analyses with graywackes found in other parts of the world can be made by reference to table 2. Prominent characteristics of Franciscan graywackes are: (1) soda commonly exceeds potash, or, expressed differently, the K_2O/Na_2O ratio is less than 1, (2) the ratio of ferric to ferrous oxide (Fe_2O_3/FeO) is generally less than 1, and (3) combined water (H_2O+) is generally more than 2 percent.

Molecular norms are also given in tables 1 and 2, and because not all geologists are familiar with this type of presentation of data, or the ease with which the molecular norms can be obtained from a chemical analysis, the method will be briefly explained. In the conversion of analyses given in weight percent of the constituent oxides into minerals, use is made of the molecular units of Niggli (1936), and the method of calculation follows that of Eskola (1954) and Barth (1955). The method is based on determining the number of cations of the various cationic elements in a unit volume of rock. This is done by first reducing the

Table 1. Analyses and molecular norms of Franciscan graywackes.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
SiO_2	56.8	67.3	68.5	68.8	71.7	71.2	72.2	62.7	67.5	67.2	58.4	70.7	72.9	70.3	69.0	68.9	67.0	67.3	60.9	67.1	70.8
TiO_2	n.d.	1.8	0.6	0.3	0.3	0.4	0.5	0.5	0.6	0.5	0.5	0.4	0.6	0.4	0.7	0.6	0.6	0.6	0.6	0.5	0.4
Al_2O_3	11.4	12.4	12.8	14.5	13.2	13.1	11.7	13.1	14.6	14.6	14.2	14.2	11.3	14.0	11.7	12.7	14.1	15.5	16.4	14.9	14.0
Fe_2O_3	1.5	0.6	1.3	0.6	0.3	1.0	0.7	2.1	2.7	1.9	2.4	1.8	1.1	0.8	1.0	1.5	0.9	0.4	1.4	1.0	0.6
FeO	5.0	4.0	3.4	2.5	3.6	2.4	3.2	1.3	1.9	2.3	1.4	1.3	2.8	2.6	4.2	2.8	4.0	3.8	4.4	2.9	2.5
MnO	0.2	0.1	--	--	--	0.1	0.1	0.1	0.1	0.1	0.2	--	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
MgO	3.1	2.3	2.2	1.9	1.8	2.2	2.7	1.3	1.7	2.3	1.2	1.3	2.7	2.1	3.8	2.5	2.8	1.9	3.1	1.6	1.7
CaO	7.6	3.3	1.8	2.2	1.8	1.5	0.6	6.0	1.1	1.8	8.2	0.7	0.6	1.3	1.3	1.9	1.3	0.6	3.9	2.0	1.5
Na_2O	3.3	3.0	6.0	3.9	2.7	4.3	3.2	3.6	3.7	3.7	3.3	4.3	3.8	4.1	2.0	2.7	3.4	4.2	4.2	3.1	3.7
K_2O	0.9	1.2	1.3	2.7	1.3	1.1	1.4	1.7	1.9	1.9	2.0	2.4	0.9	1.2	2.3	2.1	1.6	3.2	0.6	2.3	2.2
H_2O+	3.2	2.5	2.1	1.6	2.5	1.9	} 2.7	3.2	3.5	3.4	3.1	2.4 {	2.2	2.4	3.3	2.8	2.8	1.8	3.7	2.6	2.2
H_2O-	1.4	0.3	0.3	0.3	0.1	0.3							0.4	0.2	0.3	0.7	0.6	0.2	0.5	0.8	0.2
CO_2	5.1	0.6	n.d.	0.1	0.3	0.1	0.1	3.6	--	--	4.8	--	0.1	0.1	--	0.3	0.1	--	0.1	0.2	0.1
P_2O_5	0.1	0.1	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Total	[a]99.57	[a]99.41	[c]100.47	[a,b]100.13	[a,c]99.93	[a]99.85	99	99	99	100	100	100	99.72	[a]99.69	100	100	99	100	100	99	100
MOLECULAR NORM-CATANORM																					
Q	23.5	34.8	20.4	26.4	41.9	33.5	40.8	29.8	33.5	29.8	25.0	31.9	40.3	34.1	37.4	36.8	31.4	22.8	18.8	31.9	32.8
or	5.5	7.0	8.0	16.5	8.0	6.5	9.0	10.5	12.0	11.5	12.0	14.5	5.5	7.0	14.5	13.0	10.0	19.5	4.0	14.5	13.5
ab	31.0	28.0	54.5	36.0	25.5	39.5	30.0	33.5	35.0	35.0	30.5	40.5	35.5	38.0	19.0	25.5	32.5	38.5	39.0	29.5	34.0
an	4.5	12.5	4.3	8.0	6.5	5.5	1.0	6.0	5.0	8.5	9.0	2.5	0.5	5.0	5.5	7.0	5.0	2.0	18.0	8.0	6.5
C	4.0	2.2	--	2.5	5.9	3.3	5.3	3.7	5.2	4.0	3.9	4.1	4.5	4.9	4.7	4.2	5.7	4.9	2.9	5.2	3.7
en	9.0	6.8	6.2	5.4	5.2	6.6	7.8	3.8	5.0	6.4	3.4	3.6	7.8	6.0	11.2	7.2	8.0	5.4	9.0	4.8	4.8
fs	7.0	3.4	3.2	3.0	5.0	2.4	3.8	--	--	1.8	--	--	3.0	3.0	0.5	2.6	5.0	5.4	5.0	3.2	2.8
mt	1.6	0.8	1.4	0.8	0.3	1.2	0.8	2.1	3.0	2.1	2.5	2.0	1.2	0.9	1.2	1.6	0.9	0.4	1.5	1.2	0.8
il	--	2.6	1.0	0.4	0.6	0.6	0.8	0.6	1.0	0.6	0.6	0.6	0.8	0.6	1.0	1.0	1.0	0.8	1.0	0.8	0.6
hm	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--
ap	0.3	0.3	0.5	0.8	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.6	0.3	0.3
cc	13.6	1.6	0.5	0.2	0.8	0.6	0.4	9.6	--	--	12.6	--	0.6	0.2	--	0.8	0.2	--	0.2	0.6	0.2
MOLECULAR NORMS MAKING USE OF COMBINED WATER																					
Q	21.0	35.9	21.9	25.9	40.9	34.3	41.1	30.0	34.0	30.5	24.6	31.0	39.8	33.5	39.0	37.5	31.8	24.6	19.9	32.7	32.3
or	--	3.0	8.0	14.5	--	--	--	2.5	--	3.0	4.5	8.0	--	--	5.5	5.0	--	9.0	--	3.0	8.5
plag	35.5	40.5	58.8	44.0	32.0	45.0	31.0	39.5	40.0	43.5	39.5	43.0	36.0	43.0	24.5	32.5	37.5	40.5	57.0	37.5	40.5
chl	13.4	8.5	7.9	7.2	8.5	7.5	9.6	3.1	4.1	6.9	2.9	3.0	9.0	7.5	13.5	8.1	10.9	9.0	11.6	6.6	6.4
kaol	3.6	1.2	--	3.4	5.4	1.4	3.4	1.0	0.8	1.2	1.8	3.6	4.6	4.2	2.2	2.0	3.4	--	2.6	1.2	3.4
ms	7.7	5.6	--	2.8	11.2	9.1	12.6	11.2	16.8	11.9	10.5	8.5	7.7	9.8	12.6	11.2	14.0	14.7	5.6	16.1	7.0
mt	1.6	0.8	1.4	0.8	0.3	1.2	0.8	2.1	3.0	2.1	2.5	2.0	1.2	0.9	1.2	1.6	0.9	0.4	1.5	1.2	0.8
il	--	2.6	1.0	0.4	0.6	0.6	0.8	0.6	1.0	0.6	0.6	0.6	0.8	0.6	1.0	1.0	1.0	0.8	1.0	0.8	0.6
hm	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--
ap	0.3	0.3	0.5	0.8	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.6	0.3	0.3
cc	13.6	1.6	0.5	0.2	0.8	0.6	0.4	9.6	--	--	12.6	--	0.6	0.2	--	0.8	0.2	--	0.2	0.6	0.2
																		C=0.7			
%An in plag	13	31	7	18	20	12	3	15	12	20	23	6	1	12	22	22	13	5	32	21	16

1. "Neocomian Sandstone" from headwaters of Bagley Creek, Mount Diablo, Calif. (Turner, 1891, p. 412). Analysis by W. H. Melville.
2. Graywacke (NA 450), New Almaden district, Santa Clara County, Calif. Analysis by Mrs. A. C. Vlisidis.
3. Franciscan "sandstone," Sulphur Bank, Calif. (Becker, 1888, p. 82). Analysis by W. H. Melville.
4. Franciscan "sandstone" from quarry of Oakland Paving Co., Piedmont, Alameda County, Calif. (Davis, 1918b, p. 22). Analysis by J. W. Hanson.
5. Franciscan "sandstone," junction of Buckeye Gulch and Hospital Canyon, Carbona quadrangle, Stanislaus County, Calif. (Taliaferro, 1943a, p. 136). Analysis by Herdsman Laboratory, Glasgow.
6. Graywacke (302/74), Valley Ford, Sebastopol quadrangle, Sonoma County, Calif. (Bloxam, 1956, p. 493). Anaysis by E. H. Oslund.

7-12. By rapid rock analysis method described in U. S. Geol. Survey Bull. 1036-C Analyses by P. L. D. Elmore, I. H. Barlow, S. D. Botts, and Gillison Chloe. H_2O treated as combined water in calculating molecular norms.

7. Franciscan graywacke (59-76) from saddle 4,900 ft N. 54° W. of Bummer Peak, Skaggs Springs 7½-minute quadrangle, NE¼ of Skaggs quadrangle, Sonoma County, Calif.
8. Franciscan graywacke (59-108) from 450 ft N. 40° W. of "peak 1135" near center of east edge of Skaggs Springs quadrangle, Sonoma County, Calif.
9. Franciscan graywacke (59-358) from 3,150 ft S. 85° W. of Gabes Rock, Cazadero 7½-minute quadrangle, SE¼ of Skaggs quadrangle, Sonoma County, Calif.
10. Franciscan (coastal belt) graywacke (59-337) from saddle 1,200 ft south of The Nubble, Tombs Creek 7½-minute quadrangle, NW¼ of Skaggs quadrangle, Sonoma County, Calif.
11. Franciscan (coastal belt) graywacke (59-119) from ridge 7,000 ft N. 62° E. of Reese Gap, Skaggs Springs quadrangle, Sonoma County, Calif.
12. Franciscan (coastal belt) graywacke (59-308) in canyon of Wheatfield Fork of Gualala River at north boundary of Tombs Creek quadrangle, Sonomo County, Calif.
13. Franciscan graywacke (80-RGC-58-1), 4,000 ft N. 25° W. of Blunt Point Lighthouse, Angel Island, Marin County, Calif. By rapid rock analysis method. Analysis by P. L. D. Elmore, S. D. Botts, I. H. Barlow, and M. D. Mack.
14. Franciscan graywacke, Quarry Point, Angel Island, Marin County, Calif. (Bloxam, 1960, p. 559). Analysis by T. W. Bloxam.

15-21. By rapid rock analysis method described in U. S. Geol. Survey Bull. 1036-C. Analyses by P. L. D. Elmore, S. D. Botts, I. H. Barlow, and Gillison Chloe.

15. Schistose graywacke (S-39-A), on shore 750 ft southeast of Campbell Point, Angel Island, Marin County, Calif.
16. Franciscan graywacke (SF-373) near sea level 3,350 ft east of Lands End, San Francisco North quadrangle, San Francisco, Calif.
17. Franciscan graywacke (SF-2114), west side U. S. Highway 101, at a point 5,050 ft northwest of lighthouse at Lime Point, San Francisco North quadrangle, Marin County, Calif.
18. Arkosic graywacke (SF-2122), Franciscan(?), quarry 4,100 ft east from "peak 1314," San Bruno Mountain, San Francisco South quadrangle, San Mateo County, Calif.
19. Franciscan volcanic graywacke (SF-2140), north side of intersection of Masonic and Roosevelt Aves., San Francisco, Calif.
20. Franciscan graywacke (SF-2141), east side of Laguna Honda, San Francisco, Calif.
21. Franciscan graywacke (SF-2148), 200 ft west of Kearny Street and 50 ft south of Francisco Street, Telegraph Hill, San Francisco, Calif.

[a] Total of original analysis which reports all oxides to 0.01.
[b] Also contains BaO 0.04, ZrO_2 0.05, and SO_3 0.15.
[c] Also contains ZrO_2 0.04.

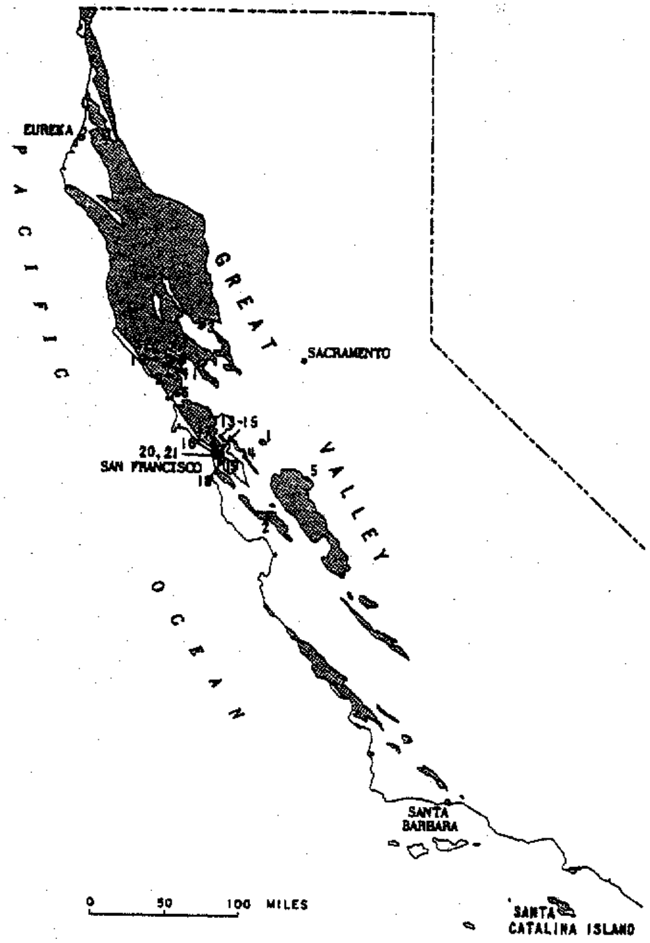


Figure 7. Location of analyzed graywackes listed in table 1.

weight percent of the oxides to equivalent molecular proportions by dividing by the molecular weight of a single-cation oxide: e.g., for SiO_2 one simply divides by the molecular weight of silica, but for Al_2O_3 one divides by the molecular weight of $AlO_{3/2}$, etc. (In this step one may also multiply each component by 1,000 to eliminate decimals.) All the hydrogen of combined water is considered to be in the form of (OH) ions in the rock, so it, as well as other rarer constituents such as F and Cl, are regarded as anions and therefore not included. When the equivalent molecular proportions of the cations have been obtained, they are summed, and each is divided by the sum, thus yielding the percent of each cation in a unit volume and in a total of 100 cations. These cations can then be readily combined to form various minerals, and a systematic procedure for making the combination to yield a standard "catanorm" is given by Barth (1955). Because the cations are made initially to total 100 percent, the minerals made into an assemblage that utilizes all the cations will also total 100 percent. This method of recasting an analysis into normative minerals is appreciably faster than the C.I.P.W. method, but its greatest advantage is the ease with which the cation proportions can be recast into the different normative mineral assemblages that most closely approximate the actual mineral assemblages of different analyzed rocks. The final results are usually expressed, as they are in this report, as molecular norms, which differ only slightly from weight norms and are equally suitable for construction of the various types of diagrams used to compare some, or all, of the components of analyzed rocks.

The standard catanorms calculated from the graywacke analyses are useful for comparative purposes, but, because they are designed to represent the mineral assemblages that might result from the cooling of a magma of the same composition, they do not give a proper picture of the mineral components actually present in the graywacke. For example, nearly

Table 2. Comparison of Franciscan graywackes with other graywackes.

	1	2	3	4	5	6
SiO_2	67.5	64.2	64.7	68.1	71.1	69.7
TiO_2	0.5	0.5	0.5	0.7	0.5	0.6
Al_2O_3	13.5	14.1	14.8	15.4	13.9	14.3
Fe_2O_3	1.2	1.0	1.5	1.0	tr	1.0
FeO	3.0	4.2	3.9	3.4	2.7	2.5
MnO	0.1	0.1	0.1	0.2	0.05	0.1
MgO	2.2	2.9	2.2	1.8	1.3	1.2
CaO	2.4	3.5	3.1	2.3	1.8	1.9
Na_2O	3.6	3.4	3.1	2.6	3.7	3.5
K_2O	1.7	2.0	1.9	2.2	2.3	2.4
H_2O+	2.5	2.1	2.4	2.1	1.9	1.9
H_2O-	0.4	0.1	0.7		0.26	0.4
CO_2	0.8	1.6	1.3	--	0.12	0.1
P_2O_5	0.1	0.1	0.2	0.2	0.1	0.2
Total	99.5	99.8	100.4	100.0	99.8	99.9
MOLECULAR NORM-CATANORM						
Q	31.3	25.7	30.1	34.3	32.4	32.7
or	10.6	12.0	11.5	13.5	14.0	14.5
ab	33.8	31.5	29.0	24.5	34.5	33.0
an	6.2	6.5	6.0	10.5	7.5	8.0
C	4.0	4.6	6.3	5.7	3.0	3.5
en	6.3	8.2	6.4	5.2	3.6	3.4
fs	3.1	5.4	4.6	3.6	3.8	2.2
mt	1.3	1.0	1.6	1.2	--	1.2
il	0.8	0.6	0.6	1.0	0.6	1.0
ap	0.4	0.3	0.5	0.5	0.3	0.5
cc	2.0	4.2	3.4	--	0.2	0.2
MOLECULAR NORM—MAKING USE OF COMBINED WATER						
Q	31.5	28.2	30.3	35.4	31.1	31.4
or	3.5	1.5	--	--	13.0	11.5
plag	40.0	40.0	35.0	35.0	42.0	41.0
chl	7.9	11.4	9.1	7.4	6.1	4.6
kaol	2.4	--	3.4	0.6	5.2	4.6
ms	9.8	14.7	16.1	18.9	1.4	4.2
mt	1.3	1.0	1.6	1.2	--	1.2
il	0.8	0.6	0.6	1.0	0.6	1.0
ap	0.4	0.3	0.5	0.5	0.3	0.5
cc	2.0	4.2	3.4	--	0.2	0.2
%An in plag	15.5	16.2	17.1	30.0	17.8	19.5

1. Average of 21 Franciscan graywackes included in table 1 of this report.

2. Average graywacke (Pettijohn, 1949, p. 250).

3. Average of 23 graywackes (Pettijohn, 1957, p. 307). Omitted from analysis and total is SO_3 of 0.04.

4. Average of 30 graywackes (Tyrrell, 1933, p. 26). Fe_2O_3 modified to give correct summation.

5. Composite of 20 Wellington graywackes, New Zealand (Reed, 1957, p. 22).

6. Average of 14 New Zealand lower Mesozoic "Alpine" graywackes (Reed, 1957, p. 22).

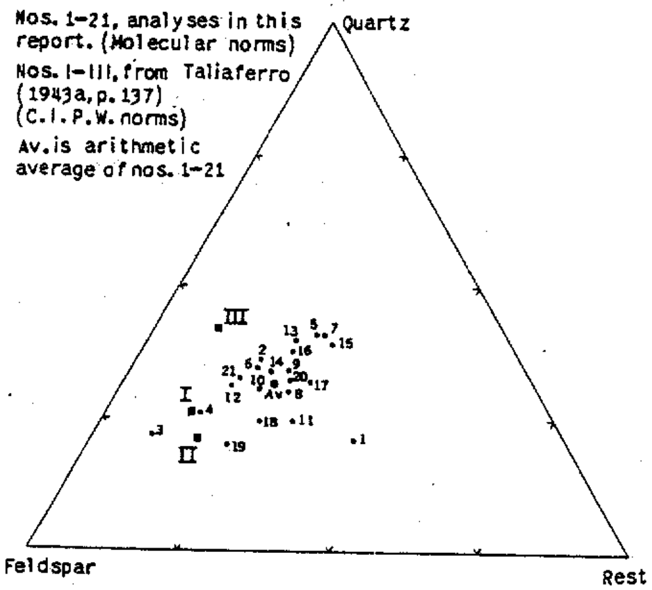


Figure 8. Ternary diagram showing normative quartz, feldspar, and "rest" in 24 Franciscan graywackes.

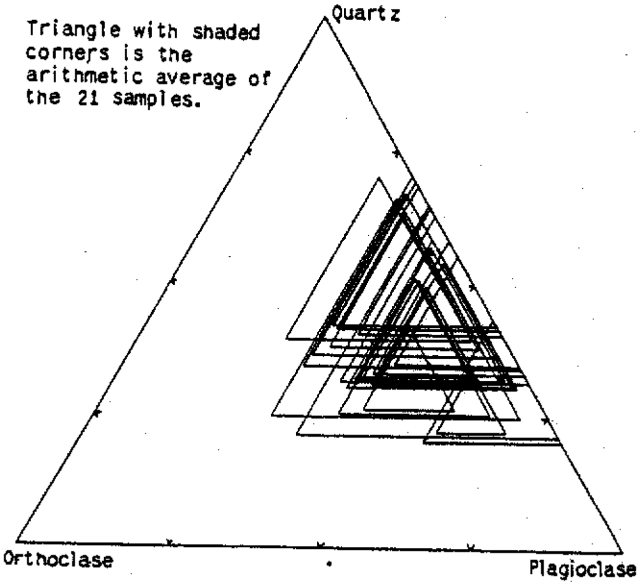


Figure 9. Ternary diagram showing normative quartz, orthoclase, plagioclase, and "rest" in 21 Franciscan graywackes.

all of the molecular norms contain corundum (C), which does not mean the sediments contain corundum but instead indicates an excess of alumina over that required to form feldspars from the alkalies. In addition, all of the analyses show normative orthoclase, yet staining of the samples has indicated that the potassium in most is not present in feldspar but rather, in such minerals as muscovite, celadonite, or a K-bearing clay mineral.

To give a closer approximation of the mineral composition of the graywackes, we have calculated the other molecular norms shown on tables 1 and 2 using a theoretical chlorite $[3(Mg,Fe)\cdot 2Si\cdot 4(OH)]$ muscovite $[K\cdot 3Al\cdot 3Si\cdot 2(OH)]$, and kaolinite $[Al\cdot Si\cdot 2(OH)]$. To form these hydrous or (OH)-bearing minerals requires the use of the water, which is not used in calculating the standard catanorm; but, making use of the water permits one to establish a balance between muscovite, orthoclase, and kaolinite. The resultant molecular norm is a better approximation of the actual mineral content of the graywacke, but as no K is assigned to celadonite, illite, or other K-bearing clay, there is too much normative muscovite, or in some cases, too much orthoclase.

The molecular norms calculated by this method have been used to construct two ternary diagrams, figures 8 and 9, which serve to give a visual impression of the components and variations in Franciscan graywacke.

Figure 8, on which the corners are quartz, total feldspar, and "rest," indicates the ratio of quartz to total feldspar, including the feldspar in rock fragments as well as in monomineralic grains, ranges from 3:2 to 1:3. It also shows the mafic components range from 10 to 32 percent, although the inclusion of 13.6 percent calcite with the "rest" of one of the samples makes it appear to have 44 percent mafics. Other norms and modes gleaned from the literature are also shown in the diagram.

Figure 9, with corners of quartz, orthoclase, and plagioclase, shows each sample as a triangle, with the side opposite a corner indicating the percent of that corner component. As the values used for quartz, orthoclase, and plagioclase are true percents, rather than recalculated so as to add to 100 percent, the size of the triangle indicates the amount of other components. The range in quantity of each of the apex components can be read from the diagram, and it is interesting that there is no apparent trend toward a change in the mafic, or "rest," component with a change in any of the other three main components.

As these diagrams are almost entirely based on recalculation of analyses they may not accurately represent the exact mineral composition of any of the rocks, but, owing to the difficulties of making precise point counts of sections, or grain counts based on mineral separations, the results may be as accurate as modal analyses. In any event, they show well the range in mineral composition present in the Franciscan graywackes.

Origin. In summary, graywackes of the Franciscan eugeosynclinal assemblage are similar in texture and composition to orogenic, eugeosynclinal deposits found in other parts of the world. The vast volume of terrigenous material, as well as the great thickness locally of individual beds and the presence of a high matrix-content, points to a very rapid deposition or "pouring-in" of the sedimentary material. The absence of interlayered limestone or calcareous cement in most of the Franciscan also suggests continuous and rapid deposition. Lack of rounded quartz and feldspar grains, as well as the high percentage of labile rock fragments, indicates rapid mechanical erosion of a nearby source area. The low Fe_2O_3/FeO ratio and paucity of interlayered clay beds also indicate the lack of chemical weathering in the source area. Apparently marine conditions prevailed throughout the deposition of Franciscan rocks, and, although graded beds and sole markings are not commonly seen, the sandstone textures, the lack of large-scale crossbedding and ripple marks, as well as the absence of an indigenous shelly fauna, point to turbidity current and fluxo-turbidity current deposition in a deepwater environment (Dzulynski and others, 1959). A few scattered observations show a general north-south orientation of current-produced sole markings, but reliable observations showing current direction are so few that no conclusion regarding direction of source should be made now on this basis.

The nature of the source area from which the Franciscan sediments were derived is imperfectly understood. The lithic fragments indicate a mixed crystalline and sedimentary terrane, and the presence locally of volcanic-rich graywacke and tuffaceous beds points to a volcanic source for some of the sediments. Much of the latter material, however, may have been derived from penecontemporaneous, intra-Franciscan volcanism.

The Franciscan graywacke is similar to other graywackes in having a K_2O/Na_2O ratio of less than 1.0 (Pettijohn, 1957; Middleton, 1960, p. 1017), and in having albite as the dominant feldspar. The reason for the low K_2O/Na_2O ratio, both in the Franciscan and other similar units, is not understood, but Middleton (1960, p. 1017, 1018) has suggested the three following possible explanations:

1. Soda-rich source rocks. Alkaline granite, quartz diorite, granodiorite, andesite, basalt, spilite, and granite gneiss would provide a ratio of less than 1.0.
2. Regional soda metamorphism. Little support is given to this idea because of the lack of petrographic evidence pointing to this mechanism.
3. Incomplete weathering of source rocks. Little favor is given this concept because K-feldspars are more resistant to normal weathering than are plagioclase feldspars, and Na_2O is removed from rocks during weathering at least as rapidly, and commonly more rapidly, than K_2O.

To this list should also be added the possibility of derivation either from a suite of older eugeosynclinal rocks with similar characteristics, or from their metamorphosed equivalents.

Middleton (1960, p. 1018) concludes that "* * * the peculiar characteristics of high-rank graywackes are a result of a partial volcanic (spilitic) provenance, combined with rapid erosion and little chemical weathering." This statement is obviously applicable to the Franciscan graywackes, but certainly does not explain fully their anomalous composition.

Alteration. Much of the Franciscan graywacke has not been appreciably altered or sufficiently metamorphosed for it to contain discernible new minerals or to have developed schistosity. In some areas, however, the graywacke has been subjected to various kinds of alteration, more drastic than those that can be attributed to diagenesis. One cannot always be sure what kind of alteration is involved, and some of the most carefully studied changes have been ascribed to different types of metamorphism or alteration by different geologists. However, there is general agreement that regional or load metamorphism, contact metamorphism, pneumatolytic alteration, and hydrothermal alteration have each affected the graywackes in certain local areas. The most widespread alteration of the graywacke is the result of regional or load metamorphism, but, as this type of metamorphism also affects the other rocks of the assemblage, it is discussed at considerable length under the separate heading of *Metamorphic rocks*. In this part of the text, some metagraywackes formed by regional metamorphism are mentioned briefly because they resemble the unaltered graywacke so closely that their metamorphic character may not be recognized; however, the main discussion here will deal with the alterations brought about by processes that are more local.

Regional metamorphism of Franciscan graywacke under conditions of only static load and deep burial may result in the formation of nonschistose rocks, which superficially appear unmetamorphosed but are properly assigned to either the zeolite or blueschist metamorphic facies. Graywackes that should be assigned to the zeolite facies can generally be recognized by the presence of white, sugary veins of laumontite. Graywackes that have been subjected to blueschist facies metamorphism may contain either jadeite or glaucophane, depending on how soda released by the breakdown of plagioclase has been recombined. Metagraywackes containing glaucophane are normally recognizable because even a little glaucophone gives the rocks a bluish cast, but unsheared graywackes that are extensively jadeitized are not readily recognized. They are, however, heavier than normal graywacke, and we have found that all graywackes with a specific gravity greater than 2.70 contain metamorphic minerals and are really metagraywackes.

Graywacke altered by contact metamorphism is rare, as are situations where one might expect this kind of alteration. Virtually no granitic rocks intrude the Franciscan graywacke, intrusive Franciscan mafic rocks are uncommon, as are more acid Tertiary intrusives, and apparently most of the ultramafic masses were injected plastically as serpentine at temperatures far below their melting point. However, Chesterman (1960) has carefully described graywacke at Leech Lake Mountain (Covelo quadrangle) in which new minerals are formed by contact metamorphism along the margins of serpentinized peridotite sills. He found that in the graywacke within a foot of the ultramafic intrusive diopside-jadeite is abundant, and mafic rock fragments have been destroyed; at about a foot from the contact the pyroxene is aegirine and minor blue amphibole is present. Three feet from the contact glaucophane has given way to actinolite, and 15 feet from the contact a blue-green hornblende is present. In this area other graywacke engulfed in the peridotite has been converted to rodingite containing a diopside-jadeite-acmite pyroxene. The development of a little blue amphibole in the contact rocks is of particular interest, as many geologists have attributed the orgin of the glaucophane schists of the Coast Ranges to metamorphism that is related to mafic and ultramafic intrusives, though they also generally suggest that the process is pneumatolytic and involves the introduction of material.

Pneumatolytic alteration of graywacke, involving introduction or loss of elements, may be difficult to distinguish from regional metamorphism, in which there is often some limited migration of elements but no overall change in the chemical composition of the entire rock mass. The formation of glaucophane schists has been attributed by Taliaferro (1943b, p. 175) and others to pneumatolytic alteration, but it is the writers' belief that analyses generally indicate these schists are comparable in chemical composition to the rocks from which they were derived (table 14a and b). These glaucophane-bearing metagraywackes and schists are therefore treated as products of isochemical reactions in the later section on metamorphic rocks. Veins of quartz, calcite, albite, and adularia occur rather commonly in the Franciscan graywackes, and they too have been cited as evidence of pneumatolytic alteration. However, these veins can be equally well explained as resulting from local solution of minerals in the graywacke, and they may provide one of the earliest indications of load metamorphism. The veins are most common in areas containing some metamorphic rocks but are more widespread than the limits of regionally metamorphosed graywacke now recognized. Unfortunately, no one has yet systematically mapped their distribution even throughout the extent of a single 15-minute quadrangle. Though pneumatolytic alteration appears to us to be uncommon, some unusual Franciscan rocks have unquestionably been enriched in boron. The most striking examples are tourmalinized graywackes at the East Peak of Mount Tamalpais, in Marin County, mentioned by Rice (1960). In the most altered graywacke, tourmaline amounts to more than 50 percent, and adularia is also a major constituent. As the rocks are vuggy, they are believed by Rice to have been altered when at shallow depth. Another boron-bearing silicate, axinite, has been found in veins with prehnite a few miles farther west at Stinson Ranch. Axinite veinlets also are reported to occur in the Trout Creek manganese mine ores, Black Rock Mountain quadrangle, Trinity County (Hewett and others, 1961, p. 58). In none of these areas is there any nearby intrusive igneous rock that can be regarded as the source of the boron.

Hydrothermal alteration has modified Franciscan graywacke over areas ranging in size from a few square feet to nearly a square mile (Bailey, 1946, p. 214; Yates and Hilpert, 1945, p. 22, 1946, p. 253). Most of the larger areas of alteration are in the vicinity of mercury deposits, but some that are obviously related to Tertiary volcanism contain no known mercury minerals, and still other, generally small, areas can be related only to fault zones. In the Eastern Mayacmas mercury district, Lake and Napa Counties, hydrothermally altered graywacke is widespread and particularly well developed near the Oat Hill mine. In the Western Mayacmas district altered graywacke occurs about some of the mercury mines, but the alteration is considerably more pronounced along a zone of more recent hydrothermal activity that includes The Geysers and the Little Geysers but contains only minor amounts of mercury. In Lake County hydrothermally altered graywacke is prominent along a fault that extends from Bartlett Springs northwest to Crabtree Hot Springs in Lake Pillsbury quadrangle. The alteration seems to have been most intense near Bartlett Springs, but only at Crabtree Hot Springs has a little quicksilver and arsenic mineralization been noted (Fairbanks, 1893b, p. 61).

Areas of hydrothermal alteration can generally be recognized readily, because the alteration leads to a bleaching of the graywacke, and also, in most areas, to the development of closely spaced veinlets of quartz, ferroan dolomite, calcite, or siliceous limonite. The bleaching of the rocks is a result of removal of iron, which may go into a carbonate, or an oxide, or combine with sulfur to form pyrite. A more subtle and more pervasive change is the alteration of the feldspars to clay minerals, and, in the most extreme alteration, quartz is lost so that the final product is largely clay. The particular clay mineral formed is different from place to place, but the clays from only a few areas have been adequately studied. Pre-1950 reports refer to kaolin or kaolinitization, but because these minerals were identified without benefit of X-ray techniques, they probably should be discounted. We found that greasy graywacke from the Culver-Baer mine, Sonoma County, consisted largely of montmorillonite, with minor kaolinite and chlorite. Julius Schlocker (oral communication, March 1961) found that in the San Francisco area some graywackes have been completely altered to kaolinite group minerals, others contain abundant montmorillonite, and in still others the end product is a chlorite rock, or a mixture of chlorite, random layered chlorite and mica, and talc. He also found that pyrite is generally formed as a result of hydrothermal alteration. D. E. White (oral communication, March 1961) reports yet a different type of hydrothermal alteration at the Sulphur Bank mine, Lake County, where clays are absent below the water table, but where an ammonium-bearing mineral, apparently a feldspar[1] or zeolite, has replaced the origi-

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[1] A new mineral, named buddingtonite; see Erd, R.C., and others: Am. Mineralogist, v. 49, p. 831-850.

nal plagioclase of the graywacke. In The Geysers area, in eastern Sonoma County, J. R. McNitt (written communication, 1961) found acid leaching in the oxidation zone converted Franciscan graywacke into a porous mass of alunite, opal, and residual quartz; below the oxidation zone the hydrothermal alteration of the graywacke resulted in the formation of pyrite, the growth of sericite in the groundmass and feldspar grains, and the deposition of calcite and quartz in fractures. Both kaolinite and dickite were identified in muds thrown from the steam wells.

Shale

Shale, including siltstone, probably amounts to about 10 percent of the Franciscan sedimentary rocks. It has been so little studied that no definitive description is now possible nor is the relative abundance of siltstone and claystone known. It is obvious, however, that there are two unlike and readily distinguishable varieties of shale—a dark-gray to black variety occurring chiefly interbedded with graywacke, and a red or green ferruginous variety occurring interbedded with chert. Because the latter is restricted in its distribution and clearly has an origin closely related to that of the chert, it is discussed in this report along with the cherts and is omitted from the following description.

Occurrence and megascopic features. The Franciscan shale, though generally dark gray or black, is in some places a grayish tan or even olive color, and these rocks tend to weather to still lighter shades. However, weathered shale usually is not seen in outcrop because of soil cover, and natural exposures that are predominantly shale are uncommon. Shale is best seen where it forms thin seams between much thicker layers of graywacke, but locally it forms units a few feet thick. Sections of still greater thickness with only a few interbeds of graywacke are unusual in the Franciscan, but some beds as much as 500 feet thick have been reported. Where shale is especially abundant it forms a zone of structural weakness that is readily crumpled and sheared, and in many roadcuts what may once have been sections of shale a few hundred feet thick are now seen to be so disturbed that no estimate of initial thickness is possible. Widespread shearing may also partly account for the general absence of graded bedding, which seems to be common only in the somewhat unusual, graywacke-shale sequence east of Mount Hamilton.

The shales are normally fissile and dull in luster, but in some areas they are phyllitic and shiny, apparently because of an increase in the size of micas. Although the shales are highly folded in many places, slaty cleavage has been observed only in western Tehama County in an area where the graywacke has been converted to a semischist.

Microscopic features. Mineralogically the Franciscan shales seem to be quite similar to the graywackes, with a high proportion of angular mineral or rock fragments and only a small amount of clay minerals. The mineral grains that can be identified in

Table 3. Analyses of shales accompanying graywackes in the Franciscan.

	1	2	3	4	5	6
SiO_2	62.54	63.2	60.0	67.1	63.2	58.51
TiO_2	0.87	0.68	0.73	0.55	0.71	0.66
Al_2O_3	14.81	16.1	18.1	13.6	15.7	15.55
Fe_2O_3	2.02	0.7	1.0	1.3	1.3	4.03
FeO	5.47	4.9	5.0	3.5	4.7	2.50
MnO	0.05	0.09	0.11	0.06	0.08	tr
MgO	3.38	3.1	2.9	2.4	3.0	2.44
CaO	1.40	1.1	1.1	2.6	1.5	2.99
Na_2O	2.90	2.4	1.8	1.4	2.1	1.28
K_2O	2.13	2.5	3.2	2.0	2.4	3.28
H_2O+	2.91	3.7	4.4	4.0	3.7	3.69
H_2O-	0.82	0.49	0.64	0.10	0.52	1.31
CO_2	0.08	--	0.10	--	0.04	2.51
P_2O_5	0.15	0.20	0.17	0.19	0.18	0.17
S	0.05	0.22	0.34	0.39	0.25	0.22
Organic	0.96	--	--	--	--	--
Subtotal	100.54	99.4	99.6	99.3	99.4	99.14
Less O=S	0.03	0.11	0.17	0.19	0.13	0.11
Total	100.51	99.3	99.4	99.1	99.3	99.03
MOLECULAR NORM–CATANORM						
Q	26.3	29.6	27.6	41.2	31.2	35.2
or	13.5	15.5	20.5	12.5	15.5	21.0
ab	27.5	23.0	17.5	13.5	20.4	12.5
an	6.0	4.5	4.5	12.5	6.9	--
C	6.5	9.2	11.8	5.8	8.3	11.6
en	9.8	9.2	8.6	7.2	8.7	6.6
fs	6.4	6.2	6.0	3.4	5.5	--
mt	2.2	0.7	1.2	1.5	1.4	4.2
il	1.2	1.0	1.0	0.8	1.0	1.0
hm	--	--	--	--	--	0.2
py	--	0.6	0.9	1.0	0.6	0.6
ap	0.3	0.5	0.3	0.5	0.4	0.3
cc	0.2	--	0.2	--	0.1	6.0
$MgCO_3$	--	--	--	--	--	0.8
MOLECULAR NORM-USING COMBINED WATER						
Q	27.9	29.3	26.5	42.1	31.5	33.1
plag	33.5	27.5	22.0	26.0	27.2	12.5
musc	18.9	21.7	28.7	17.5	21.7	29.4
kaol	2.2	6.0	7.2	1.6	4.2	6.4
chl	13.5	12.6	12.1	8.9	11.8	5.5
mt	2.2	0.8	1.2	1.5	1.4	4.2
il	1.2	1.0	1.0	0.8	1.0	1.0
hm	--	--	--	--	--	0.2
py	--	0.6	0.9	1.0	0.6	0.6
ap	0.3	0.5	0.3	0.5	0.4	0.3
cc	0.2	--	0.2	--	0.1	6.0
$MgCO_3$	--	--	--	--	--	0.8

1. Franciscan black siltstone (NA-315) from Fern Hill, New Almaden district, Santa Clara County, Calif. Analysis by Mrs. A. C. Vlisidis, U.S. Geological Survey.

2-4. By rapid rock analysis method described in U.S. Geol. Survey Bull. 1036-C. Analyses by P. L. D. Elmore, S. D. Botts, I. H. Barlow, and Gillison Chloe.

2. Franciscan siltstone (SF-1140) from North Broadway Tunnel at a point 150 ft east of center line of Jones Street, San Francisco, Calif.

3. Franciscan shale (SF-2126) from quarry 1200 ft NW of Point San Pedro, San Quentin quadrangle, Marin County, Calif.

4. Franciscan metashale, south side of State Highway 152 at B.M. 950, 2,800 ft W. of east edge of Pacheco Peak quadrangle, Santa Clara County, Calif.

5. Average of 1-4.

6. Average of 78 shales (Clarke, 1924, p. 631). Not included are 0.05 BaO and 0.81 C.

thin section are the same as those in the graywacke, being chiefly quartz and feldspar, and fine-grained chlorite and sericite. The principal clay-size constituents were determined by X-ray on about two dozen samples from the San Francisco area by J. Schlocker. He reports (oral communication, 1963) that in the gray, green, or black shales mica generally predominates, chlorite is normally also abundant, and kaolinite is either absent or very minor. Both the mica and chlorite may contain some expandable layers. In tan shales, which are presumed to be weathered, mixed-layer mica-montmorillonite or vermiculite predominates and may amount to as much as 90 percent of the fine fraction. Although the fresh shales are dark in color, the organic content is probably low except in those varieties showing obvious carbonized plant remains. Authigenic pyrite is rarely found. Uncommonly the shales are calcareous, and limestone nodules have been found in only a few places. Unusual phosphatic nodules were found in shales in San Francisco by Julius Schlocker (oral communication, 1962).

Chemical features. Chemical analyses of four Franciscan shales are shown in table 3, along with their average and an average of 78 other shales for comparison. Both anhydrous and hydrous norms for these are included, as it is often more convenient to compare normative minerals than oxide percents. These Franciscan shales differ from the given average shale in that they contain more silica, have a smaller potash to soda ratio, and have a ferric to ferrous iron ratio that is not only smaller but generally less than 1. In these respects Franciscan shales are more like the average Franciscan graywacke (see table 1, and fig. 14). It is interesting that in the standard catanorm all the shale samples have considerable orthoclase, but in contrast to the graywackes, all the normative orthoclase can be converted to muscovite if the combined water is used in forming a normative mineral assemblage. This is partly the result of the shales containing more combined water, but it results chiefly from their containing somewhat more alumina, which is also shown by the larger amount of corundum (C) in the standard catanorm.

Conglomerate

Conglomerates are invariably reported to be "rare" or "uncommon" in the assemblage of Franciscan rocks, but they are so widespread that they were noted in nearly every 15-minute quadrangle in which Franciscan rocks have been mapped. Their typical occurrence is as lenses a few tens of feet thick and exposed over lengths of a few hundred feet or less; however, the largest exposure reported is a lens 2,000 feet long and 75 feet thick in the section west of Mount Hamilton. Because the conglomerate is so limited in extent, none of the maps referred to in this study shows it with a separate lithologic symbol.

The matrix of the conglomerate is everywhere graywacke and is generally regarded to be the same as in the enclosing graywacke beds. The largest boulders reported have a maximum dimension of 2½ feet; the average size of the clasts is between 1 and 4 inches. No general trend toward an increase in either the average or maximum size of pebbles or boulders, either across or along the area of deposition, is apparent to us, although Taliaferro (1943a, p. 140, 143) stressed a westward coarsening as indicating derivation from a landmass to the west.

The clasts of the conglomerate can be conveniently grouped, as shown in figure 10, into one of two categories: (1) lithic types that were not formed originally as part of the Franciscan and must have been brought into the depositional area, and (2) lithic types that are present in the Franciscan and thus indicate either cannibalism of previously deposited Franciscan rocks or introduction of similar foreign rocks. Included in the first category are quartzite, black chert, and various quartz and feldspar porphyries which form a prominent part of most of the Franciscan conglomerates. Granite, quartz-diorite, and granitic rocks of intermediate composition also are assigned to the first category, because the Franciscan is not known to be intruded by granite. In the second category are included graywacke, shale, red and green chert, mafic volcanic rocks, and glaucophane schist. It will be noted in figure 10 that most conglomerates in the area south of Sebastopol contain some of these possibly intraformational rocks along with rocks of the first category, but a few Franciscan conglomerates, such as those of the Tesla quadrangle, consist entirely of rocks that could have an intraformational source. It is perhaps also significant that the areas containing conglomerates with clasts of possible intraformational origin are also the areas containing granitic pebbles and boulders.

Only unusually hard and resistant varieties of rocks comprise the clasts that must have an extraformational source, and they are invariably well rounded and in places polished. In contrast, several of the rocks of possible intraformational origin, such as the graywackes and shales which are relatively easily broken and abraded, commonly also occur as subrounded to angular fragments. The extraformational clasts have obviously been abraded much more than those of possible intraformational origin. The extraformational clasts have been transported in streams or rivers for at least tens of miles, or traveled shorter distances and become stagnant along a shoreline where they were subject to wave action, or are second generation pebbles reworked from older conglomerates. Conversely, the pebbles of possible intraformational origin have not received such intense abrasion. The origin of conglomerates composed only of the hard extraformational pebbles can be readily explained by several hypotheses, but that of conglomerates composed

Location	Maximum size in inches	Range or average size in inches	Extra-formational									Possibly intra-formational							
			Granite	Quartz diorite	Quartz porphyry	Felsic volcanics	Limestone	Arkose	Quartzite	Black chert	Vein quartz	Mafic volcanics	Colored chert	Graywacke	Shale	Conglomerate	Glaucophane schist	Schist	Serpentine
1. Blue Lake quadrangle		½-1	X		▨		X		▨	▨	X	X							
2. Lower Lake quadrangle	10									X	X	▨	X	X	X				
3. Western Mayacmas district	6				▨	▨			▨	▨		X	X	X					
4. Eastern Mayacmas district	6				▨				▨	▨									
5. Healdsburg quadrangle	6	1-6			▨						X	X							
6. Sebastopol quadrangle	<10				▨				▨	▨		X							
7. North of San Francisco Bay		>6		▨	▨				▨	▨	▨		▨	▨				▨	
8. Angel Island	12	2½			X	X		▨	▨	▨		X	▨	▨	X				
9. Mount Diablo	12	2							▨	▨		▨			X				
10. Belmont, San Mateo quadrangle	24	1½		▨				▨	▨	▨			▨	▨	X		X		
11. Montara Mtn. quadrangle										▨									
12. Pleasanton area, Livermore quadrangle			▨						▨	▨		▨							
13. Tesla quadrangle	4	<1											▨	▨	▨				
14. San Jose-Mount Hamilton quadrangle	10		▨	▨	▨				▨	▨	X			▨					
15. East half of Mount Hamilton quadrangle	12		▨	X	▨								▨	▨	▨		X	X	X
16. Mount Boardman quadrangle	18		X	X	▨		X		▨	▨	X			X	X		X	X	
17. New Almaden district	9	2			▨	▨		X	▨	▨	X	▨		▨	X	X			
18. San Juan Bautista quadrangle									▨										
19. Quien Sabe quadrangle	30	½-2	▨		▨				▨	▨	▨		▨	▨		▨			
20. San Benito quadrangle	18	2-3			▨				▨	▨				X					
21. Priest Valley quadrangle	18												▨						
22. Cape San Martin quadrangle				X			X		▨			X	X				X		
23. Cape San Martin quadrangle	8	1		X	X							X		▨	X				
24. San Simeon quadrangle	16	5	▨		X				X	X				X					
25. San Luis Obispo quadrangle			▨						▨				▨				X		
26. San Benito Island, Baja California									▨	▨		▨							

▨ = >5 percent, "abundant" or "common"

X = <5 percent, "less common" or "rare"

1. Manning, G. A., and Ogle, B. A. (1950, p. 20)
2. Brice, J. C. (1953, p. 13-14)
3. Bailey, E. H. (1946, p. 205)
4. Yates, R. G., and Hilpert, L. S. (1946, p. 236)
5. Gealey, W. K. (1951, p. 12)
6. Travis, R. B. (1952, p. 14)
7. Weaver, C. E. (1949a, p. 22; 1949b, p. 17)
8. Schlocker, Julius (oral communication, 1960)
9. Pampeyan, E. H. (oral communication, 1960)
10. Schlocker, Julius (oral communication, 1960)
11. Darrow, R. L. (1951)
12. Hall, C. A. (1958, p. 4)
13. Huey, A. S. (1948, p. 18)
14. Crittenden, M. D., Jr. (1951, p. 18)
15. Soliman, S. M. (1958)
16. Maddock, M. E. (1955)
17. Bailey, E. H. (in press)
18. Allen, J. E. (1946, p. 26)
19. Leith, C. J. (1949, p. 14)
20. Wilson, I. F. (1943, p. 196)
21. Taliaferro, N. L. (1943a, p. 142)
22. Bell, G. L. (1939)
23. Taliaferro, N. L. (1943a, p. 142)
24. Taliaferro, N. L. (1943a, p. 141)
25. Fairbanks, H. W. (1904, p. 2)
26. van West, Olaf (1958)

Figure 10. Rocks in Franciscan conglomerates.

of these and intraformational rocks are more restricted as to possible origin.

The conglomerates provide clues to the origin and depositional environment of the Franciscan assemblage of rocks even though they form a very minor part of the entire unit. The anomaly presented by the conglomerates composed of pebbles of mixed origin has been pointed out; other unusual features of the conglomerates are: (1) their very rare occurrence, both in time and space, yet widespread distribution, (2) their coarseness, especially as related to the small size of the conglomerate lenses, and (3) the unsorted or unwashed character of their matrix. The last two of these features are readily explained by postulating that the conglomerates were moved to their position by density currents moving normally to the axis of the basin. Mixed conglomerates might be expected in areas where the margin of the basin was uplifted to form a shoreline subject to wave action near the mouth of a river carrying extraformational rocks. Whatever the origin of the conglomerates, they represent an unusual event happening infrequently and at widely spaced localities, but repeated many times during the depositional period.

The presence of quartzite, black chert, and porphyries has been pointed to as an indication of a western source by Taliaferro (1943a, p. 143). We believe that the quartzite and black chert might well have been derived from erosion of Paleozoic and lower Mesozoic rocks of the western Sierra Nevada and the Klamath Mountains, or by reworking of pebbles from older formations found in these areas, as, for example, conglomerate of the Bragdon Formation of Mississippian age (Kinkel and others, 1956, p. 40). The porphyries bear some resemblance to the volcanic rocks of Jurassic age in the central Sierra Nevada, although their quartz content seems to be somewhat higher, and they also resemble the Balaklala Rhyolite of Devonian age in the Klamath Mountains (Kinkel and others, 1956, p. 17-32).

Most of the rocks that might be of intraformational origin also might have been derived from erosion of the Paleozoic and lower Mesozoic formations of the Sierra Nevada and Klamath Mountains. However, the source of some which appear on hand lens examination to be nondiagnostic probably could be determined if they were adequately studied in thin section. For example, colored cherts from pre-Franciscan rocks may contain radiolaria that differ from those in Franciscan cherts, and the mineral assemblages of some of the pre-Franciscan metamorphic rocks, if worked out in detail, doubtless will be found to differ from the assemblages found in the Franciscan. Probably the only kind of rock that can be positively identified in the field and confidently interpreted as being derived from erosion of Franciscan terrane is glaucophane schist, which is highly uncommon in the Sierra Nevada and Klamath Mountains, although parts of the South Fork Mountains contain crossite-epidote schist. However, jadeitized graywacke would have the same significance, if it could be recognized.

Glaucophane schists are reported to be present in the conglomerate in the area east of Mount Hamilton (Maddock, 1955; Soliman, 1958), in Belmont and San Carlos (Schlocker, oral communication, 1960), and in the core of Mount Diablo (Davis, 1918b); we have also found these schists in the New Idria diapiric mass and in the massive conglomerate of the "coastal belt rocks" along Buckeye Creek (Hopland quadrangle) in northern Sonoma County. These occurrences seem to offer evidence of intraformational erosion and redeposition of preexisting Franciscan rocks in younger parts of the same unit. Further, considering the overall rarity of glaucophane schist in the Franciscan terrane, it is a reasonable inference that Franciscan conglomerates containing pebbles of glaucophane schist also contain a larger proportion of other intraformational rocks, even though these cannot be so positively identified.

VOLCANIC ROCKS

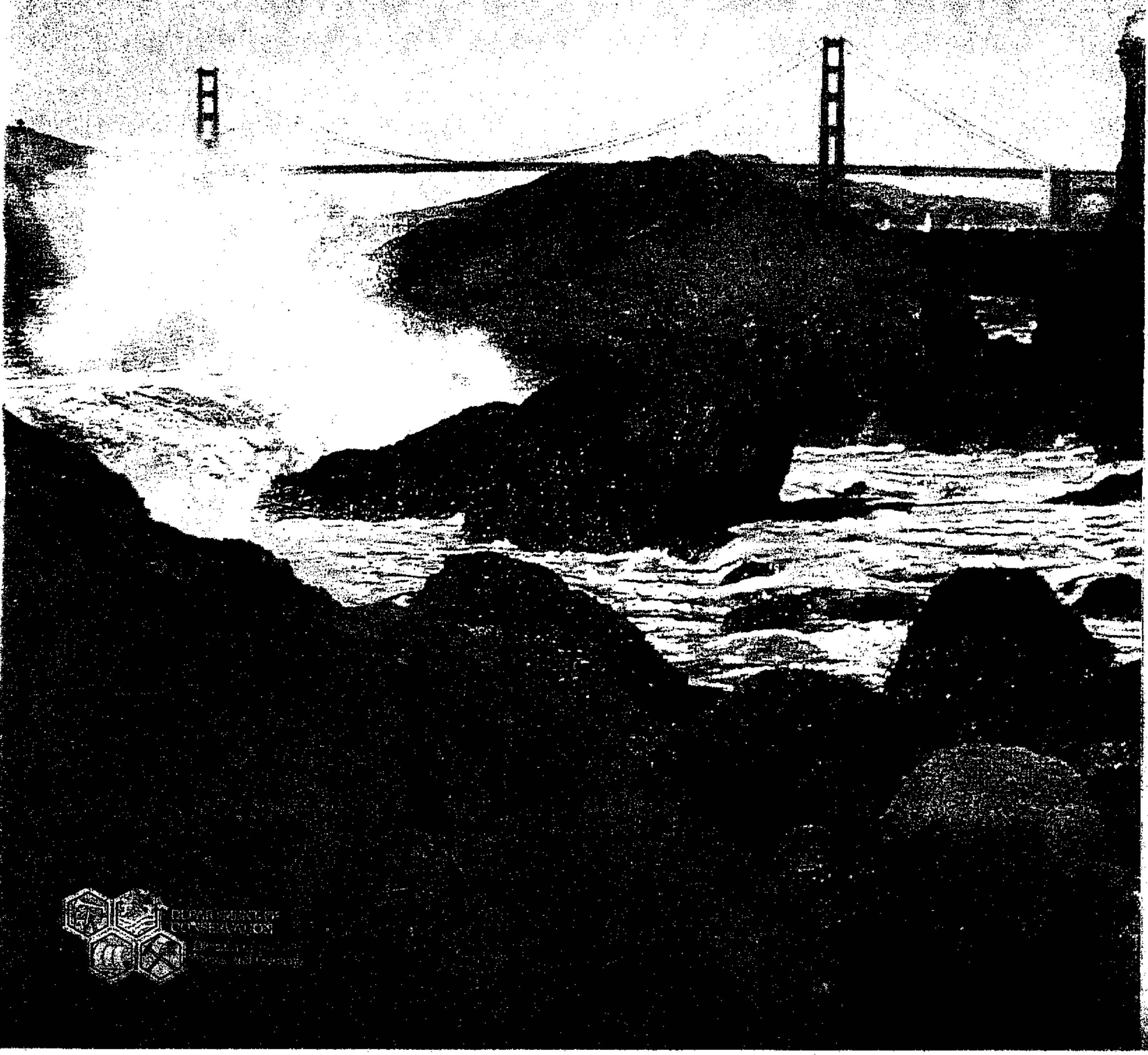
Occurrence and megascopic features. Volcanic rocks, which probably comprise about 10 percent of the Franciscan eugeosynclinal assemblage, are widespread, but as they are somewhat erratically distributed in space, and probably also in time, the quantity present in any area the size of a 15-minute quadrangle ranges from as little as 1 percent to as much as 30 percent of the Franciscan exposure. Although considerable uncertainty exists regarding the relative ages of the various exposed sequences of Franciscan rocks, the volcanic rocks seem to be least common in an old part of the Franciscan lying east of Mount Hamilton and in the young "coastal belt" of Bailey and Irwin (1959). The relative abundance of volcanic rocks within the Franciscan geosyncline shows no systematic variation from east to west or north to south.

The volcanic rocks clearly include large amounts of both massive and fragmental types, but their original character in many places is difficult to ascertain because of their altered and broken condition. Pillow lavas are common and widely distributed. Although some sequences hundreds of feet thick clearly consist entirely of pillows, the more common exposures of greenstone contain distinguishable pillows only here and there, and the character of the rest of the mass is uncertain. Masses described as flows are generally so regarded simply because they do not show features diagnostic of their true origin. Others described as sills, for example the main "sill" on Angel Island (Ransome, 1894), have been found later to contain pillow structure, suggesting an extrusive origin. Good exposures of pillows can be seen along the west side of U.S. Highway 101, 1½ miles north of the Golden Gate Bridge, at Squaw Rock 5 miles south of Hopland, or in quarries 5 miles south of Willits. Other thick volcanic sequences are largely tuffs or tuff breccias made up of altered mafic glass and fine-grained vesicular basalt and show only crude bedding and sorting. Good examples can be seen along Los Gatos Creek just south of Los Gatos (Los Gatos quadrangle), or near Bodfish Creek in the San Juan Bautista quadrangle (Allen, 1946, p. 23).

DFG EXHIBIT 11

GEOLOGIC FIELD TRIPS IN
NORTHERN CALIFORNIA

Centennial Meeting of the Cordilleran Section
of the Geological Society of America



DEPARTMENT OF
CONSERVATION
Division of
Mines and Geology

THE SAN ANDREAS FAULT ZONE NEAR POINT REYES: LATE QUATERNARY DEPOSITION, DEFORMATION, AND PALEOSEISMOLOGY

Karen Grove,[1] Tina M. Niemi [2]

INTRODUCTION

This field trip will examine late Quaternary sedimentary deposits along a section of the San Andreas Fault (SAF) that lies in a valley between the Point Reyes Peninsula and Bolinas Ridge (Figure 1). The Point Reyes Peninsula (west of the fault valley) is part of the Salinian terrane, a displaced fragment of continental crust that consists of Cretaceous plutonic and older metamorphic rock overlain by lower Eocene to Pliocene marine sedimentary rocks (Clark and Brabb, 1997). Bolinas Ridge (east of the fault valley) consists of highly deformed Mesozoic Franciscan subduction-complex rock. Because of persistent right-lateral displacement, the SAF juxtaposes bedrock units that have been offset by at least 300 km.

The SAF at this location was last active during the 1906 San Francisco earthquake, when maximum horizontal displacement of about 5 m was measured by G.K. Gilbert near Olema (Lawson, 1908). Niemi and Hall's (1992) paleoseismology study on the 1906 trace south of Olema revealed a time-averaged minimum dextral slip rate of 24±3 mm/yr during the past 2,000 years and an average recurrence interval for large earthquakes of 221±40 yr. The 1906 SAF trace lies in the center of the valley whose edges are defined by additional faults that Galloway (1977) named the eastern and western boundary faults (Figure 1C). These faults probably extend the length of the valley, although in places they are obscured by alluvial fan, stream or landslide deposits, or by vegetative cover.

The narrowest part of the SAF valley, at Five Brooks (Figure 1C), is the north end of a topographic and structural high where Franciscan basement is exposed at the land surface and overlain to the south by the Plio(?)-Pleistocene Merced Formation, a shallow-marine deposit (Figure 2). North of Five Brooks, basement is mostly covered by a suite of late Quaternary sediments deposited in the SAF zone during a time of climate change and fault-related deformation.

This trip will focus on two late Pleistocene formations—the Millerton Formation (MF) and Olema Creek Formation (OCF)—and late Holocene deposits. The MF and OCF were deposited at seaward and landward ends of a paleoestuary; the transition between them is covered by younger sediments (Figure 2). The deposits have been incised and are now exposed in creek beds and Tomales Bay headlands. The MF and OCF provide a record of post-130 ka deposition and deformation in the fault zone. Late Holocene nonmarine deposits have been trenched to evaluate fault offset and deforma-tional style. They provide a record of recent deposition and deformation in the fault zone.

FIELD STOP DESCRIPTIONS AND ROAD LOG

Road log begins at the intersection of State Highway 1 and Dillon Beach Road, in the village of Tomales.

Miles	Cum Miles	Location
0.0	0.0	In Tomales, head west from Highway 1 onto Dillon Beach Road.
2.0	2.0	Turn left from Dillon Beach Road and go through the gate onto a dirt road. NOTE: Permission must be obtained from Audobon Canyon Ranch (ACR)

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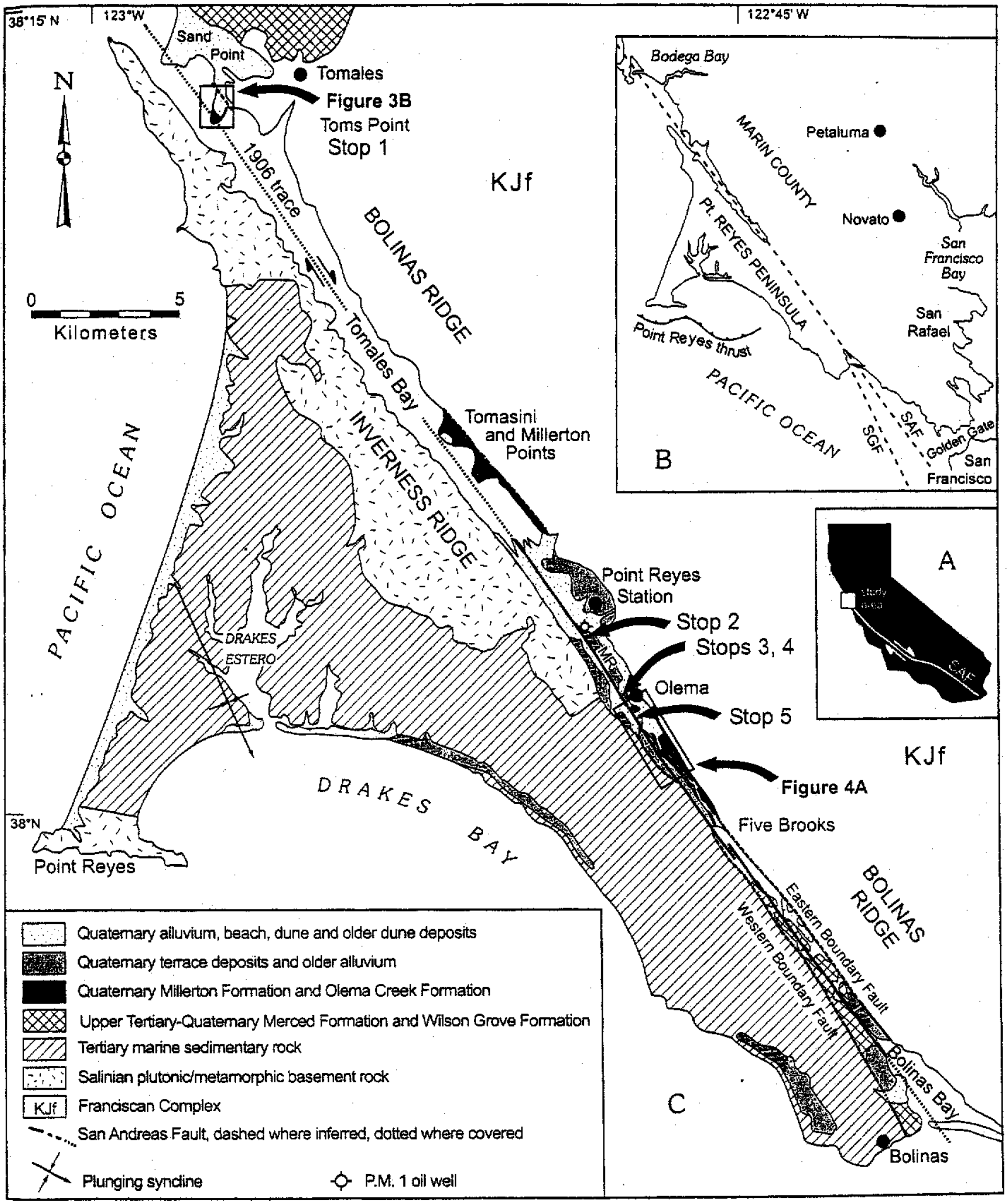


Figure 1. (A) Location of study area in California. SAF=San Andreas Fault. (B) The Point Reyes Peninsula, separated from Marin County mainland by SAF. The San Gregorio Fault (SGF) joins SAF south of study area. Offshore faults from McCulloch (1989). (C) Generalized geology map modified from Galloway (1977), Clark and Brabb (1997). MR, medial ridge.

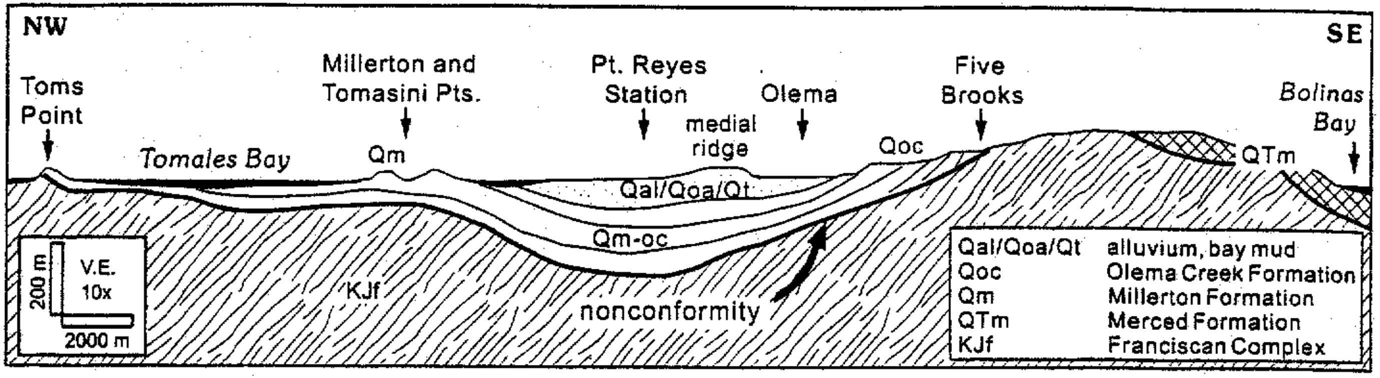


Figure 2. Interpretation of subsurface geology along length of SAF valley. Constraints are surface geology, an oil well log at the latitude of Point Reyes Station, water well logs in the valley between Point Reyes Station and Five Brooks, and gravity data between Point Reyes and Olema.

to enter the property and to obtain combinations for locked gates.

Miles	Cum Miles	Location
1.1	3.1	Intersection with second dirt road and first locked gate. Turn right and continue through gate, taking left fork when the choice arises.
1.1	4.2	Second locked gate and entrance to the ACR Preserve.

STOP 1—Toms Point

The coastal Miwoks were inhabiting the area around Tomales Bay when Europeans arrived in the region. Unfortunately (as throughout California), the natives and their culture were effectively exterminated soon after the Spanish missions were established in the early 1800s (Mason, 1980). Toms Point was named for Tom Wood, a deserter from a ship who settled with an Indian woman and her people, and built a home (constructed from wreckage salvaged from the sea) along the north end of Tomales Bay (Quinn, 1981). Tom's prowess with horses led to his acting as business manager for the tribes of Marin, Sonoma and Solano counties (Quinn, 1981). In the mid-1850s, American, English and French sailing ships would land near Toms Point to barter with the Indians: "summertime would see a thousand Indians along the shore, waiting to trade their hides, skins, and tallow for bright calicos, trinkets, blankets and whiskey" (Mason, 1980). Since the late 1850s, dairy farms established by European immigrants have dominated the landscape.

The MF is exposed at three headlands along the northeast edge of Tomales Bay—Millerton Point (type locality), Tomasini Point, and Toms Point (Figure 1C). These headlands are erosional remnants of deposits that formerly extended across the bay. The MF consists of estuarine and alluvial gravel, sand and mud, with extensive faunal and floral assemblages. Estuarine mud near the base of the formation at Toms Point has yielded ages around 130 ka from thermoluminescence dating (Grove and others, 1995; TL locality on Figure 3B) and aminostratigraphic dating (Kennedy and others, 1992).

The MF consists of fining-upward sequences that record interplay between tectonic activity and climatic change (Figure 3). The fining-upward sequences probably correspond to transgressions associated with the three stage 5 substages (Figure 3A). When sea level began to rise, streams that had become established during the lowstand (e.g., stage 6) deposited sand and gravel in the valley. As sea level rose (to substage 5e), marine water entered the valley and created a progressively deepening bay and a fining-upward sedimentary sequence (A in Figure 3D). When the sea withdrew (to substage 5d), marine water left the valley and some incision occurred until streams became established, and sand and gravel were again deposited. During

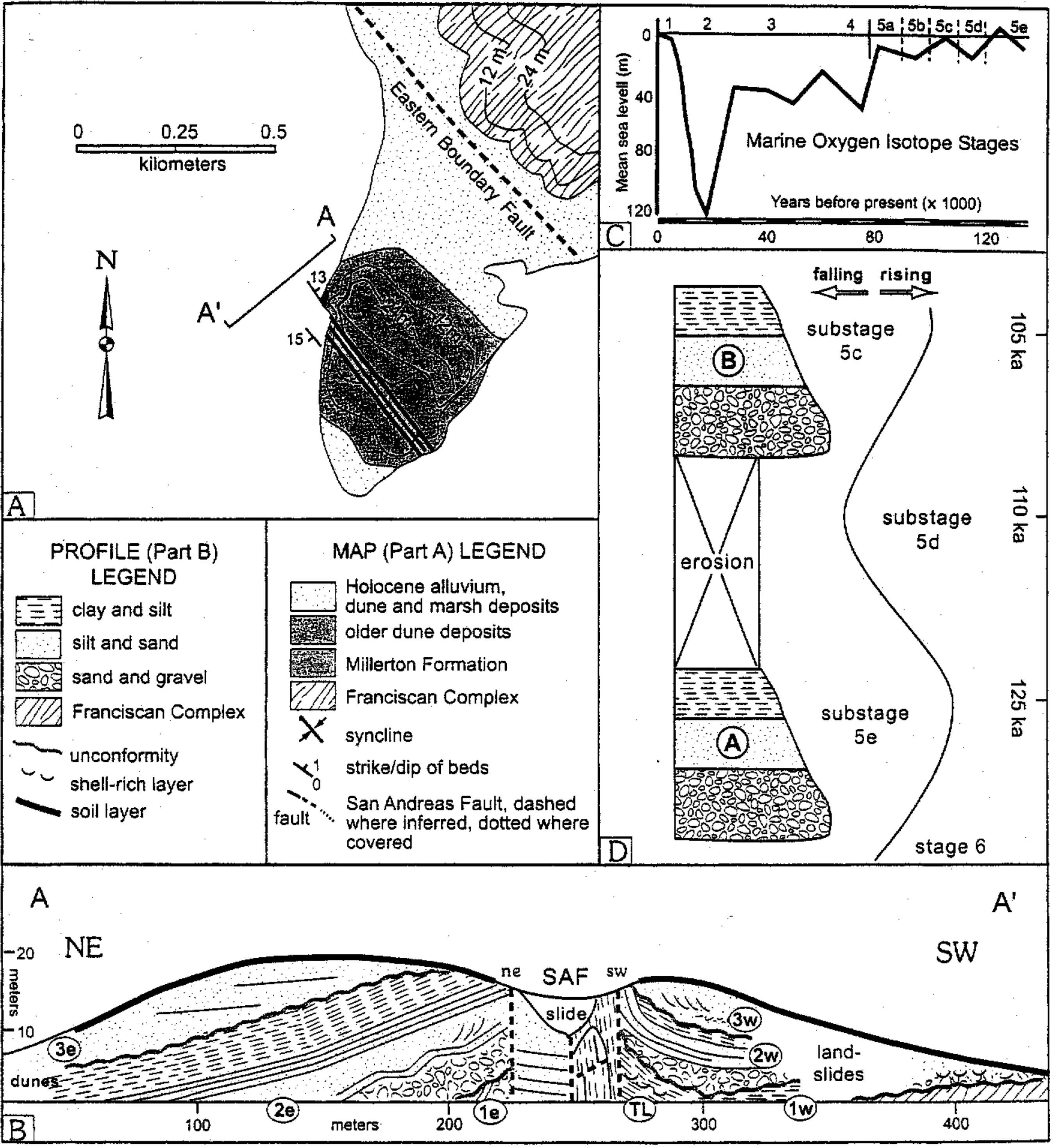


Figure 3. (A) Geology map of Millerton Formation (MF) at Toms Point. (B) Sketch from photomosaic of MF along northwest side of the headland (profile location A-A' in 3A). Note that direction of profile is rotated from map direction to match the view seen from beach level at Toms Point. Circled numbers refer to unconformity-bounded sequences on the northeast (e) and southwest (w) sides of fault zone. Matching numbers do not imply corre-lations across the fault. SAF=San Andreas Fault. TL=thermoluminescence sampling site. Vertical exaggeration, 3X. (C) marine oxygen isotope stages. *Adapted from Toscano, 1992.* (D) Model for Millerton Formation sequences. Lithologic patterns same as profile legend. Fining-upward cycles are deposited during times of rising sea level. During times of falling sea level there is nondeposition and erosion. Earthquakes deform the strata during that time, and an angular unconformity is produced when deposition resumes.

the depositional hiatus (erosion in Figure 3D), numerous earthquakes occurred and previously deposited sediments were deformed by faulting and folding. When streams became reestablished, they eroded the underlying tilted sediments and produced a surface of erosion. As sea level rose (to substage 5c), another fining-upward sequence was deposited with angular discordance, creating an angular unconformity (B in Figure 3D).

Following retreat of the sea at the end of stage 5, only nonmarine sediments were deposited in streams, marshes, ponds, and dunes that filled the low areas between uplifting fold limbs (cycles 3e and 3w in Figure 3B). During stage 2, when sea level fell at least 120 km below its present level, the valley was deeply incised and most of the MF, which extended across the valley, was removed. This erosional phase continues today as the bay headlands are subjected to weathering processes. Estuarine deposition resumed during the Holocene transgression in modern Tomales Bay.

Walk along the northwest side of the headland to obtain an "up-close view" of sedimentary facies of the MF and deformation associated with the SAF (a low tide is helpful). Note that slumping and erosion along the cliff cause exposures to change yearly; consequently your view may differ somewhat from that shown in Figure 3B. At Toms Point the MF is bisected by three active strands of the SAF, which truncate beds and juxtapose contrasting stratigraphic sequences. After the 1906 earthquake, G.K. Gilbert (*in* Lawson, 1908) described the deformation at Toms Point, but it is not clear from his descriptions which strands were active during the 1906 event.

Exposed on the northeast side of the fault zone is the uppermost part of one fining-upward sequence (1e on Figure 3B) and a complete sequence that fines upward from fluvial gravel to estuarine sand and mud (2e). A third sequence (3e) consists of nonmarine sand dune deposits. The beds dip northeast, and are increasingly steep in the older sequences (Figure 3B). A depositional model is presented above and in Figure 3D. Strata are highly sheared adjacent to the northeast SAF strand (Figure 3B).

A spring that causes perennial wetness corresponds to the middle SAF strand, which separates two deformed fault blocks (Figure 3B). Vertical beds between the central and southwestern strands include a distinctive peat bed offset by a small thrust fault. The stratigraphic sequence southwest of the fault zone is more difficult to see because of extensive landsliding and vegetative cover, but at least two fining-upward sequences and a nonmarine sequence is visible (Figure 3B). Franciscan basement rock is exposed at the base of this section.

Walk to the top of the headland to obtain a view of the valley and to see the morphology of the fault zone at the land surface. A linear depression parallel to the fault strands visible on the northwest cliff face probably resulted from the weak nature of the deformed strata. The sequences observed on the northwest cliff face are also visible on the southwest cliff face, but exposures are poorer because of extensive landsliding and vegetative cover. To the north, the SAF also cuts through Sand Point, but the trace is obscured by sand dunes.

Retrace the 4.2 miles to Tomales via dirt roads and Dillon Beach Road, being certain to close all locked and unlocked gates securely behind you. Log resumes in Tomales, at the intersection of Dillon Beach Road and State Highway 1.

Miles	Cum Miles	Location
0.0	0.0	Turn south (right) onto Highway 1. The road continues along the south side of Walker Creek and then along the east shore of Tomales Bay.
6.7	6.7	Cypress Point, ACR
4.3	11.0	Tomasini Point, MF exposures in the cliff faces.

0.7	11.7	Millerton State Park. Type locality for the MF.
5.0	16.7	Point Reyes Station. Continue south on Highway 1.
0.2	16.9	Intersection with Sir Francis Drake Road. Turn west (right).
0.8	17.5	Intersection with Bear Valley Road. Turn south (left).
0.5	18.0	Turn left onto dirt road leading to Olema Marsh.

STOP 2—Olema Marsh

Park in the dirt parking lot and walk up the ridge to the east. This is a medial ridge that bisects the valley (Figure 1C); the part to the east is drained by Olema Creek, and the part to the west is drained by Bear Valley Creek. At this stop we will get an overview of the valley and discuss the subsurface geometry of the fault zone. The marsh is over the 1906 trace of the SAF.

An oil well was drilled in the 1950s at the north end of the medial ridge close to this stop (location shown in Figure 1C). No oil was found, but the lithologic and electric logs provide information about the subsurface geology. Franciscan basement rock was encountered at a depth of about 280 m and a coarsening-upward sequence of interbedded coarse- and fine-grained sediments is probably the subsurface transition between the OCF and MF (Figure 2). The lithologic logs of water wells drilled in the valley contain descriptions of sediments similar to the OCF and MF. Facies beneath the surface at the Olema Marsh are probably transitional between more marine facies of the MF and more nonmarine facies of the OCF.

A high-resolution gravity survey parallel to the valley showed decreasing gravity values between Olema and Point Reyes Station (Quinn and Grove, 1994), consistent with increasing depth to basement rock between where it outcrops at the surface near Five Brooks (Figure 1) and where it is nearly 300 m deep here at Stop 2. The gravity data, combined with lithologic and electric-log data from wells, provide evidence for the subsurface configuration of units shown in Figure 2.

Stop 2 is at a subsiding part of the valley where sediments are collecting. Structural and stratigraphic data suggest that this basinal area was south of Olema during OCF deposition and that the basin was subsequently contracted, causing the subsiding area to migrate northward (Grove and others, 1995). This migration may be the result of interacting fault strands that include not only the 1906 strand but also the eastern and western boundary faults. Three fluvial terrace levels that overlie OCF deposits between Olema and Five Brooks attest to progressive uplift of the valley since OCF deposition. Truncation of the OCF by valley-bounding faults attests to their recent activity and progressive narrowing of the valley.

Return to Bear Valley Road, where mileage resumes.

Miles	Cum Miles	Location
0	0.0	Turn left onto Bear Valley Road and continue southward.
1.2	1.2	Turn right into the entrance for the Point Reyes National Seashore Headquarters and continue to parking lot at the end of the road.

STOP 3—Point Reyes National Seashore Headquarters

The Bear Valley Visitor Center of Point Reyes National Seashore is on the site of Skinner Ranch at the time of the 1906 earthquake. After the 1906 earthquake, G.K. Gilbert mapped 4.4 to 4.9 m of right-lateral slip from a displaced fence, a row of raspberry bushes, path, and the southeast corner of the cow barn on Skinner Ranch (Lawson, 1908).

Although none of these features have survived, the sidehill bench of the 1906 fault trace and a reconstruction of both the barn and the offset fence can be seen along the Earthquake Trail.

At this stop we will look at an exposure of the uppermost part of the OCF in the banks of Bear Valley Creek. The OCF is discontinuously exposed for 3.5 km along the length of the SAF valley between the 1906 trace and the eastern boundary fault, where it is primarily visible in the incised banks of Olema Creek and its tributaries (Figures 1C and 4A). Silty-clay deposits near the base of the OCF yielded a thermoluminescence date of 132±28 ka (Grove and others, 1995). The OCF is deformed into upright, open folds with axes trending northwest at low angles to the SAF trend (Grove and others, 1995).

Detailed stratigraphic measurements of the OCF revealed a minimum thickness of 160 m (Grove and others, 1995; Figure 4B). There is a general upward trend from marine mud to nonmarine alluvium. Fine-grained silt and clay are more prevalent in the southern (older) part of the outcrop belt, and coarser-grained sand and gravel dominate the northern (younger) part. The OCF probably grades upward into the older alluvium unit (Qoa) that makes up the medial ridge, including the location at Stop 3 (Figures 1C and 4A). Figure 4B illustrates the four depositional facies that comprise the OCF. Gravel clasts in the formation are predominately granitic, and sand clasts are primarily quartz and feldspar grains also derived from a granitic source. Since deposition of the OCF, the granitic bedrock source has been offset several km to the northwest from the OCF outcrop belt (Figure 1C).

The lower part of the OCF is interpreted as deposits from the fluvially-dominated part of an estuary interbedded with sand and gravel brought to the estuary by streams and alluvial fans (Grove and others, 1995). This setting was similar to the area around the head of Tomales Bay today. Because sea level during substage 5e was higher than today, marine water could flood farther south into the valley.

The upper part of the OCF is interpreted as deposits in a broad alluvial valley, where stream channels meandered over a floodplain with marshes and shallow lakes formed in depressions between faults. Alluvial fans fed sediment into the valley from the west. This setting was similar, although the valley was wider, to the modern Olema Creek floodplain located northeast of the medial ridge (Figure 1C). Marine water did not reach Five Brooks after the 5e substage. Alternations between fine- and coarse-grained deposits reflect the combined influences of subsidence along the SAF zone and climatic variations that affected the position of base level and the amount of sediment delivered to the basin.

Upward decreasing dips in the OCF imply that deposits in the south end of the outcrop belt began to be shortened and uplifted as deposition continued farther north. Sediments shingle northward from Five Brooks (Figure 2), as a result of the migrating depocenter. Angular unconformities, such as those observed in the MF, are not seen in the OCF, probably because at this position in the valley, deposition was more continuous during sea-level regressions, and deformation was more disseminated throughout the formation. The OCF is beveled by three levels of terrace deposits (Figure 4A).

To get to Stop 3, walk from the parking lot along the south (right) path of the Earthquake Trail several minutes until the path turns north (left). Instead of following the path, continue straight through the grass meadow and into Bear Valley Creek. NOTE: You must obtain permission from the Park Rangers to walk off the trail and into the creek. Also be aware of high creek flows during winter months. Exposed along the east bank of the creek are sediments of the OCF. The sediments are channel sand and gravel with interbedded finer-grained overbank deposits. This is the upper, alluvial part of the OCF (Figure 4), which north of Olema is mostly buried beneath younger alluvium, including terrace deposits (Figure 2). Note the granitic clasts, which were derived from granitic basement in the Salinian terrane. The south end of the granite basement is west

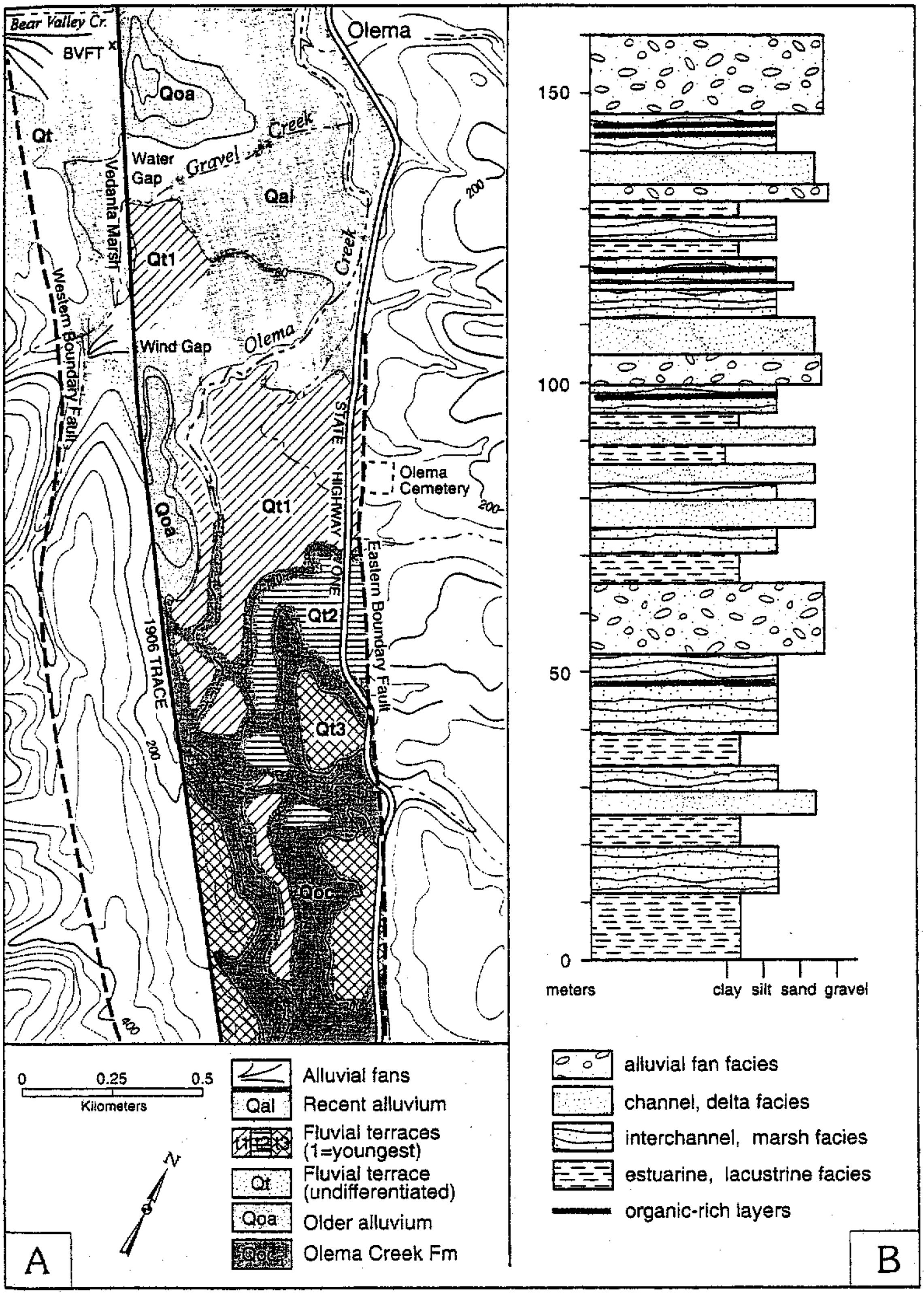
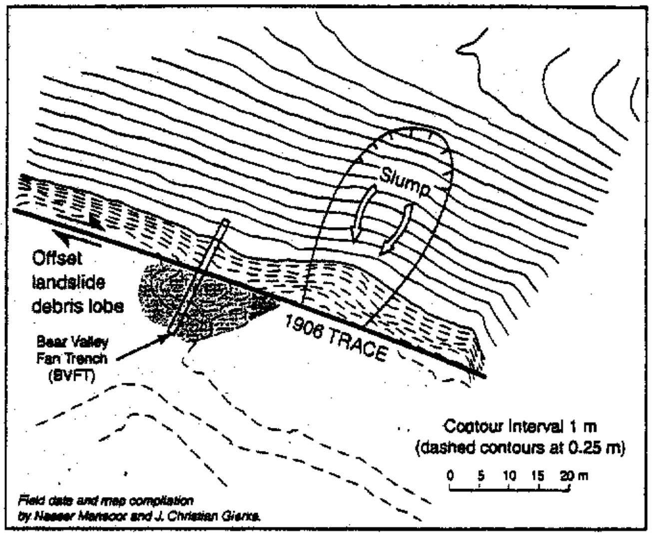


Figure 4. (A) Topographic map of the northern end of the OCF outcrop belt showing the exposure pattern of OCF (Qoc) and overlying cut-and-fill terrace deposits. Contour interval: 40 feet. Qt1: topographically lowest (youngest) terrace; Qt2 and Qt3: topographically higher and older. Qoa (older alluvium) overlies Qoc and is probably continuous with it. Both Qoc and Qoa have been incised and the incised valley is currently being filled with Qal (younger alluvium). *Adapted from Grove and others (1995).* (B) Generalized stratigraphic column of Olema Creek Formation (Qoc) facies. *Detailed measured section in Grove and others (1995).*



Field data and map compilation
by Nasser Mansoor and J. Christian Giarks.

Figure 5. Detailed topographic map of a landslide debris lobe offset along the 1906 trace of the San Andreas Fault. See Figure 4 for location.

of Stop 3 but is offset northward from most of the OCF outcrop belt (Figure 1C).

STOP 4— Point Reyes National Seashore Headquarters / Vedanta Retreat

The outcrop of the OCF at Stop 3 is exposed in the banks of Bear Valley Creek. We will follow the creek southeast until it makes a sharp bend. Climb up the south bank of the creek across a fence onto private property of the Vedanta Retreat. Walk southeast along the 1906 trace of the SAF at the base of the medial ridge for about 100 yards. Here we will view a subsurface exposure of the SAF in a paleoseismic trench.

The SAF zone in this area contains stream deflections, shutter ridges, ponded drainages, and sag ponds that attest to the intricate relationship between fault slip and the evolution of drainage patterns. The topography of this region has been created by recurrent tectonic movement and by climatically-controlled cycles of incision and aggradation of fluvial systems. A medial ridge in the center of the fault valley is the remnant of late Pleistocene fluvial deposits (Qoa) and terraces (Qt) that stratigraphically overlie MF and OCF (Figure 2) (Hall and Hughes, 1980). The straight southwestern margin of medial ridge is largely coincident with the 1906 trace of the SAF while the northeastern margin has been eroded by the meanders of Olema Creek during the Holocene. The medial ridge is breached in three places—by a broad wind gap near the entrance to the park, a water gap and a wind gap (Figure 4A) on the Vedanta property to the south (Stop 5).

Bear Valley Creek is a perennial stream with a drainage area of approximately 12 km^2 predominantly within the Monterey Formation. It flows northeastward until it reaches the medial ridge where it is deflected to the northwest, parallel to the SAF. The Bear Valley drainage probably cut the 150-m-wide water gap in the medial ridge at the Vedanta Retreat approximately 460 ±75 m to the southeast (Figure 4A). Repeated slip on the SAF has offset the drainage from the gap. Assuming the erosion of the medial ridge occurred during the Wisconsinan deglaciation (after 18 ka), the measured offset yields a slip rate for the SAF of 21-30 mm/yr (Niemi, 1992).

At the Bear Valley fan trench site, several geomorphic units are exposed at the surface. The slopes of the medial ridge, here composed of granitic detritus, are pervasively disrupted by land-sliding. This is seen in the hillside landslide scars and hollows, colluvial aprons, and landslide debris at the base of the ridge. West of the medial ridge in the meadow are the gentle slopes of the Bear Valley alluvial fan. Along the fault between the fan and the ridge is a linear depression formed by localized coseismic subsidence.

The trench site was chosen at a location where a small landslide debris lobe has been offset from the hillside scar by repeated faulting of the SAF. Detailed topographic mapping of the site (Figure 5) shows the debris lobe has been offset about 20 m from the hillside hollow. The active trace of the SAF is clearly exposed in the trench as an west-dipping fault. The fault juxtaposes light-colored, ridge-derived debris to the west against dark-colored, organic rich soils to the east. Repeated earthquakes on the fault at this location caused the zone of subsidence between the debris lobe and the ridge.

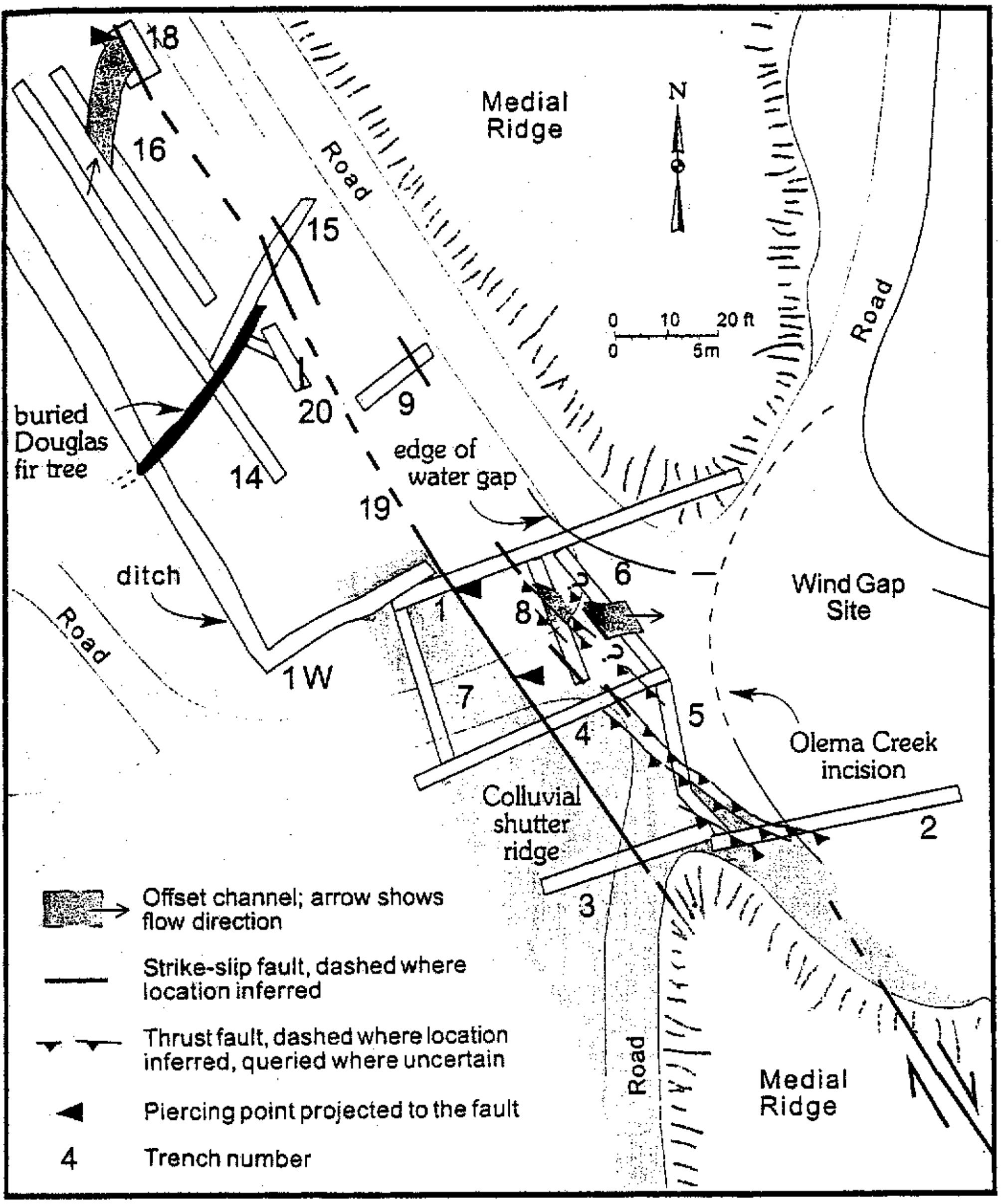


Figure 6. Sketch map of the wind gap showing locations of trenches and faults. Buried paleogeographic features shown include offset channel, limit of colluvial shutter ridge, edge of water gap, and incised Olema Creek cutbank. Projections of piercing points to the San Andreas Fault are marked by arrows.

Walk back to the Point Reyes Seashore Headquarters parking lot entrance, and proceed to the Headquarters entrance (at Bear Valley Road) where mileage resumes.

Miles Cum Miles Location

0 0.0
Turn right onto Bear Valley Road and continue east toward Olema.

0.5 0.5
Intersection of Bear Valley Road and Sir Francis Drake Road/Highway 1. Turn right and continue south to the stop sign in Olema.

0.1 0.6
Olema stop sign. Continue south on Highway 1.

0.2 0.8
Entrance to the Vedanta Society Retreat. Turn right and continue to the Retreat buildings.

NOTE: Permission must be obtained from the Vedanta Society to continue beyond the buildings.

STOP 5—Vedanta Retreat

This stop at the Vedanta Retreat is the site of a paleoseismological study of the SAF. The objective of this study was to document the late Holocene slip rate on the 1906 trace of the SAF from offset streams and to characterize pre-1906 seismic events based on the sedimentary record exposed in backhoe trenches (Niemi, 1992; Niemi and Hall, 1992).

Along the Vedanta driveway, we cross Olema Creek, which flows northwestward into Tomales Bay. The entrenchment of Olema Creek several meters into its floodplain deposits is apparently historical (Niemi and Hall, 1996). South of the driveway is the late Holocene floodplain of the once-meandering and aggrading Olema Creek. On the right, within a water gap in the medial ridge, is the large colonial white house built in 1869 as the residence of judge and cattleman Payne Shafter, who once owned nearly all of Point Reyes Peninsula. G.K. Gilbert made these observations of the 1906 rupture on the Shafter Ranch: 1) the SAF is a single strand within a secondary zone of cracking 3-4.5 m wide, 2) local subsidence ponded a lake of water 70 cm deep along the fault trace, and 3) the 1906 trace shifted from the base of the medial ridge to a sidehill bench southeast of a gap in the ridge (Lawson, 1908).

The wind gap study site is an abandoned water gap that was cut across the medial ridge, which at this location is composed entirely of Monterey Formation detritus probably derived from Bear Valley Creek (Figure 4A). South of the gap, the 1906 trace lies high on the ridge and is marked by a linear sidehill bench and sag. At the gap, the 1906 trace steps 20 m to the left, creating a restraining geometry marked by thrust faults (Figure 6).

Subsurface information about fault characteristics and channel morphologies within the wind gap and in the marsh to the west was obtained by trenching. Before 1,700 years ago, streams originating west of the fault, principally Gravel Creek, flowed eastward through the gap. Slip on the SAF has deflected this stream and diverted its drainage to the northwest by two processes: 1) lateral translation of a shutter ridge into the gap, and 2) development of a graben-like trough along the fault trace. Gravel Creek has subsequently built an alluvial fan into the south end of the marsh and now reaches Olema Creek by flowing through the water gap at the Vedanta Retreat barn.

East of the SAF at the north end of the wind gap, a distinct channel deposit, 2.5-3.0 m wide, of pebble- to cobble-sized Monterey clasts and wood debris represents the last narrow Gravel Creek channel to flow through the gap. West of the SAF in trenches parallel to and northwest of the wind gap, a channel of the same dimensions, lithology, and age has been identified (Figure 6). Detrital sticks within both channel deposits have radiocarbon ages that cluster about 1,800 years B.P. These matching channel segments show 42.5 ± 3.5 m of right separation, suggesting a minimum slip rate of 24 ± 3 mm/yr.

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DFG EXHIBIT 12

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Bibliographic note: Earlier volumes in this series (1988-1996) were entitled First [Second,..., Ninth] Keck Research Symposium in Geology (Abstracts Volume)

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Paleoseismicity and Crustal Deformation along the Northern San Andreas Fault, Fort Ross to Point Arena, California

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INTRODUCTION

The primary goals of this project were to constrain rates of slip, timing of paleoseismic events, and rates and styles of deformation along the northern San Andreas fault (SAF) from Fort Ross to Point Arena in coastal California (Figure 1). A crew of 17 geology students, professors, government scientists, and private consultants used a variety of techniques to assess rates and styles of deformation along the SAF. Methods of analysis included backhoe excavations across the SAF; mapping of geologic units, fault structures, and offset geomorphic features along the SAF with aerial photos, satellite images, and a total geodetic station; and surveying of uplifted marine terraces along the fault with GPS equipment.

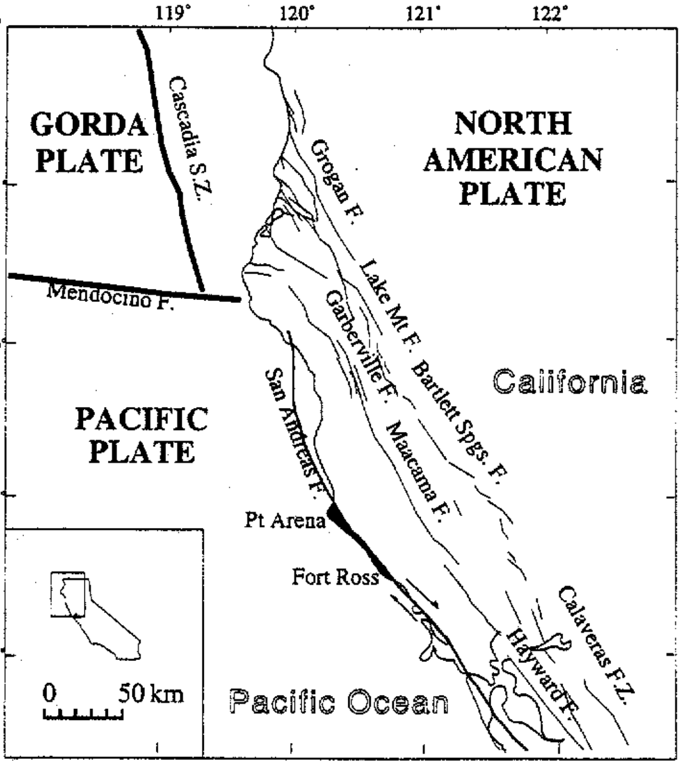

Figure 1. Tectonic setting, northern San Andreas fault. Field area shaded gray.

THE SAN ANDREAS FAULT IN NORTHERN CALIFORNIA

The San Andreas Fault (SAF) is a transform boundary separating the Pacific and North American plates (Figure 1). It formed about 26-28 m.y. ago, when part of the ancestral spreading center of the Farallon (present-day Gorda) plate was subducted beneath the North American plate (Atwater, 1970). In northern California, the SAF separates Franciscan-bearing terranes to the east from a block of late Mesozoic to late Cenozoic volcanic and sedimentary rocks that were deposted in a shoaling basin along the plate margin. This block, named the Gualala Block, has been translated hundreds of kilometers to the north by right-lateral slip along the SAF.

Although the general details and history of the evolution of the SAF have been determined by many geologists over the past century, a number of problems remain. Here, we focus on those problems pertinent to the coastal area between Forth Ross and Point Arena, spanning the entire length of the Gualala block. This area was the focus of a Ph. D. dissertation by Dr. Carol Prentice at California Institute of Technology (Prentice, 1989). Our work here builds upon her investigation.

A fundamental geologic problem regards the occurrence of isolated, anomalous exposures of rocks typical of the Franciscan Complex west of the SAF, within the Gualala Block. If they are indeed Franciscan rocks, then their incorporation into material west of the SAF requires a more complex model of fault evolution than simple right-lateral slip. Relevant to this issue of the nature of deformation along the SAF is the existence of compressional structures and uplifted Quaternary marine terraces at several locations along the northern segment of the fault. One of these locations is the Gualala block, which is flanked along its western perimeter by a flight of wave-cut marine platforms that vary in altitude, indicating both uplift and differential tilting since the time of formation. At Point Arena, extensive outcrops of thrust faults indicate that compression is occurring, even though the orientation of the SAF at this location, which makes a slight clockwise bend, would suggest that extension might occur, not compression. Another significant problem is related to the timing and rate of slip along the right-lateral fault. Only one historic event has occurred on the northern segment of the SAF. The rupture trace of this event, the 1906 San Francisco earthquake, was about 435 km, from San Juan Bautista to Point Delgada (Prentice et al., 1999). (Recent determination that rupture did indeed extend all the way to Point Delgada was the result of a 1995 Keck project (see Merritts and Beutner, 1996).) Several workers have used paleoseismological methods to determine slip rates based on several earthquake events (e.g., Prentice, 1989; Niemi and Hall, 1992). Most rates are on the order of 19-25 mm/yr, but much more information is needed to fully understand the history of seismic activity along the northern segment of the SAF.

STUDENT PROJECTS

Students worked on each of these different fundamental problems related to deformation along the northern SAF. Two students worked on projects that used paleoseismological techniques to constrain slip rates. With guidance from paleoseismologists Carol Prentice and Rob Landgridge of the USGS, Chris Crosby excavated three trenches near a stream that appeared to be offset at Fort Ross, where the SAF comes onshore. Historic photos indicated that several meters of offset occured during the 1906 earthquake; however, the trenching investigation found no evidence of offset in late Holocene deposits. After detailed surveying with a total geodetic station, and careful reoccupation of 1906 photo sites, the trio of investigators determined that the 1906 rupture--and the offset stream seen in historic photos--is now hidden beneath Highway 1 (the Coastal Highway). The ~7-m, right-jog in the stream at Fort Ross appears to indicate right-lateral offset, but in fact is not related to faulting. Crosby determined, instead, that it is due to landsliding that deflected the stream, a conclusion that many will find intriguing, since the site is a common stop for examining an offset stream along the "San Andreas fault".

Aletha Lee worked with two geologists from William Lettis and Associates, John Baldwin and Keith Knudsen, to excavate several trenches across and along the SAF at Point Arena, in a fluvial terrace deposit of Alder Creek. The trenches were sited in order to match piercing points across the fault so as to estimate slip rates. Numerous samples of charcoal were taken to establish age control of the strata exposed in the trench walls. Aletha analyzed samples of sediment from the trench walls and exposures along Alder Creek to assess preliminary correlations of piercing points from the logging. By comparing the sedimentologic analysis with her highly detailed (and beautiful!) trench logs, she concludes that a single channel has indeed been offset by repeated faulting.

David Allderdice collected samples of rocks that appeared to be Franciscan both east and west of the trace of the SAF. He benefited from much guidance by Robert McLaughlin of the USGS, an expert on Franciscan rocks and geologic mapping along the San Andreas fault. From his petrologic analysis, Allderdice concludes that rocks which contain little or no potassium feldspar, sampled from locations close to the SAF, can be readily correlated to other terranes east of the fault, in the Franciscan Central Belt. Furthermore, rocks with Franciscan affinities close to the SAF are relatively unsheared and coherent, suggesting that they were incorporated as large discreet blocks. Allderdice concludes that the blocks might have been emplaced in the Gualala block along widely spaced faults, with little post-lithification internal deformation.

In another project related to the issue of complex deformation along the SAF, Meadow Koslen worked with Michael Rymer of the USGS to complete detailed structural analyses of numerous exposures of thrust faults near Point Arena. Rymer has extensive experience with detailed structural analysis elsewhere along the SAF where deformation is highly complex. Koslen cleaned five exposures of thrust faults along the faces of cliffs and sinkholes that reveal thrusting of Miocene-age Point Arena Formation over Quaternary-age terrace deposits. Koslen concludes from detailed logging of these exposures that the faults are a single, low-angle thrust sheet with a curviplanar geometry. Her detailed topographic surveying reveals up to 24 cm of surface deformation above this thrust sheet. In addition, her analysis of both fold and fault structures enabled her to develop a history of compressional strain along the SAF, revealing a change in direction of compressional deformation during late Quaternary time.

The remaining five projects were related closely to one another, and all dealt with the problem of vertical deformation and differential tilting along the coastline. One of the best methods of assessing rates of uplift, and variations in such rates, is analysis of the inner edge altitudes of wave-cut, bedrock marine platforms. However, the method relies upon correlation of these platforms with sea-level highstands. As a consequence, one student—Jessica Darter—did a thorough literature review in order to compile an up-to-date sea-level curve. This curve, with data on the timing and altitude of numerous late-Quaternary highstands, is essential to the work of four other students. These students divided the coastline into separate regions. Each student used GPS equipment and a coastal beacon signal to acquire highly detailed surveys with excellent vertical and horizontal control (submeter resolution for vertical, and cm-resolution for horizontal position). In the south, Erica Richardson surveyed flights of marine terraces between the Russian River, just south of Fort Ross, and the town of Gualala, about midway along the Gualala block. Richardson found that uplift rates are low (between 0.5 and 1 m/ky), but slightly higher than rates determined farther south along the SAF. In addition, she determined that uplift rates increase gradually to the north. In a novel manner, she was able to calculate a slip rate for the SAF by matching a marine terrace west of the SAF Fort Ross with its corollary to the south, near the Russian River.

Stacy Tellinghuisen worked from the town of Gualala northward to Point Arena, at the edge of the SAF. She determined that uplift rates remain fairly low, between about 0.5 and 0.7 m/ky, however, she found several locations where terraces are faulted—sometimes many meters—and hence occur at elevations much lower than elsewhere nearby. Her findings provide clues for where to look for active faults. Furthermore, the terrace elevations and uplift rates drop significantly at Point Arena, as they near the San Andreas Fault. Tellinghuisen proposes the existence of a south-dipping thrust or reverse fault in the vicinity of the Coast Guard Station that is dropping the Gualala Block down on the north side of the fault. This fault might well be that mapped in such detail by Koslen.

Charles Hampton worked from just north of the SAF northward to the town of Mendocino. All of his marine terrace survey transects were on the North American plate, whereas those of Tellinghuisen and Richardson were on the Pacific Plate (with exception of Richardson's survey transect south of Fort Ross near the Russian River). Hampton determined that uplift rates increase from north to south; in essence, this is a mirror image of what was found by Richardson. Hampton's surveys included some particularly extensive marine terraces with excellent exposures of inner edges, and he was able to acquire an exceptional amount of control on the variation in inner-edge altitude along the coast. Combining his data with that of Richardson and Tellinghuisen produces a span of surveyed coastline some 100 km in length. Immediately north of where Hampton completed his last transect, Merritts (1989) has completed similar types of analyses all the way to the end of the SAF, at the Mendocino triple junction, an additional distance of 140 km. We now have the most complete database (in terms of distance and quality of altitudinal control) of terrace deformation that exists along the SAF, and perhaps anywhere in the world.

As is clear from the summary of the marine terrace work of Richardson, Tellinghuisen, and Hampton, vertical deformation is most intense close to the SAF as it approaches shore at Point Arena. In this complex area, numerous reverse and thrust faults occur, and marine terraces are laterally offset as well as vertically disrupted by faulting and perhaps even folding. Michael Toomey tackled this complex area, striving to correlate marine terraces across the SAF in order to determine how rates of uplift change. He concluded that uplift rates do indeed increase markedly from west to east across the fault, and furthermore that the terrace inner edges are offset laterally. Carol Prentice had done preliminary work on this idea, and Toomey followed up on her suggestion to do detailed GPS surveying along the terrace inner edges. Toomey derived a possible slip rate based on his estimates of plausible terrace ages and amount of terrace offset. His rate is similar to that of other workers on the northern San Andreas fault, but spans a much greater time period of tens of thousands to hundreds of thousands of years, whereas those from trench excavations span only a few thousand years at most.

INTERACTIONS WITH SCIENTISTS FROM OUTSIDE THE PROJECT

The first day of the project was spent at the USGS in Menlo Park in order to orient students to the research questions. Dr. Carl Wentworth, USGS, gave one of several presentations. He completed a Ph.D. at Stanford based on a structural geologic analysis of rocks in the Fort Ross to Point Arena area. John Baldwin and Carol Prentice summarized their research in the Fort Ross to Point Arena area, and Dorothy Merritts explained the variety of possible research projects. The second day was spent with Jeff Hamilton, a specialist in GPS surveying. He provided five hours of hands-on training in the use of differential GPS methods to all members of the project. The next few days were spent completing a reconnaissance of the project areas, under the guidance of Dr. Tom Anderson of Sonoma State University. An expert in sedimentary rocks in the area, Tom provided an excellent foundation for our work. As a local geologist with much mapping experience, he knew of many excellent places to point out specific geologic features. Exposures of Tertiary turbidites were particularly impressive.

After the first few days, students began to select and develop their individual projects. At this time, Noah Snyder of MIT visited for several days. He was instrumental in helping several students to define their project goals and agendas, and he accompanied several students to their field areas. Bob McLaughlin of the USGS visited for one day near the end of the field season in order to work with Dave Allderdice on mapping Franciscan rocks.

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DFG EXHIBIT 13

KECK Geology CONSORTIUM

13th Symposium in Geology

Proceedings

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Uplift of Holocene marine terraces along the San Andreas fault: Fort Ross to Gualala, California

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Faculty sponsor: Dave Bice

INTRODUCTION

The Gualala block in Northern California (Merritts, this volume) marks the northern most exposure of the North American plate west of the San Andreas Fault. Exposed Pleistocene marine terraces dominate the topography of Northern California's coastline. These elevated wave-cut platforms result from a combination of sea-level fluctuations and tectonic uplift along the seismically active plate boundary between the North American and Pacific plates. Terraces in coastal regions provide a relatively complete and detailed record of Quaternary crustal deformation over great distances. As a result, the Gualala block terraces provide an opportunity to examine the lateral offset and uplift rates along this segment of the fault.

This study will focus on the deformation that occurred from the Russian River to the Town of Gualala. A series of thirteen transects was completed in the field and provided the profiles necessary to make uplift correlations. Using the displacement of these marine terraces from their original formation elevation to present day location, I calculated the uplift rates along this section of the San Andreas Fault. I considered the rate of lateral offset along the fault using the displacement of the entire block northward. Missing terrace platforms south of the Gualala block, east of the San Andreas fault create a rough gauge of lateral motion.

METHODS

In the field. Transect locations were chosen using aerial photos and topographic maps. Using Global Positioning Systems (GPS), we mapped out the positioning of the terraces within centimeter accuracy. Localized relief along platforms cause elevation variation (Bradley & Griggs, 1976); therefore, we collected data points throughout the transects creating a more complete and accurate cross-section image. Points of consideration included inner edges (IE), outer edges (OE), mid treads (MT), and mid risers (MR). In conjunction with the landform type, the distance to bedrock was also recorded. By creating this highly accurate, detailed database I hoped to correlate the different aged terraces with higher precision.

In the Lab. The plots using the GPS data displayed the terrace elevations from two perspectives. Profiles of individual terraces displayed individual platforms. By combining all of the transects along the coast I attempted to correlate each terrace platform laterally along the coast.

The differences in altitudinal spacing of paleo-terraces create a framework for determining the tectonic activity in an area (Lajoie, 1986; Merritts & Bull, 1989; Muhs et al., 1990). Using a recently compiled sea level curve, I completed terrace correlations despite the lack of dateable material along the northern coast of California.

Using these data, the Gualala terraces are applied to the sea-curve for correlation. These correlations allow for uplift rates to be calculated by subtracting the real sea-level from relative sea-level (Lajoie, 1986).

apparent (uplift) = relative(terrace elevations) – real(sea-level curve)

By plotting the difference between the original elevations of the terrace in comparison to its present day elevation I hope to determine the nature of variations in uplift rate along the San Andreas fault.

RESULTS

Using the thirteen transects (Fig. 1) covering the southern half of the Gaulala block I distinguished six different wave-cut platform elevations. When compared to the New Guinea sea-level curve the Gualala terraces correlate to sea-level high-stands ranging from 80 ka to 330 ka (Fig. 2). Once the correlation of terrace platforms have been made, uplift rates can be calculated. However, along the Gualala block the limited supply of datable coral samples complicate the terrace correlation process.

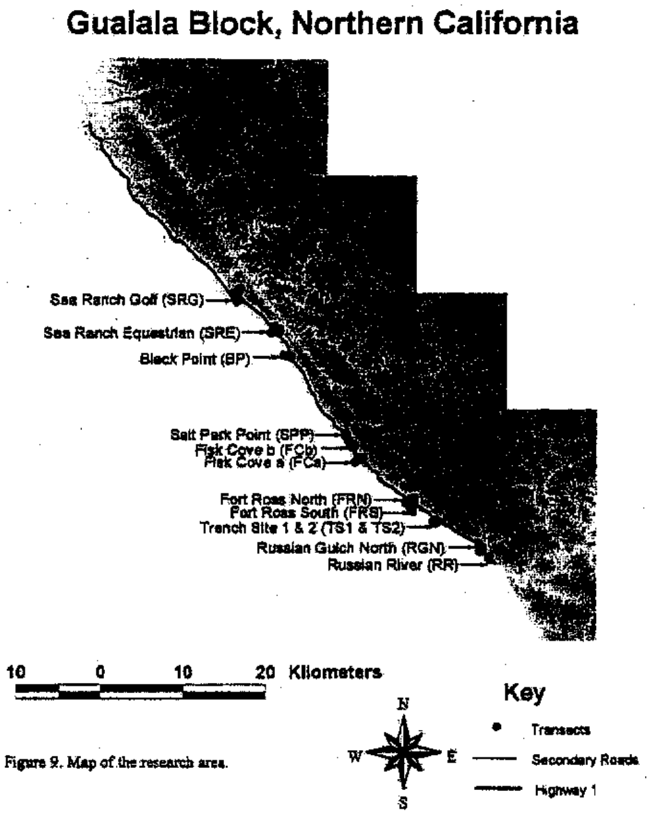

Figure 9. Map of the research area.

DISCUSSION

Transect Correlation. The lowest terrace along the Gualala block remains the only dated terrace in this region. Near the lighthouse at Point Arena, Kennedy collected *Balanophyllia* corals from two localities (Kennedy, 1982). The team used Uranium-series dating to determine this benchmarking terrace as an erosional expression of the 80K high stand.

There is a certain level of subjectivity when correlating sea-level high-stands with terraces plotted on the YZ plot, where Y runs parallel to the coast and Z indicates elevation. In the case of the Gualala block, due to the lack of dated platforms, even more assumptions are made. The area near Sea Ranch produced the most reliable correlations, while the alignment of southern transects proved more obscure. The area experiencing the greatest amount of confusion lies at the southern most edge of the Gualala block where the transects are closest to the San Andreas fault.

A series of questionable terrace platforms appear in the southern transects at roughly 60m of elevation. One explanation for the unexpected southern terrace is that the platform reflects the 194 high-stand that was poorly developed in the northern areas of this section. In fact, a complete sequence of terraces at a single transect location rarely occurs (Bull, 1984). This terrace correlation seems unlikely considering the fact that the northern section displays the most complete terrace sequence with between 5 and 7 platforms at each transect.

After further consideration, I determined that the most plausible explanation for this 60m terrace resulted from a series of psuedo inner edge points. Poor satellite reception on the day of the Fisk Cove transects seems to have resulted in misplacements in the GPS data record. Vertical precision prior to the Fisk Cove transect generally hovered around .5 m; however, during the Fisk Cove transect precision was as high as 2.36 m. Overall, the GPS data provided high level of accuracy; however, in this situation, the unusually high PDOP value warrants re-consideration of the presumed elevation.

The other transects with a record of a 60m platform appear at the southern most point of the Gualala block. Here, the flight of terrace platforms are truncated by the San Andreas fault. Under these conditions, the fault scarp creates an apparent inner edge elevation. Throughout the entire region, the fault and subsequent landslides obscure the original platform shape and location. Under these assumptions, the 60m southern platform does not exist and should not factor into the uplift rate calculations (Fig. 2).

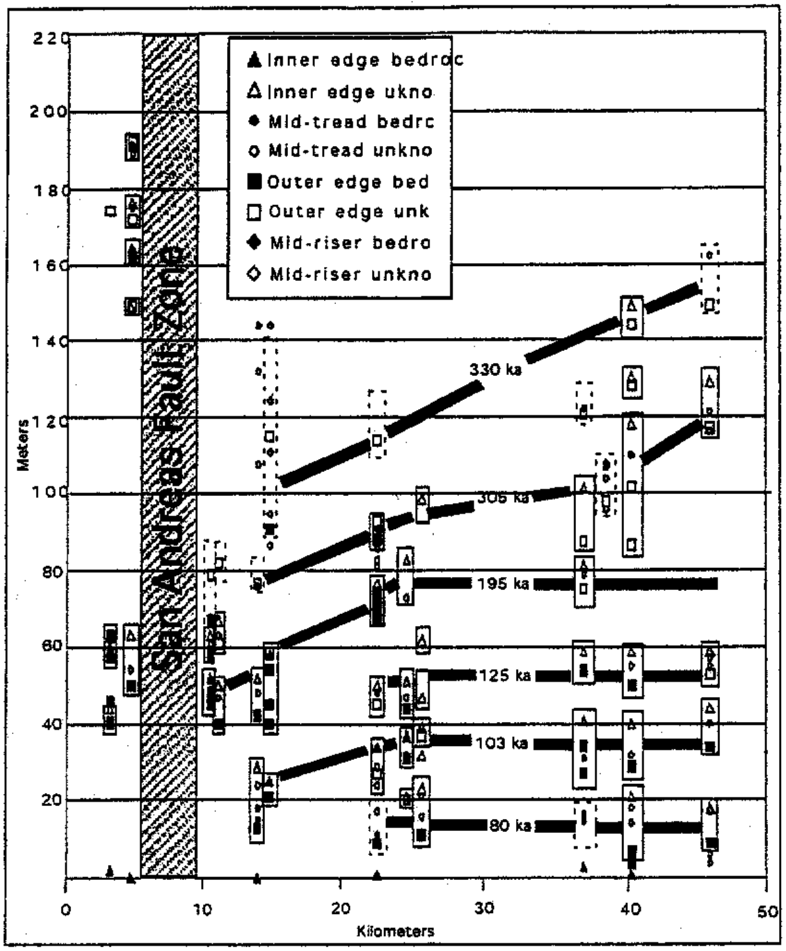

Figure 2. YZ plot with terrace correlation. Dashed boxes represent assumed platform positions where inner edges were not determined. The bold lines connecting the terraces follow general platform locations except in the case of bedrock exposed inner edges which are then connected directly. This diagram assumes the 60 m platform on the southern transects to be a misrepresentation of information.

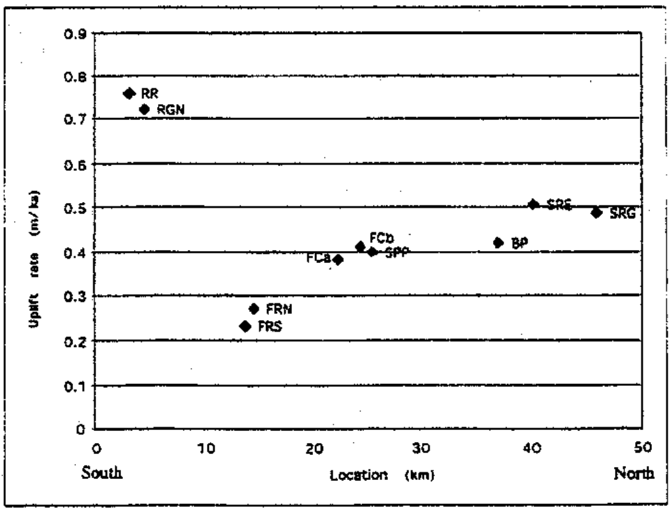

Figure 3. Uplift rates along the y axis. The progression of uplift rates following the coast line. Each uplift rate represents an individual transect. The San Andreas Fault zone lies around 10km.

Uplift Rates. Assuming the terrace correlations previously discussed, it appears that the uplift rates increase towards the north from .24 m/ka at Fort Ross to .58 m/ka at Sea Ranch Equestrian (Fig. 3). Fort Ross South transect provides the southern uplift rate on the Gualala Block, as the two southern most profiles labeled trench site 1 and trench site 2 preserved only one platform. On the North American plate east of the San Andreas, the uplift rate is considerably higher. The Russian River and Russian Gulch North profiles revealed rates of .77 m/kyr and .72 m/kyr respectively. This drastic change in uplift rates seems possible considering the shift in location across the fault. These changes in uplift rates correspond to the overall trends in uplift along the San Andreas.

Lateral Offset. The coastline south of the Gualala block consists of steep cliffs over 300 m high that extend for 5.3 km before the terrace formations reappear just north of the Russian River Valley. Due to the San Andreas right lateral displacement, the fault transported the terraces along with the Gualala block northward. By determining the age of the terraces on both ends of the cliff face, I calculated a rudimentary rate of lateral offset. The youngest terrace exposed at the southern most tip of the Gualala block corresponds to the 125Ka marine terrace at an elevation of approximately fifty meters. The first terrace to the south of the cliff sequence stands at a similar elevation suggesting that Russian River terraces also result from the 125Ka high stand.

distance/time = Lateral slip rate

Therefore:

$$5.3 \text{ km} / 125 \text{ ka} = 4.3\text{x}10^5 \text{ km/year or } 4.3 \text{ cm/year}$$

This calculation supports the present estimates of 4.8cm/y of relative movement between the North American Plate and the Pacific Plate (DeMets, 1987).

CONCLUSION

The marine terraces found along the Gualala Block seem to provide reasonable evidence for calculating uplift rates along the San Andreas Fault despite the absences in datable material. Through the data collected and the terrace correlations made, uplift increases towards the north. While the results of this study revolve around a number of assumptions, the general trend of increasing uplift towards the north is clearly established. The rates I found ranging from .24 m/ka to .58m/ka seem to correlate well with other rates calculated along the coast during this KECK project. Further studies attempting to pin point the exact elevations of past sea-level high-stands will strengthen these results.

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DFG EXHIBIT 14

Luhdorff and Scalmanini, 1998, Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie, 44 pp. and appendices.

Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie

prepared for

North Gualala Water Company

prepared by

Luhdorff and Scalmanini
Consulting Engineers

January 1998

96-1-011

The general area of this investigation is the valley floor along the North Fork Gualala River as it approaches the San Andreas fault valley, and turns abruptly southward along the fault valley. The valley floor is largely covered with dense second growth trees, brush, and understory. The specific focus of this investigation is a small open area north of the river known as "Elk Prairie", which is covered by prairie grasslands with clusters of scattered brush. The origin of this prairie vegetation, whether natural or caused by man's activities in the past, is not clear.

The only pre-existing well at Elk Prairie (NGWC Well 4) was drilled to 142 feet and encountered interbedded sands and gravels, and silt or clay beds. In order to evaluate the thickness and extent of the alluvium, NGWC contracted Bailey Scientific of Sonoma to perform a geophysical survey of the area using seismic refraction methods. Based on its survey lines, Bailey constructed a structure contour map (or subsurface elevation map) of the top of the Franciscan Complex, beneath the alluvium, based on the evidence of higher seismic velocity in the consolidated Franciscan sandstone. The structure contour map showed a narrow, deep paleo-thalweg (channel) filled with alluvium extending below the valley to depths of about 170 feet. Bailey's interpretation of the alluvial aquifer beneath Elk Prairie was summarized in a geologic cross section based on their structure contour map. The entire Bailey (1996) report is included as Appendix A.

Bailey used the results of exploratory drilling, described in the next section of this report, in interpretation of the seismic refraction data. One concern with regard to Bailey's interpretation of the extent of alluvium south of the River is that Bailey's geologic cross section and map do not reflect the lack of any geophysical data or borehole control on that side of the River; structure contour lines are not shown to be inferred or projected. The location of the base of the alluvium south of the River is basically unknown, and data from the two boreholes drilled through the alluvium south of the paleo-thalweg (MW-3 and 5) indicate that the base of the alluvium may be lower in elevation than assumed by Bailey.

The lithologic logs of the exploratory boreholes and the drillers' logs of production wells were used to prepare three geologic cross sections along and across Elk Prairie at the locations shown on Figure 2-1. These cross sections are presented on Figures 2-2 through 2-4. The surface of the Franciscan Complex shown on the cross sections is based on the Bailey Scientific analysis, although the configuration south of the river is noted to be projected, as discussed above. The cross sections show that a fine-grained silt and clay overbank/floodplain deposit occurs at the surface and appears to initially thicken northward and then thin toward the valley margin. Coarser-grained sand and gravel stream channel deposits occur near the present river channel, and extend to depths of at least 140 feet. The sand and gravel appear to be cleaner near the surface, while deeper deposits contain more silts and clays. These deeper deposits appear to interbed with fine-grained beds to the south and may be significantly older. The alluvium appears to be stratigraphically complex and may include interbedded landslide (mudflow) and possibly estuary deposits along with the fluvial (stream) and floodplain deposits. This complexity may be due to various factors which could have affected sediment deposition: high sediment yield and erosion rates, including landsliding; fault disruption, uplift and downwarping; and base level changes due to sea level fluctuations or faulting.

On the western side of the fault valley (at the locations of NGWC Wells 1, 2 and 3), the alluvium also appears to consist of sand and gravels interbedded with silts and clays. Organic and woody debris was noted in several of the boreholes. The stratified relationships of these deposits indicate that the alluvium has a complex geologic history which is difficult to delineate with the limited subsurface data available.

Based on topographic expression, alluvium could extend up the North Fork Gualala River at least 7,000 feet east of Well 4 (about 2,500 feet west of the R15W/R14W line on McQuire Ridge, 7-1/2 minute topographic quadrangle). The thickness of the alluvium in this reach is not known, but both the areal and vertical extent appear to be notably smaller than the alluvium that forms the aquifer system at Elk Prairie. Other alluvial flats or terraces may occur even further east, to near the junction of Lost Creek; however, these deposits appear to be even more discontinuous and thinner than the downstream deposits.

designed to discharge about 260 gallons per minute (gpm) and is an approved water supply source as part of NGWC's Water Supply Permit issued by the State Department of Health Services (DHS).

As part of this investigation of ground water beneath the Elk Prairie, a backup water supply well (PW-5) was constructed about 400 feet east of PW-4. Well PW-5 was drilled and constructed in November 1996, after the test hole drilling and monitoring well construction on Elk Prairie described above. PW-5 was drilled using the direct rotary drilling method by Weeks Drilling and Pump Company. The borehole was drilled to 137 feet, most of which was described as sand and gravel with some thin clay lenses or streaks of clay. An eight-inch PVC casing assembly was installed in the borehole to a depth of 97 feet; the casing is perforated from 55 to 92 feet with 0.032 inch slots. A pea gravel envelope is installed in the annular space from 50 feet to the total depth of the borehole; the upper 50 feet of the annular space is sealed with cement to the surface. The driller's lithologic log is included in Appendix B, and as-built construction details of PW-5 are shown on Figure 3-2. PW-5 has been equipped with a test pump with a capacity of approximately 260 gpm and has been approved for emergency (backup) service to the NGWC water supply system by DHS, but it is not in permanent service at this time.

Well Yields

As part of the original construction of both PW-4 and PW-5, the drilling contractor conducted step-drawdown tests (pumping tests at variously increasing capacities) to determine the respective well yields and to serve as a basis for design of pumps to be installed in them. A step-drawdown test was conducted in PW-4 at eight capacities from 168 gpm to more than 850 gpm (the limit of the measurement equipment). The duration of each step ranged from 15 minutes to two hours. The maximum drawdown achieved during step-drawdown testing was 7.4 feet. The yield of PW-4, as measured by its specific capacity (pumping capacity divided by drawdown) was typically about 130 gpm/ft (129-137 gpm/ft) throughout the step-drawdown range from 336 to 722 gpm.

Step-drawdown testing was also conducted in PW-5 at five capacities from 200 gpm to 700 gpm. The duration of each step ranged from 30 minutes at the lower capacities (200, 300, 400 gpm) to ten hours at 500 gpm and eight hours at 700 gpm. The maximum drawdown achieved during step-drawdown testing was approximately nine feet at 700 gpm. The yield of the well, as measured by its specific capacity during the longest step (500 gpm) was about 90 gpm/ft.

The small drawdowns experienced at high pumping capacities in both wells suggest that the aquifer materials in which the wells are completed have high hydraulic conductivity and transmissivity. Subject to more rigorous aquifer testing, as discussed below, the specific capacity data from the two wells suggest aquifer transmissivities on the order of 150,000 to 270,000 gallons per day per foot of aquifer width (gpd/ft).

levels have been measured biweekly at two production wells, five monitoring wells, and three staff gauges. Hydrographs and ground-water elevation contour plots developed from these data were used to determine the direction of ground-water flow in the aquifer and between the aquifer and the River. These data indicate that the reach of the North Fork Gualala River adjacent to Elk Prairie was gaining under all hydrologic conditions that occurred between March 1996 and December 1997, including pumping conditions during PW-4's normal pumping cycles for domestic water supply. While there is apparent direct hydraulic continuity between the aquifer system and the River, ground-water storage is always above the River and contributes to streamflow under all River stages.

Two constant-rate pumped well and aquifer tests were conducted in PW-4 at a pumping capacity of approximately 260 gallons per minute, which is its design capacity. The tests were conducted during low streamflow conditions in September and October, 1997 in order to observe "worst case" conditions for possible pumping impacts on streamflow. During the tests, there was no reversal of gradient, and hence no induced infiltration from the stream to the aquifer. Measurements of ground-water levels and resultant contour mapping of equal ground-water elevations show continuous ground-water discharge toward the river throughout the tests.

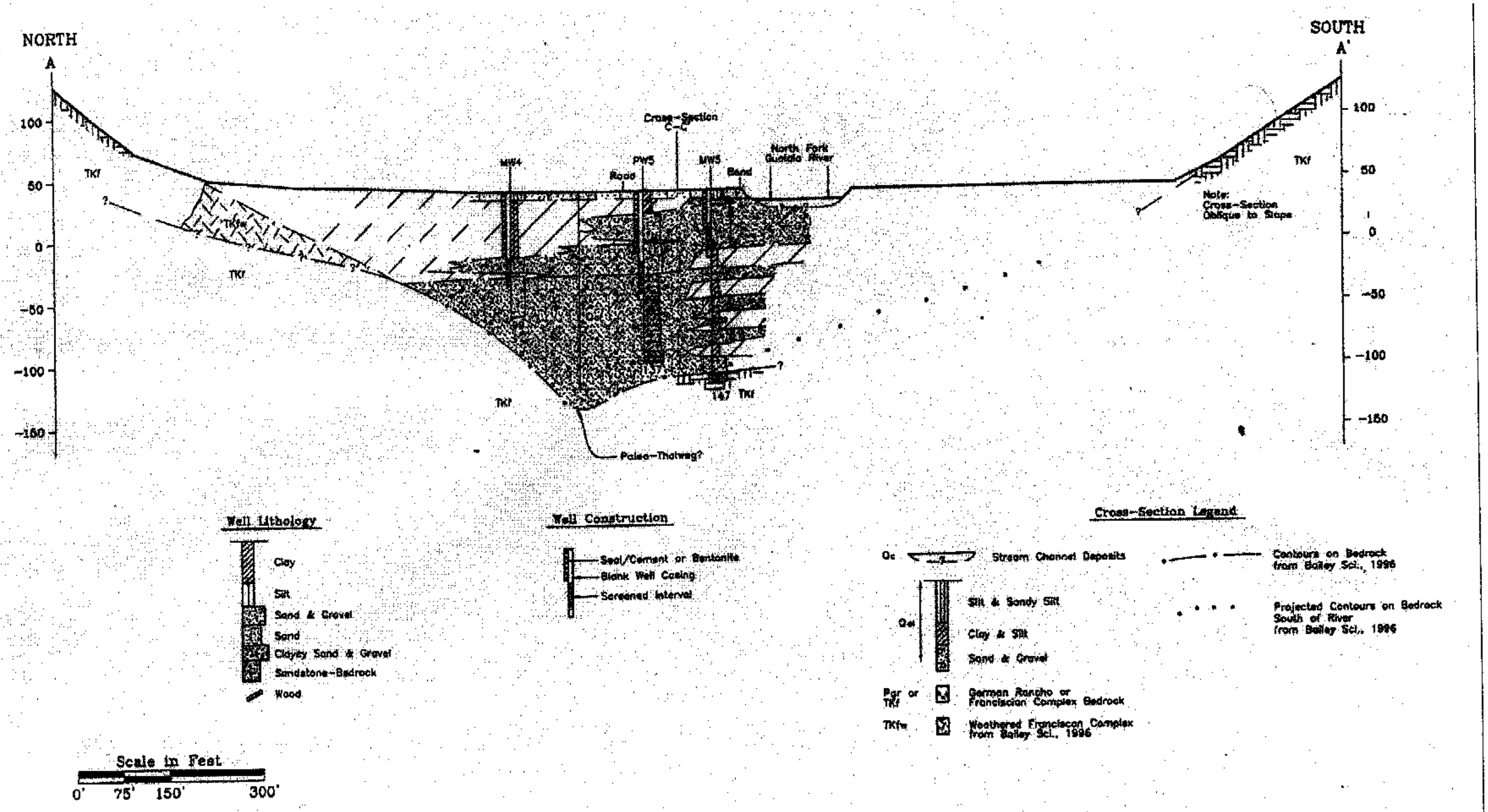
Based on interpretation of the well and aquifer testing, the average transmissivity of the aquifer materials beneath Elk Prairie is estimated to be between 300,000 and 400,000 gpd/ft, and the corresponding hydraulic conductivity is on the order of 4,500 gpd/ft^2. Both are high values, typical of coarse sands and gravels as are present in the aquifer beneath Elk Prairie. It is common that, with such high hydraulic conductivity and aquifer transmissivity, water-level drawdown in pumped wells and in the surrounding aquifer is typically small, as observed during the testing and the regular operation of well PW-4.

The ability to pump more ground-water from the alluvial aquifer beneath Elk Prairie would help NGWC meet its projected future demand. The aquifer test results indicated that more water could be pumped from the aquifer while continuing to maintain a positive gradient for ground-water discharge to the River. Various options available to NGWC to increase pumpage from Elk

Prairie were analyzed; including alternating pumpage between PW-4 and 5, increasing the pumping capacity of PW-4, and constructing additional wells at the site. Two additional production well locations and total capacities of 250 to 750 gpm were evaluated using an analytical model. Simulations based on measured aquifer characteristics at the site indicate that four of the 16 scenarios analyzed would cause a reversal of gradient between the aquifer and the River, including pumping of PW-4 and 5 simultaneously at their current capacities. The remaining 12 scenarios did not cause a simulated gradient reversal, including one scenario at 375 gpm, six scenarios at 500 gpm, two scenarios at 625 gpm, and one scenario at 750 gpm.

Based on the various components of the Elk Prairie exploration, monitoring, and testing, it can be concluded that NGWC can continue to operate well PW-4 at its design capacity, with extended pumping cycles to meet daily and seasonal fluctuations in water demand, and not cause any induced infiltration from the North Fork Gualala River. Similarly, NGWC can permanently equip backup well PW-5 with similar permanent pumping equipment and operate that well on intermittent pumping cycles without causing any induced infiltration from the river as long as both wells are not pumped at the same time. However, if PW-5 were equipped with a smaller capacity pump and PW-4 with a larger capacity pump, these wells could be pumped simultaneously at a combined capacity of up to 500 gpm. Finally, as water demand in the system increases in the future, NGWC could install one or two additional production wells at Elk Prairie, located a similar or greater distance from the River and equipped at a similar capacity, and operate them in a similar manner without causing any induced infiltration from the River. The addition of that source capacity would provide sufficient supply to meet increased water demand based on the Town's General Plan over the next 20 years.

Finally, the results of the overall Elk Prairie ground-water investigation show a perennial gradient for ground-water flow toward, and discharge into, the North Fork Gualala River from beneath Elk Prairie. There is no "channelized" ground-water flow parallel to the River at Elk Prairie. These conditions and the response of the aquifer to precipitation, to pumping, and to dry season lack of rainfall recharge all show that ground water is not recharged by influent stream seepage. Ground water is maintained by some combination of deep percolation of precipitation and subsurface flow from the basement complex. Similarities in surface and ground-water quality are not the result of recharge from the North Fork Gualala River because ground water discharges to the River under both static and pumping conditions regardless of stream stage. Consequently, ground water beneath Elk Prairie does not occur in a subterranean stream, nor does it occur as underflow of the River.



Gualala/98-1-011/Figure 2-2.dwg

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Figure 2-2
Geologic Cross-Section A-A'

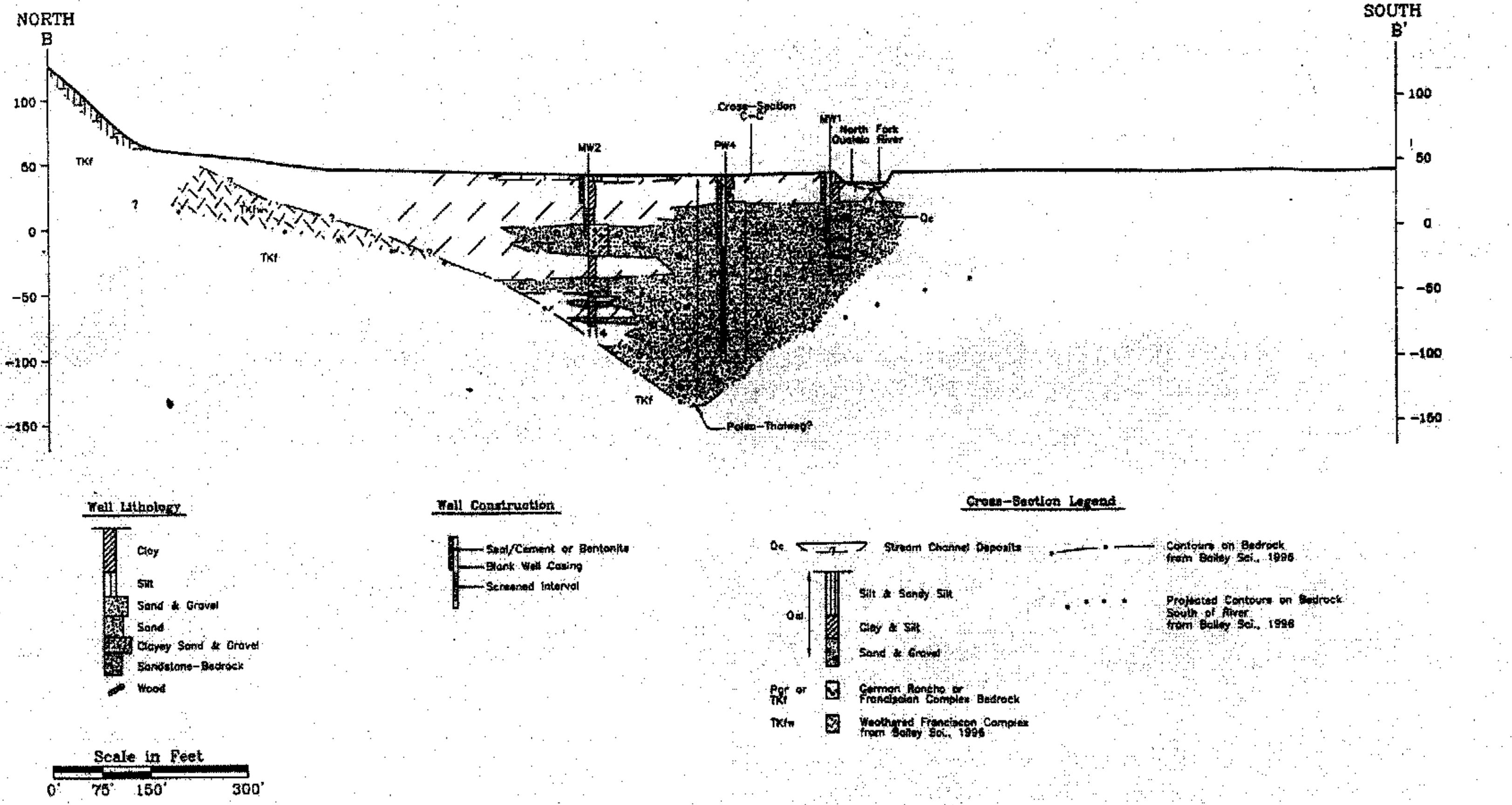

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Figure 2-3
Geologic Cross-Section B-B'

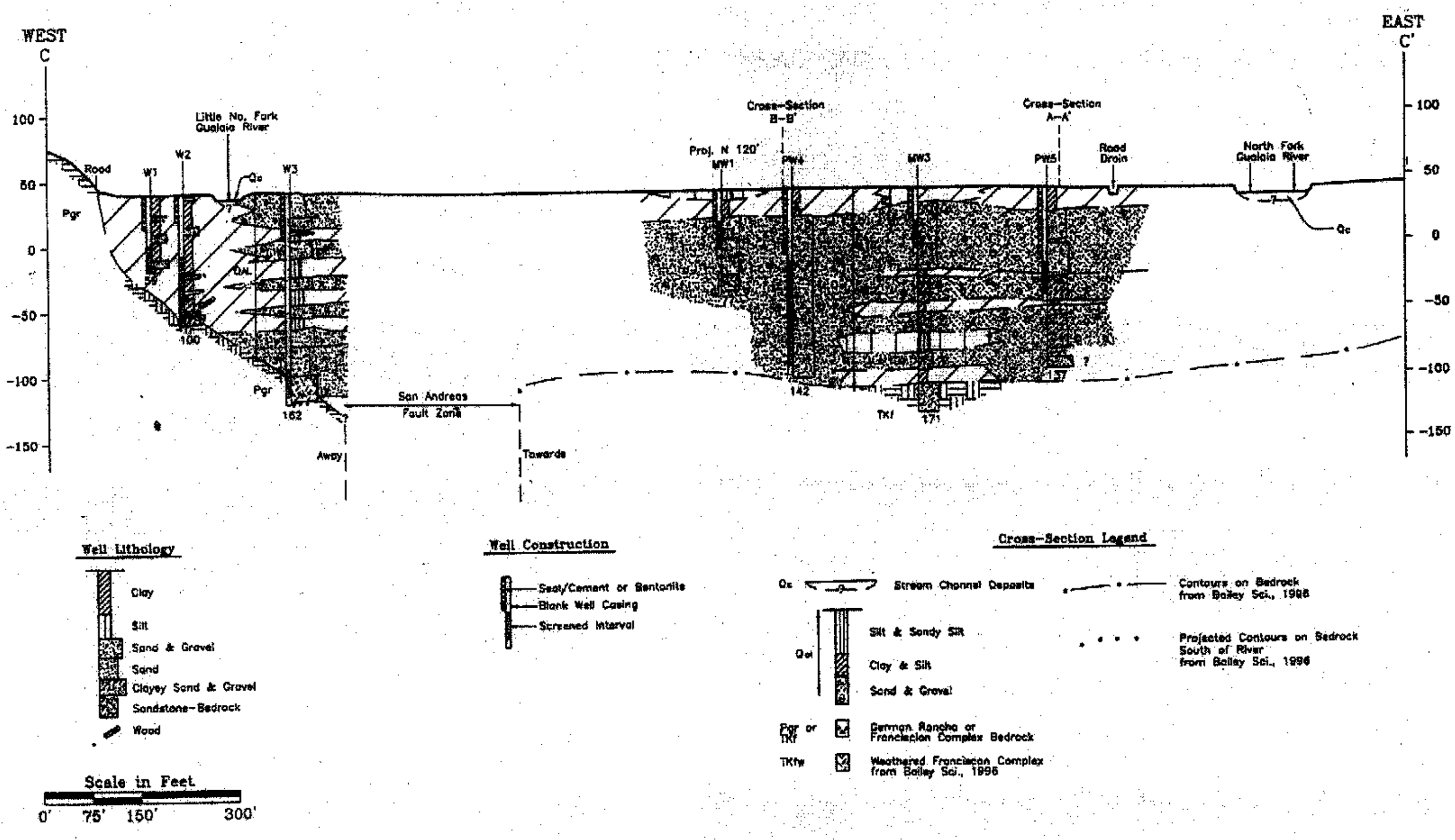

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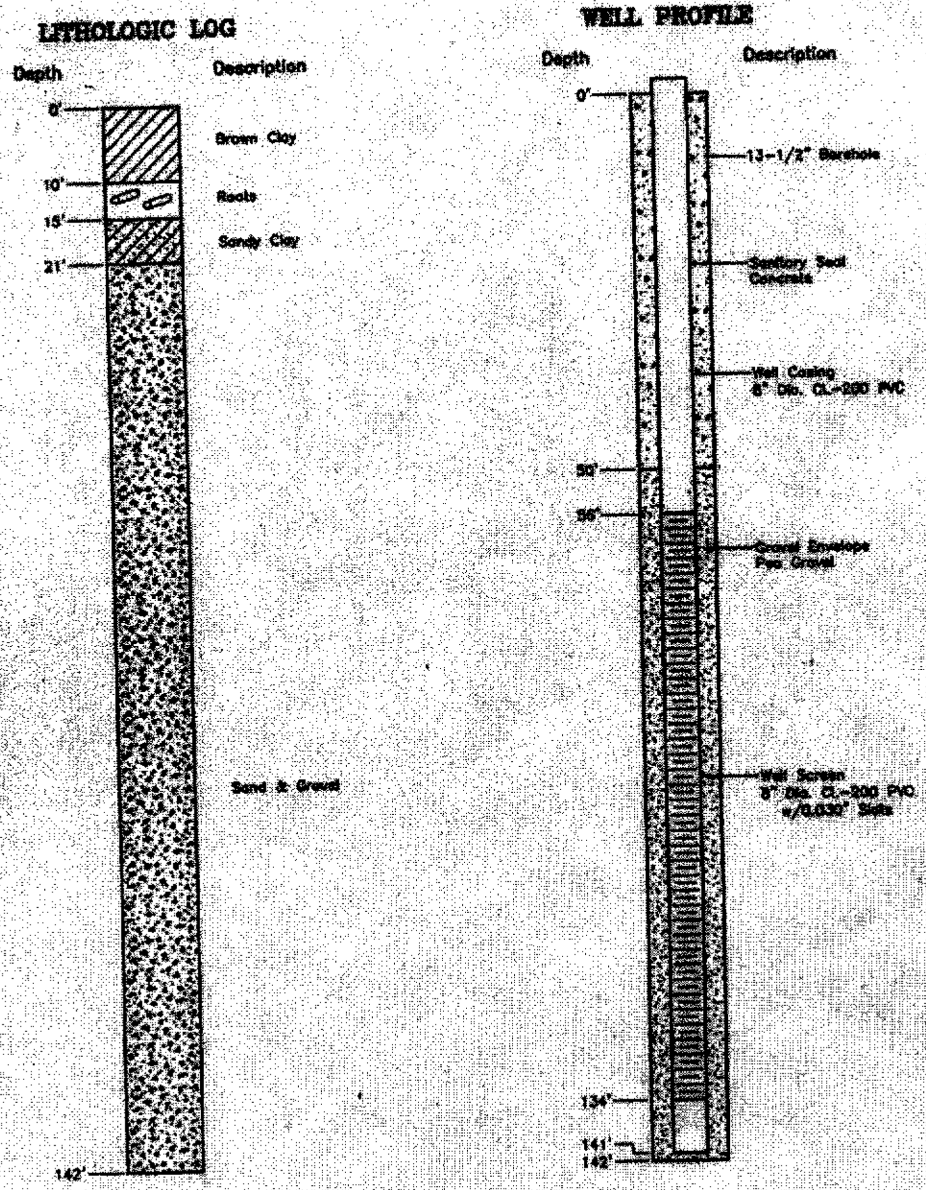
Figure 2-4
Geologic Cross-Section C-C'



Notes:
Lithologic log and well construction details from Water Well Driller's Report No. 211074, by Weeks Drilling & Pump Co. – 8/14/89

96-1-097/Figure 3-1.dwg

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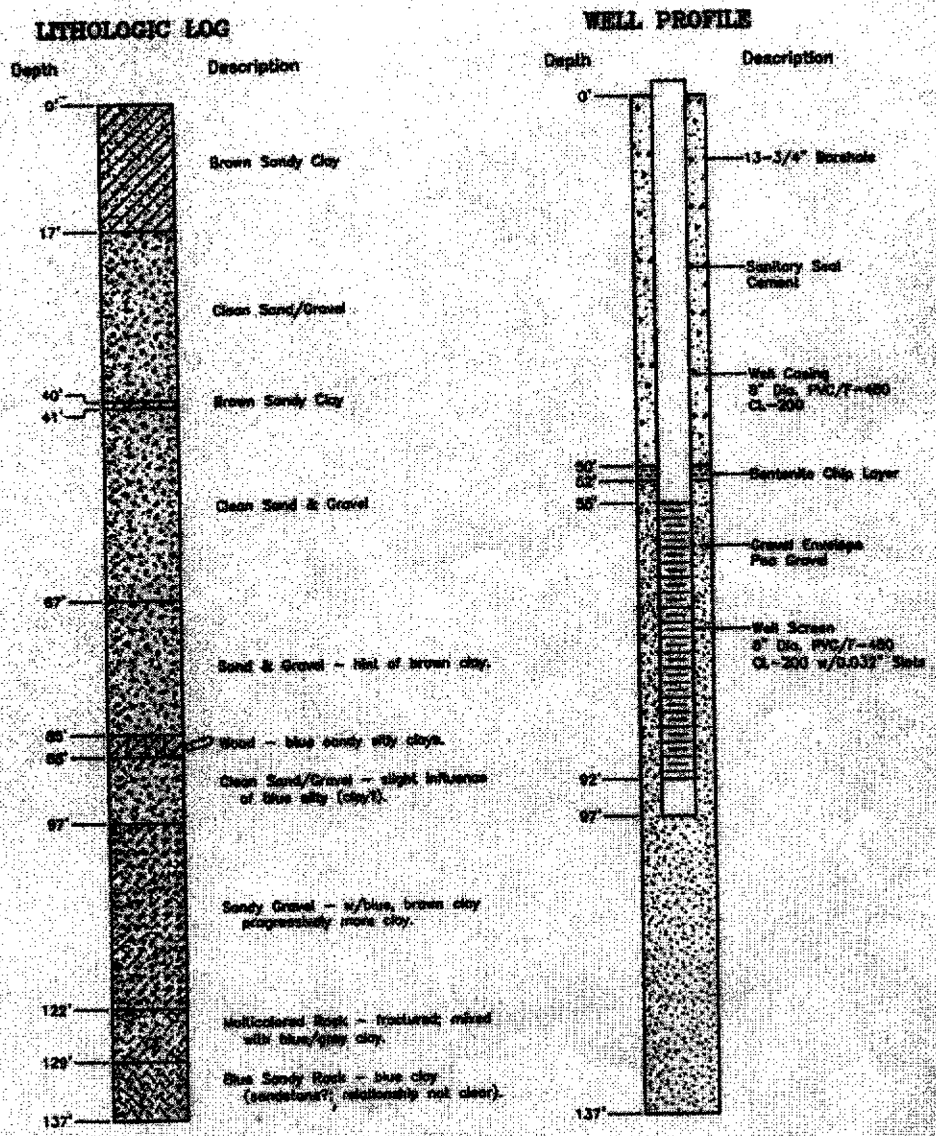
Figure 3-1
Lithology and Well Construction Details
North Gualala Water Co. Well No. 4



Notes:
Lithologic log and well construction details from Water Well Driller's Report No. 442398, Weeks Drilling & Pump Co. – 11/19/96

96-1-097/Figure 3-2.dwg

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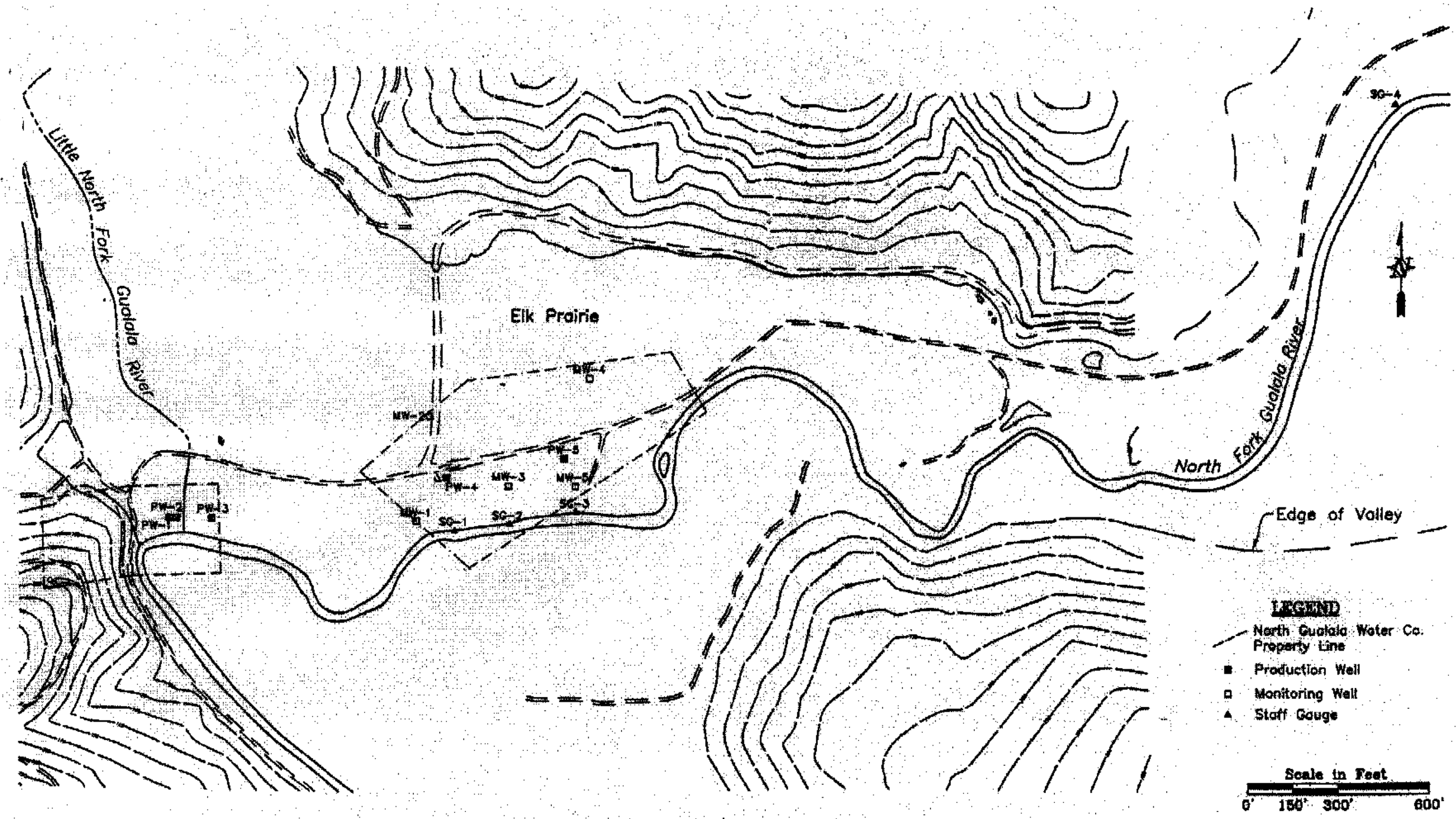
Figure 3-2
Lithology and Well Construction Details
North Gualala Water Co. Well No. 5



26-1-001/Figure 4-1.dwg

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Figure 4-1
Surface- and Ground-Water Monitoring Location Map

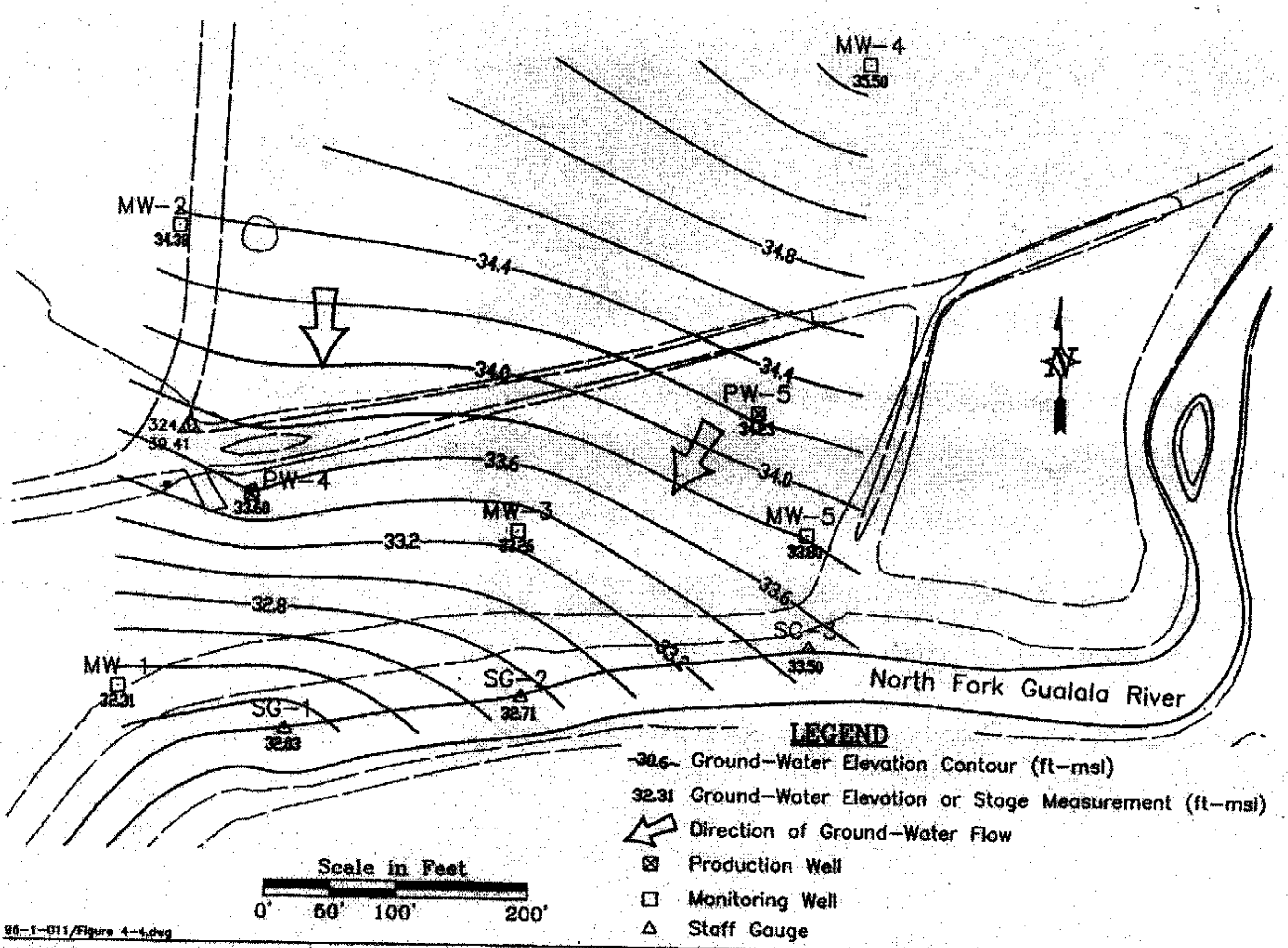

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Figure 4-4
Ground-Water Elevation Contours: 1/7/97
(High Streamflow Conditions)

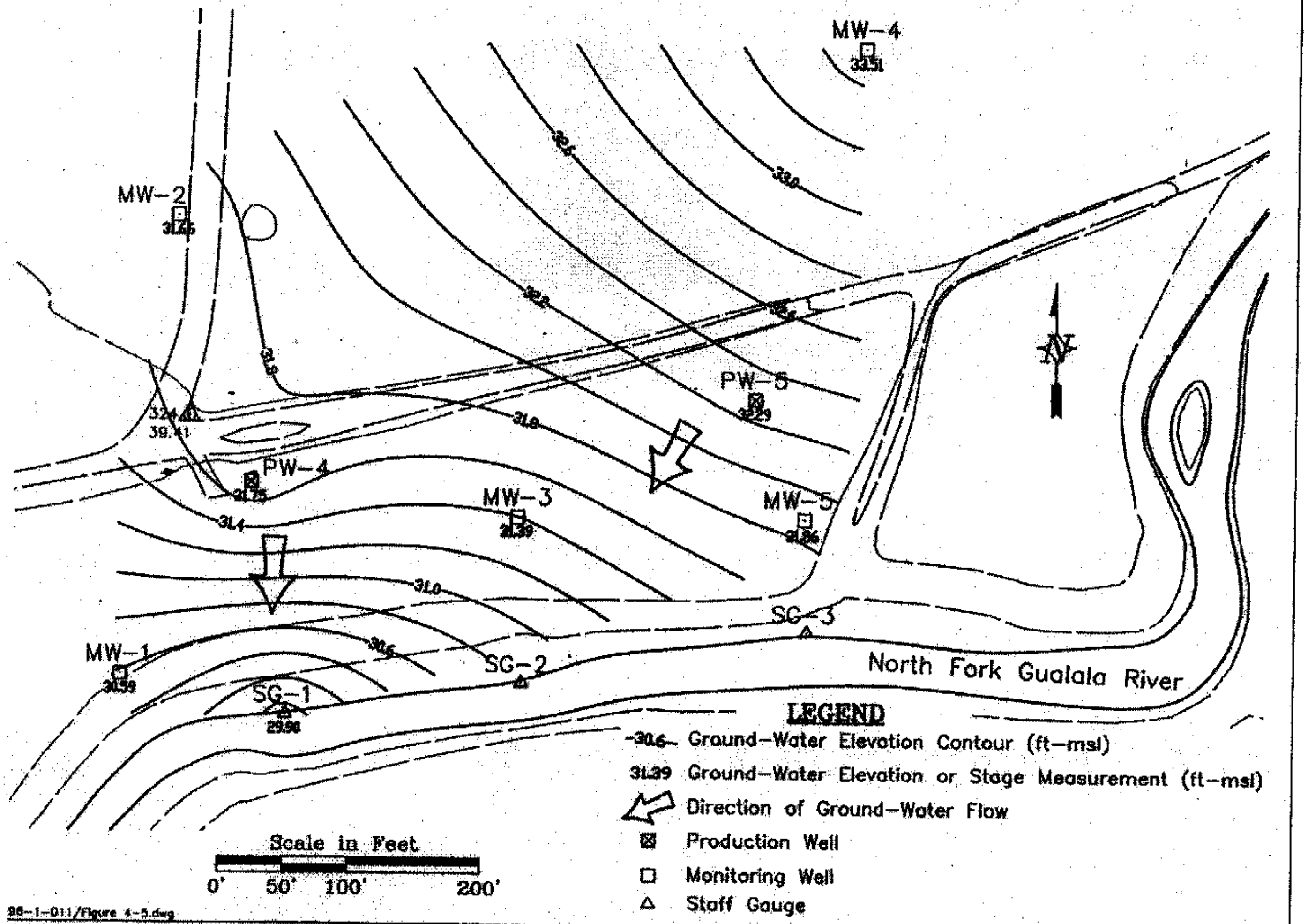

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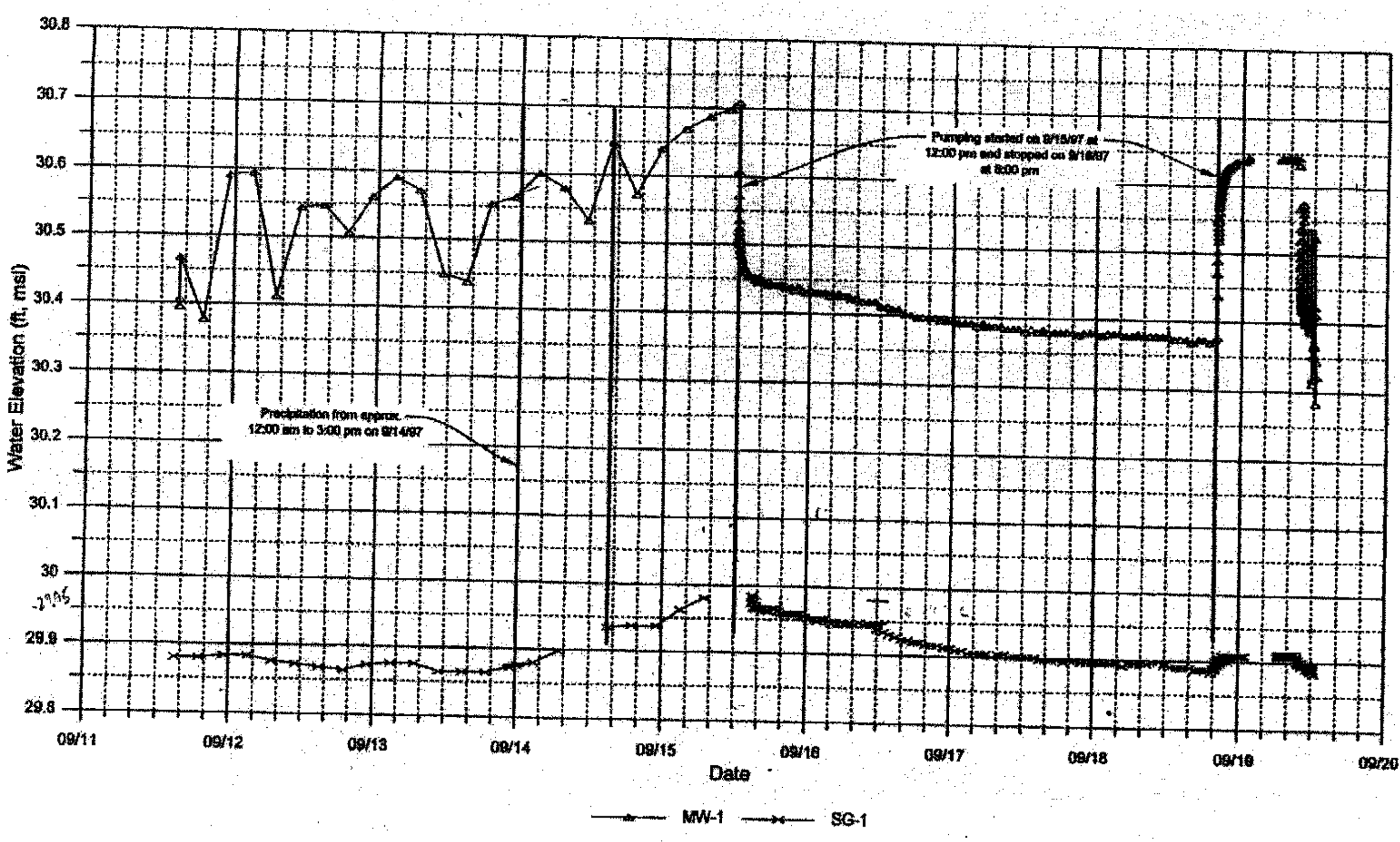
Figure 4-5
Ground-Water Elevation Contours: 10/7/97
(Low Streamflow Conditions)



95-1-011/Figure 4-7.dwg

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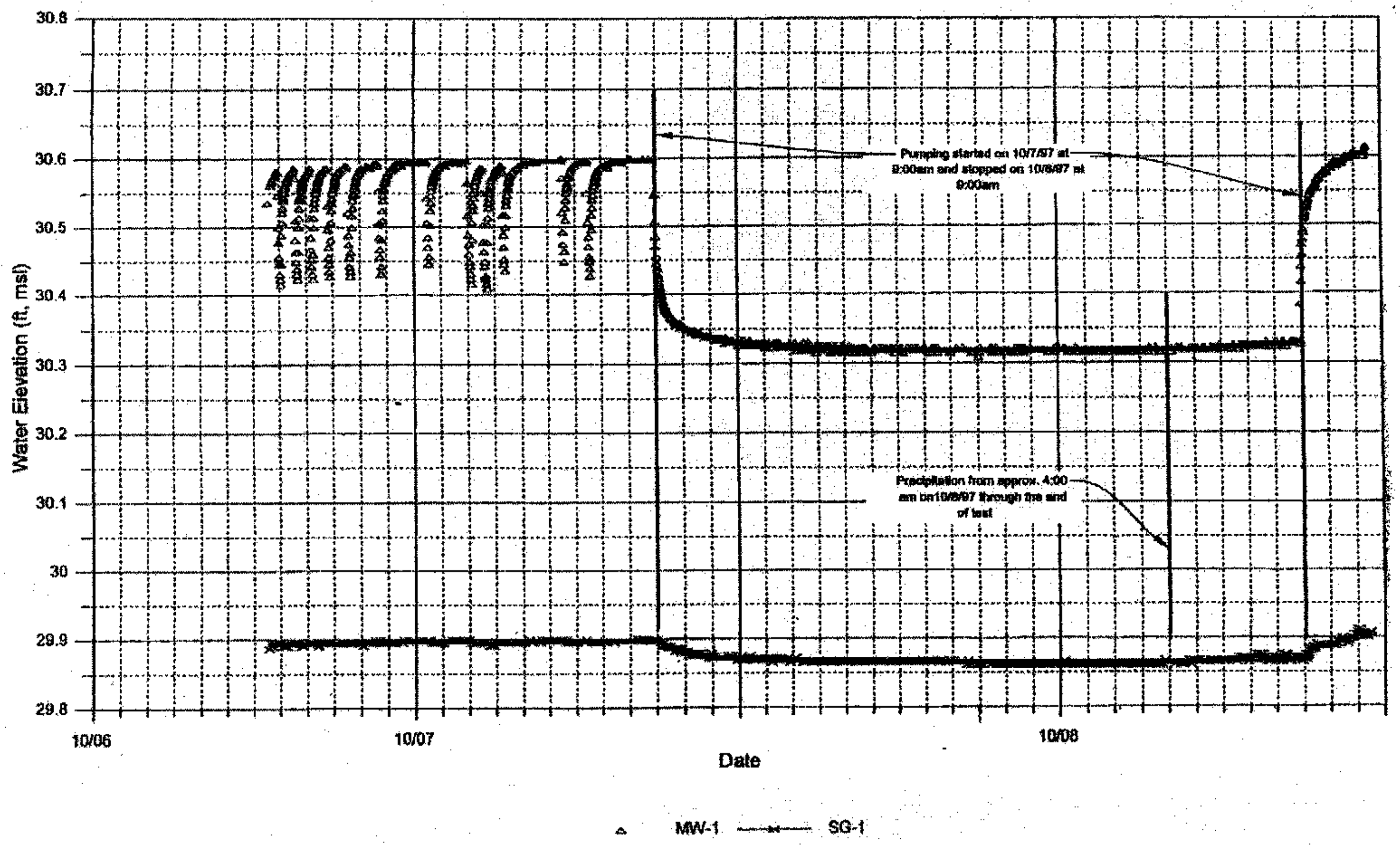
Figure 4-7
Hydrographs of MW-1 and SG-1
9/15/97 Aquifer Test



96-1-011/Figure 4-8.dwg

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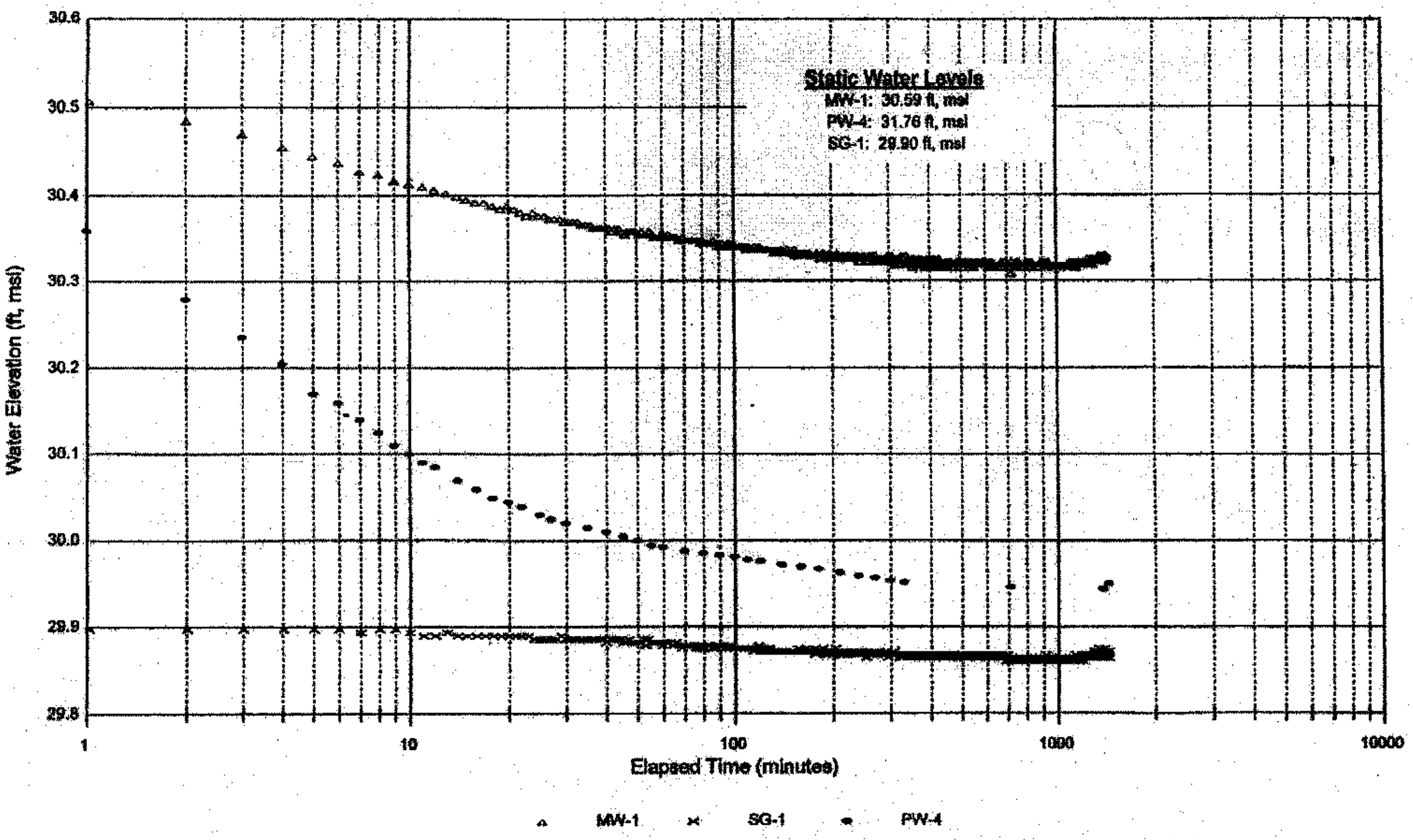
Figure 4-8
Hydrographs of MW-1 and SG-1
10/7/97 Aquifer Test



96-1-011/Figure 5-2.dwg

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Figure 5-2
Water-Level Response in PW-4, MW-1, and SG-1
10/7/97 Aquifer Test

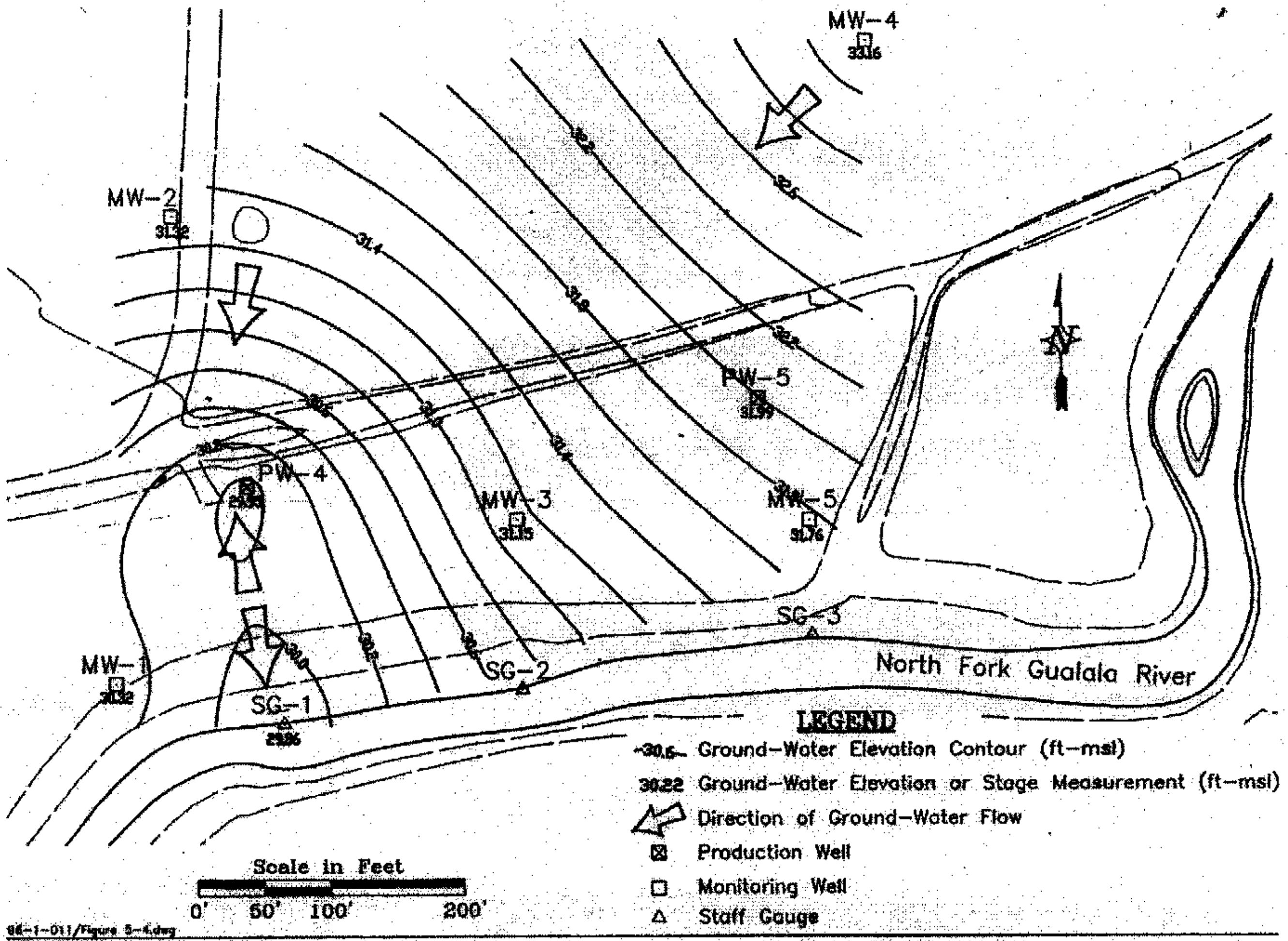

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Figure 5-4
Ground-Water Elevation Contours
Under Pumping Conditions: 10/7/97

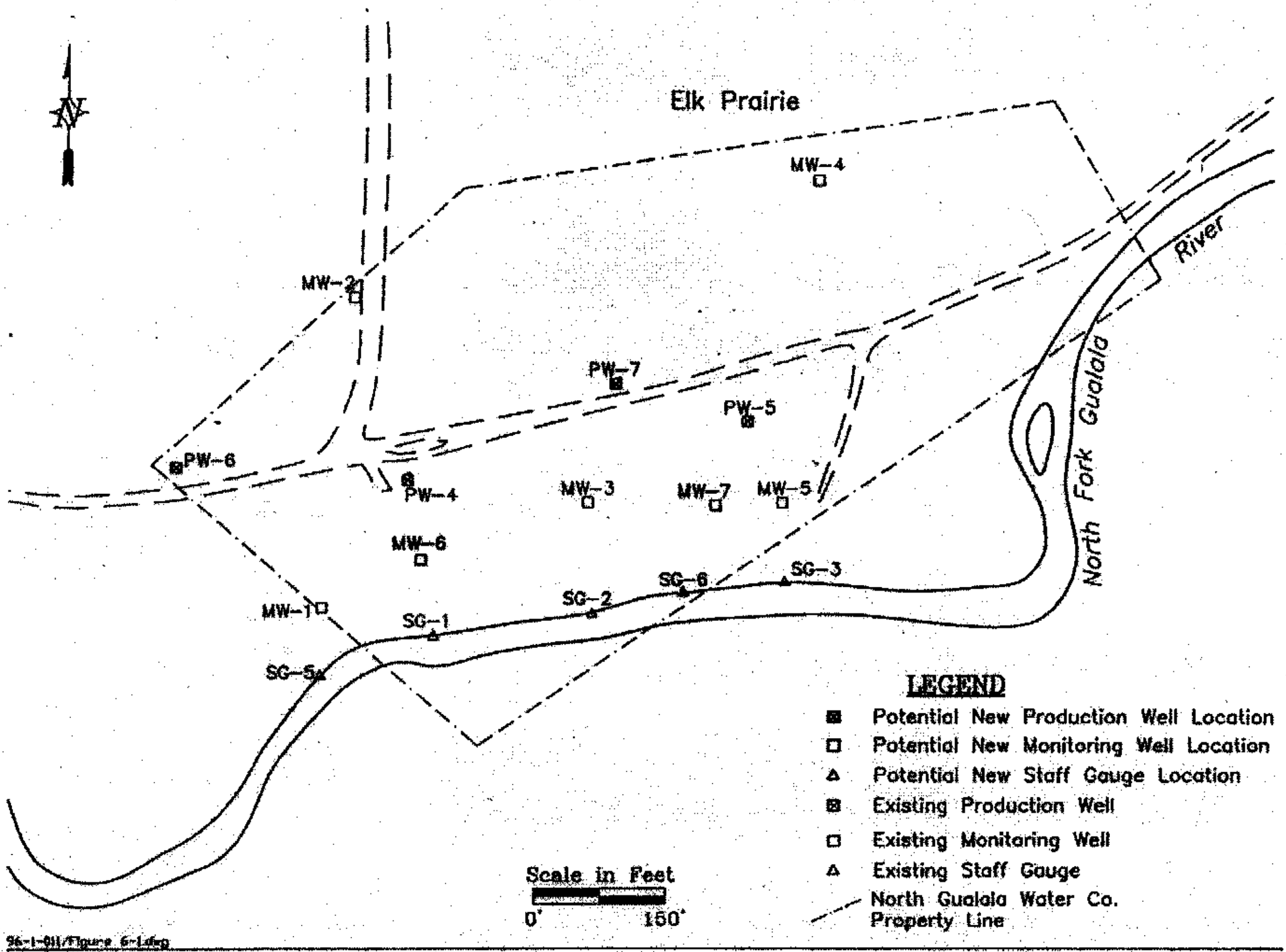

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Figure 6-1
Potential Locations of New Wells and Staff Gauges at Elk Prairie

Table 4-1
Elk Prairie Water-Level Monitoring Network

Name	Date of Installation	Reference Point Elevation (ft, msl)	Total Well Depth (ft)	Perforated Interval (ft)	Approx. Distance from North Fork (ft)	Distance from PW-4 (ft)	Start of Water-Level Monitoring
PW-4	08/04/89	45.95	141	56-134	180	—	03/21/96
PW-5	11/13/96	44.93	87	57-82	190	392	12/19/96
MW-1	10/23/96	44.01	50	25-45	50	179	10/28/96
MW-2	10/23/96	43.28	44	24-44	390	213	10/28/96
MW-3	10/20/96	42.35	48	23-43	125	205	10/28/96
MW-4	10/23/96	44.82	75	54-74	330	578	10/28/96
MW-5	10/21/96	43.87	53	28-48	90	425	10/28/96
SG-1	3/96	31.51	NA	NA	NA	181	03/21/96
SG-2	10/96	32.48	NA	NA	NA	257	10/28/96
SG-3	10/96	33.27	NA	NA	NA	441	10/28/96
SG-4	10/97	48.13	NA	NA	NA	3,388	10/07/97

Table 4-2 (continued)

Date	PW-4 (Elev. 45.95)	PW-5 (Elev. 44.93)	MW-1 (Elev. 44.01)	MW-2 (Elev. 43.28)	MW-3 (Elev. 42.35)	MW-4 (Elev. 44.82)	MW-5 (Elev. 43.87)	SG-1 (Elev. 31.51)	SG-2 (Elev. 32.48)	SG-3 (Elev. 33.27)
10/31/96	31.89		31.01	31.70	31.50	33.53	32.05	30.53	30.79	32.20
11/04/96			30.80	31.64	31.57	33.32	32.07	30.48	30.76	32.19
11/12/96			30.80	31.71	31.53	33.52	32.03	30.47	30.84	32.18
11/14/96			30.87	31.82	31.55	33.51	32.12	30.47	30.84	32.23
11/20/96			31.73	32.29	32.51	34.55	33.01	31.59	31.74	32.85
11/27/96			31.21	32.66	31.89	31.84	32.40	30.89	31.05	32.44
12/06/96			32.64	34.09	33.16	35.16	33.70	32.18	32.75	33.51
12/19/96	32.72	33.26	31.61	31.36	32.44	34.40	32.94	31.09	31.78	32.78
01/07/97	33.60	34.23	32.31	34.38	33.26	35.50	33.80	32.03	32.71	33.50
01/24/97	34.15	34.70	32.84	34.44	33.78	35.99	34.17	34.33	33.04	33.79
02/06/97	32.98	33.55	31.83	33.21	32.60	34.77	33.07	31.10	32.12	32.87
02/19/97	32.59	33.01	31.44	32.73	32.25	34.34	32.72	30.67	31.66	32.51
03/06/97	32.48	33.02	31.29	32.88	32.13	34.19	32.62	30.52	31.56	32.39
03/21/97	32.83	33.36	31.60	32.82	32.44	34.56	32.96	31.05	31.82	32.72
04/03/97	32.34	32.90	31.17	32.33	31.98	34.10	32.51	30.48	31.39	32.21
04/18/97	32.15	32.70	30.96	32.08	31.66	33.90	32.27	30.35	31.26	32.10
05/02/97	32.12	32.71	31.00	31.73	31.77	33.65	32.25	30.31	31.23	32.07
05/16/97	32.01	32.38	30.77	31.83	31.51	33.75	32.14	30.20	31.12	31.95
05/29/97	31.96	32.39	30.83	31.78	31.52	33.70	32.12	30.17	31.09	31.92
06/12/97	31.94	32.29	30.78	31.73	31.57	33.51	32.05	30.12	31.03	31.88
06/23/97	31.87	32.19	30.71	31.68	31.51	33.40	32.02	30.05	30.97	31.82
07/03/97	31.83	32.14	30.66	31.65	31.47	33.36	31.99	30.03	30.94	31.80
07/18/97	31.71	32.12	30.55	31.39	31.37	33.33	31.92	29.97	30.89	31.76
07/31/97	31.70	32.28	30.38	31.16	31.20	33.51	31.87	29.94	30.88	31.82
08/15/97	31.70	32.18	30.61	31.79	31.36	33.45	31.89	29.90	30.85	31.71
08/29/97	31.74	32.10	30.55	31.78	31.38	33.28	31.88	29.93	30.87	31.73
09/15/97	31.87	32.40	30.70	31.86	31.48	33.63	31.95	29.98		
10/02/97								29.96	30.89	31.76
10/07/97	31.76	32.32	30.59	31.66	31.39	33.52	31.86	29.90		
10/09/97	32.69	33.24	31.62	32.18	32.35	34.32	32.80	30.97	31.72	32.58
10/24/97	31.80	32.16	30.69	31.89	31.45	33.56	31.98	29.98	30.88	31.74
11/08/97	31.82	32.36	30.66	31.99	31.45	33.64	32.00	30.00	30.92	31.76
11/21/97	32.50	33.00	31.42	32.74	32.10	34.26	32.62	30.80	31.59	32.44
12/03/97	32.86	33.40	31.70	33.09	32.50	34.67	33.04	31.10	31.76	32.81

Table 4-3
Summary of Elk Prairie Aquifer Tests

Pumped Well	Observation Well or Staff Gauge	Distance from PW-4 (ft)	Test Start Date	Test Start Time	Test Duration (hrs)	Discharge Rate (gpm)	Static Water Level Before Test (ft, msl)	Pumping Water Level at End of Test* (ft, msl)	Drawdown at End of Test* (ft)
PW-4	PW-4	—	09/15/97	12:00 p.m.	80	258	31.87	29.97	1.90
	MW-1	179					30.70	30.37	0.34
	MW-2	213					31.86	31.45	0.41
	MW-3	205					31.48	31.20	0.28
	MW-4	578					33.63	33.17	0.47
	MW-5	425					31.95	31.81	0.14
	PW-5	392					32.40	32.05	0.36
	SG-1	181					29.98**	29.89**	0.09**
PW-4	PW-4	—	10/07/97	9:00 a.m.	24	258	31.76	29.95	1.81
	MW-1	179					30.59	30.32	0.28
	MW-2	213					31.66	31.32	0.34
	MW-3	205					31.39	31.15	0.25
	MW-4	578					33.52	33.16	0.36
	MW-5	425					31.86	31.76	0.11
	PW-5	392					32.29	31.99	0.30
	SG-1	181					29.90	29.86	0.04
	SG-4	3,388					44.50	44.50	0.00

* Because of precipitation late in the 10/7/97 test, pumping water levels and drawdowns for this test are based on manual measurements recorded after 12 hours.

** River stage measurements for the 9/15/97 test are affected by precipitation prior to the start of test.

Table 4-4

Surface- and Ground-Water Quality at Elk Prairie

Analytes	Reporting Limit	MCL	Water-Quality Sampling Results		
			PW-4 (9/18/97)	PW-5 (9/19/97)	SG-1 (9/18/97)
General Mineral					
Bicarbonate Alkalinity, mg/L	1		110	100	76
Calcium, mg/L	0.2		23	20	16
Carbonate Alkalinity, mg/L	1		ND	ND	ND
Chloride, mg/L	0.1	250/500 *	7.9	6.6	5.3
Copper, mg/L	0.005	1	ND	ND	ND
Hardness, mg/L	1		94	82	62
Hydroxide Alkalinity, mg/L	1		ND	ND	ND
Iron, mg/L	0.01	0.3	0.023	0.1	0.059
Magnesium, mg/L	0.05		9	7.7	5.4
Manganese, mg/L	0.005	0.05	ND	0.0098	0.12
pH, pH units	N/A	6.5/8.5	6.9	7.1	7.5
Potassium, mg/L	0.5		0.74	0.66	1.2
Sodium, mg/L	0.2		15	13	11
Specific Conductance, umhos/cm	10	900/1600 *	250	220	180
Sulfate, mg/L	0.1	250/500 *	6.4	6.2	7
Sulfactants (MBAS), mg/L	0.05	0.5	0.076	0.06	0.056
Total Dissolved Solids, mg/L	10	500/1000 *	140	130	100
Zinc, mg/L	0.005	5	0.0053	0.021	ND
Inorganic Chemical Analysis					
Aliminum, mg/L	0.1	1	ND	ND	ND
Antimony, mg/L	0.005	0.006	ND	ND	ND
Arsenic, mg/L	0.005	0.05	ND	ND	ND
Barium, mg/L	0.1	1	ND	ND	ND
Beryllium, mg/L	0.001	0.004	ND	ND	ND
Cadmium, mg/L	0.001	0.005	ND	ND	ND
Chromium, mg/L	0.01	0.05	ND	ND	ND
Cyanide, mg/L	0.01	0.2	ND	ND	ND
Fluoride, mg/L	0.1	1.4-2.4	ND	ND	ND
Lead, mg/L	0.005	0.015	ND	ND	ND
Mercury, mg/L	0.0002	0.002	ND	ND	ND
Nickel, mg/L	0.05	0.1	ND	ND	ND
Nitrate as NO3, mg/L	0.1	45	0.41	0.38	0.28
Nitrite as NO2, mg/L	0.1		ND	ND	ND
Selenium, mg/L	0.005	0.05	ND	ND	ND
Silver	0.01	0.1	ND	ND	ND
Thallium, mg/L	0.002	0.002	ND	ND	ND

Note: Water-quality samples were collected at PW-4 and SG-1 near completion of an 80-hour pumping test of PW-4. Sample was collected from PW-5 after 28 hours of recovery.

ND = Not Detected or below the reporting limit

*recommended/upper

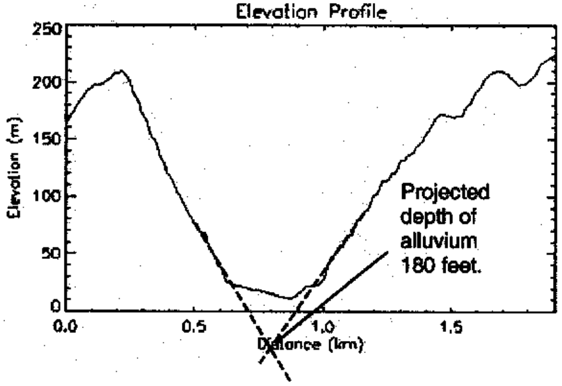
Table 4-5
Historical Surface- and Ground-Water Quality

Sample Location	Surface- or Ground-Water Sample	Date Sampled	Specific Conductance (umhos/cm)	Turbidity (NTU)	Iron (mg/L)	Manganese (mg/L)	pH (pH Units)	Total Dissolved Solids (mg/L)
North Fork Gualala River: ~150 Feet Downstream of Confluence With Little North Fork	Surface	07/01/87	153	0.30	<0.050	0.020	7.2	77
Production Well #4	Ground	08/24/89	208	0.50	0.150	<0.030	7.2	104
Production Well #4	Ground	11/30/95	259	0.30	0.110	<0.005	7.0	130
North Fork Gualala River: At SG-1	Surface	11/30/95	190	0.20	0.033	0.010	7.5	95
North Fork Gualala River: ~150 Feet Downstream of Confluence With Little North Fork	Surface	11/30/95	196	0.20	0.030	0.008	7.2	98
Production Well #4	Ground	12/18/95	263	0.12	0.014	<0.005	6.9	—
Production Well #4	Ground	01/12/96	248	0.25	<0.010	<0.005	7.4	151
North Fork Gualala River: At SG-1	Surface	01/12/96	163	0.30	0.016	0.006	7.2	78
Production Well #5	Ground	11/14/96	245	0.29	<0.020	<0.005	—	—
Production Well #5	Ground	11/20/96	228	0.65	0.270	<0.030	7.6	114
Production Well #4	Ground	09/18/97	250	—	0.023	<0.005	6.9	140
Production Well #5	Ground	09/19/97	220	—	0.100	0.0098	7.1	130
North Fork Gualala River: At SG-1	Surface	09/18/97	180	—	0.059	0.120	7.5	100

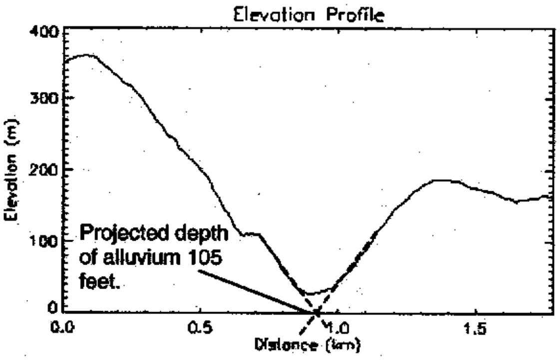
Table 5-1
Aquifer Characteristics Calculated from Elk Prairie Aquifer Tests

							Cooper-Jacob (Semi-Log)		Neuman (Log-Log)		
Pumped Well	Observation Well	Distance (ft)	Start Date	Test Duration (hrs)	Q (gpm)	Drawdown at End of Test* (ft)	Transmissivity (gpd/ft)	Storativity	Transmissivity (gpd/ft)	Storativity	Specific Yield
PW-4	PW-4	--	09/15	80	258	1.90	272,000				
	MW-1	179				0.34	592,000	0.0012	444,000	0.0013	0.06
	MW-2	213				0.41	331,000	0.0021	197,000	0.0020	0.24
	MW-3	205				0.28	702,000	0.0033	446,000	0.0016	0.04
	MW-4	578				0.47	332,000	0.0002	213,000	0.0002	0.03
	MW-5	425				0.14					
	PW-5	392				0.36	394,000	0.0004	285,000	0.0006	0.08
PW-4	PW-4	--	10/07	24	258	1.81	262,000				
	MW-1	179				0.28	631,000	0.0009	526,000	0.0016	0.10
	MW-2	213				0.34	255,000	0.0018			
	MW-3	205				0.25	695,000	0.0008	680,000	0.0018	0.31
	MW-4	578				0.36	334,000	0.0001	283,000	0.0002	0.10
	MW-5	425				0.11					
	PW-5	392				0.30	326,000	0.0005	360,000	0.0005	0.21
						Average	427,000	0.0011	381,000	0.0011	0.13
						Median	333,000	0.0009	360,000	0.0013	0.10

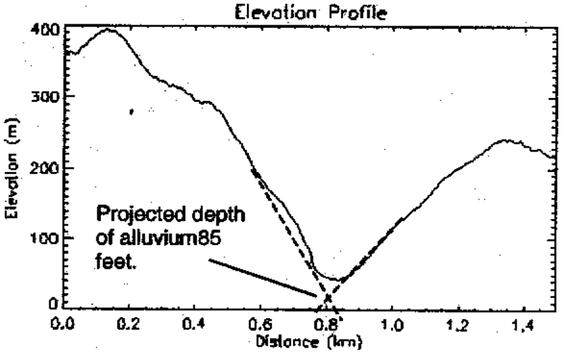
* Because of precipitation late in the second test, drawdown for this test is based on manual measurements recorded after 12 hours.



Topographic profile across North Fork Gualala at Elk Prairie. Profile derived from 10-meter DEM.



Topographic profile across North Fork Gualala at just above Robinson Creek. Profile derived from 10-meter DEM.



Topographic profile across North Fork Gualala near the end of the mapped alluvium. Profile derived from 10-meter DEM. Approximate cross-section location shown on Exhibit 3.

Estimates of depth of alluvium in North Fork Gualala based on projection of adjacent bedrock slopes.

DFG EXHIBIT 15

BAILEY SCIENTIFIC
420 Moll Court
Sonoma, CA 95476-6707
TEL/FAX : 707-939-1344

30 December 1996
Project 465

Mr. George C. Rau
Rau and Associates, Inc.
100 North Pine Street
Ukiah, California 95482

Subject: Seismic Survey
Elk Prairie
Gualala, California

Dear Mr. Rau:

In accordance with your request we herewith submit our report that details the results of our seismic refraction survey conducted on two North Gualala Water Company properties, one parcel located in Elk Prairie (North Fork Gualala River) and the other nearby (confluence of Little North Fork and North Fork).

Our study combined: (1) a review of the geologic literature pertinent to the area, (2) a geologic reconnaissance, (3) aerial photograph interpretation, and (4) a seismic refraction survey (staked and flagged). The information derived and interpreted from these investigative techniques was incorporated with additional information produced by exploratory borings and water wells drilled by others on the two properties.

Using the information derived from these various sources we herein discuss the geology and geophysics and define the depth to rock (i.e., thickness of alluvium) by presenting a map that depicts contours on "fresh" rock. In addition we have drawn a cross-section through Elk Prairie. These drawings are for your use in evaluating the hydrology of the water company's two properties.

It has been our pleasure to assist you with this interesting project, and we hope you will feel free to contact us should our type of service be required on future projects.

Respectfully submitted,

ALLEN D. BAILEY
No. 762
EXP. 1-31-98

Allen D. Bailey
Certified Engineering Geologist
No. 762

ADB:fb
Encl.

ENGINEERING GEOLOGY • GEOPHYSICS • MONITORING

velocities thus allowed us to detect the rock as measured by Traverses "U", "W", "X", and "Y".

A subsequently drilled monitoring well (MW-2) revealed that the 8500 ft./sec. seismic velocity measured at depths of 62 ft. and 68 ft. in Traverse "V" represents a very dense deposit of sand, gravel, and cobbles. The results of the monitoring wells and seismic survey indicate that this deposit, significantly shallower than the rock detected by adjacent seismic traverses, is limited to the general area of Traverse "V" on the water company property.

For locations of borings, water wells, test pit, and seismic traverses, please refer to the accompanying site map.

Taber Consultants drilled the five exploration/monitoring wells and encountered alluvium consisting of interbedded layers of clay, sand, gravelly clay, sandy gravel, and clayey gravel over rock. The gravel layers produced heavy resistance to drilling, and because of this difficulty only monitoring wells MW-3 and MW-5 extended to rock. MW-3 encountered sandstone at a depth of 149 ft. (el.-108) and extended into it for 22 ft., with resistance increasing with depth until near refusal was experienced at the bottom. MW-5 intercepted "fresh" sandstone at a depth of 147 ft. (el.-103) and penetrated an additional 8 ft., experiencing practical refusal at that point.

The depths to rock determined by the seismic survey compare favorably with depths to rock measured by the two borings of Taber Consultants. In the three borings that did not reach rock the nearby seismic traverse is in agreement to the extent that it measures rock below the bottom of the boring.

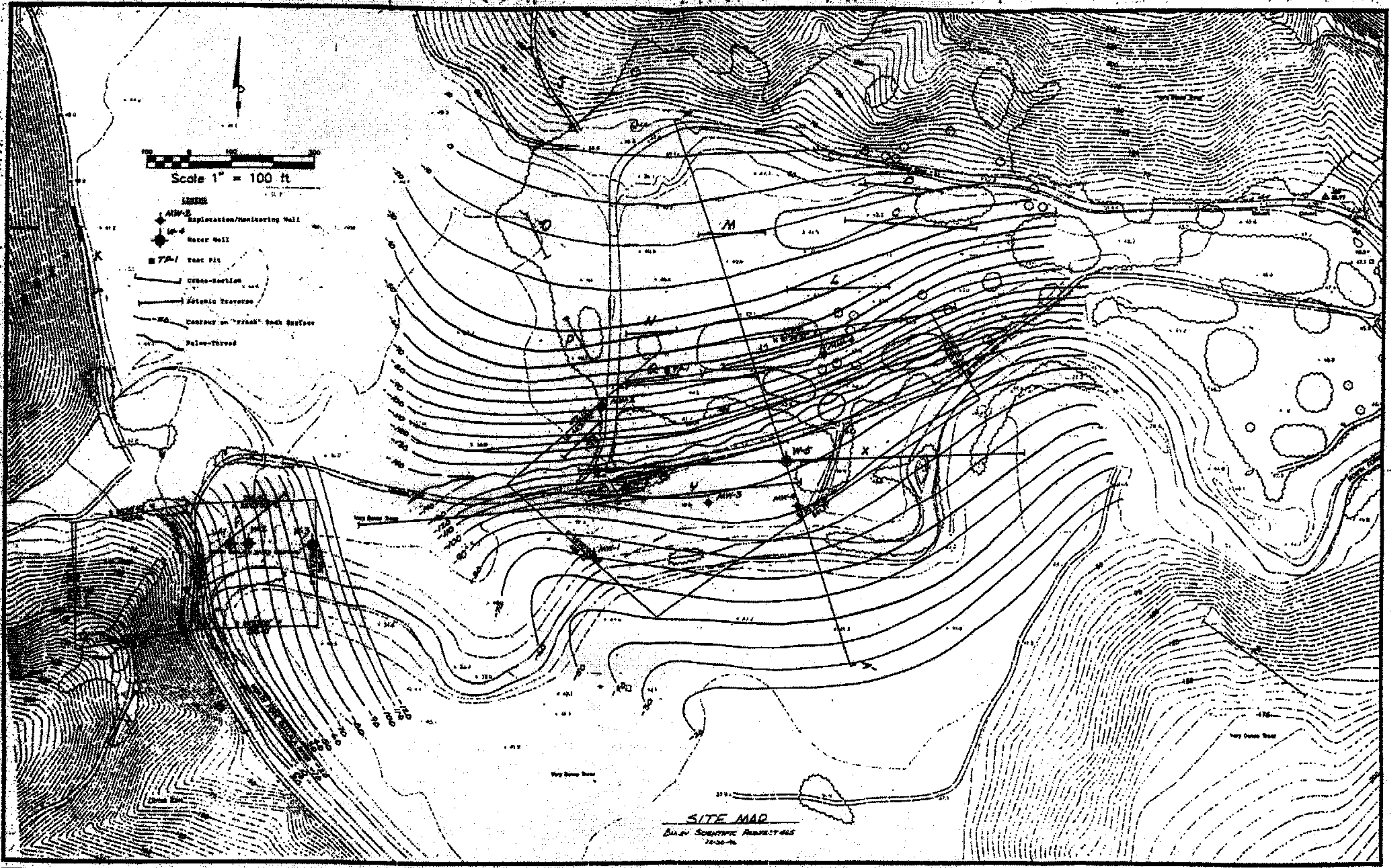
Water well W-5 was subsequently drilled by Weeks Drilling and Pump Company at the location shown on the site map. The driller, Earl Sheridan, states (oral communication and drill log)

Conclusions

Based upon the results of our investigation, we have drawn a contour map of the rock surface that lies buried beneath the water company's two parcels. This paleo-contour map expresses the buried rock surface that we have interpreted from our seismic survey and the logs of exploration/monitoring wells and water wells.

We have extended our interpretation beyond the limits of the two parcels to the adjoining hills. Due to a lack of sufficient information we have not drawn the contours across the San Andreas fault zone. However, the paleo-thread (deepest channel in the rock) undoubtedly extends into the fault zone and, at some point between the two properties, turns south and continues to the ocean. In Elk Prairie (surface approximately el.43) the lowest point that we have interpreted for the paleo-thread is approximately el.-130, which is still some 200 ft. above the lowest sea level during the maximum (approximately 18,000 years ago) of the last glacial advance (Wisconsinan). The elevation of the paleo-thread drops as it approaches the Wisconsinan sea level, which is estimated by the geologic community to have been at approximately el.-330, based upon oxygen isotope analyses of deep sea cores. As the sea level rose above the rock surface in Elk Prairie, marine and brackish water clays were interbedded with gravel and sand deposited by the North Fork as it debouched into the little embayment of Elk Prairie. All rivers along the coast have such drowned mouths; the Noyo River harbor at Fort Bragg is an excellent analog to Elk Prairie. The paleo-thread is only slightly sinuous, which is typical for a stream entrenched in rock. The modern North Fork expresses the higher sinuousity of a stream flowing through alluvium, which is less confining than rock.

Using the contours drawn on the rock's surface we have produced a cross-section (refer to site map for location) across Elk Prairie. The earth materials are divided into three units: (1) alluvium, including local landslide debris at the base; (2) soil and weathered rock, and (3) "fresh" rock. The weathered rock does not continue across Elk Prairie because it has been eroded in the central portion of the valley where the activity of the North Fork has been concentrated. Please refer to the accompanying cross-section drawing.



OWNER: NORTH GUALALA WATER COMPANY

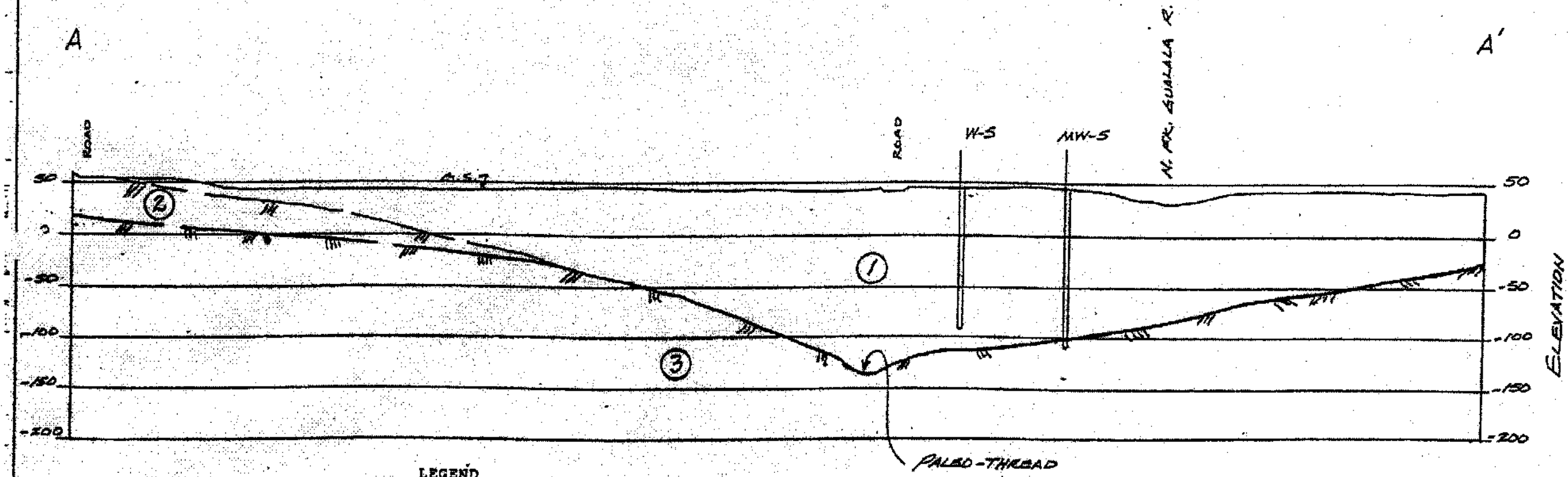
LOCATION: ELK PRAIRIE
GUALALA, CA

RAU AND ASSOCIATES INC.
CIVIL ENGINEERS · LAND SURVEYORS

DRAWING: WELL NO. 4 AND BOOSTER STATION

PROJECT: PROPERTY LINE LOCATIONS

SHEET 1 of 1 SHEETS



LEGEND

(1) **Alluvium**: Interbedded silty sand, silt, clayey gravel, silty gravel, sandy clay, and gravelly clay. Landslide debris occurs locally at the base. Seismic velocities of 1000 ft./sec. to 6000 ft./sec. with the higher end of the range likely representative of groundwater.

(2) **Weathered Rock**: Soil and thoroughly weathered to moderately weathered and well-fractured Franciscan sandstone. Seismic velocities of 1200 ft./sec. to 6000 ft./sec.

(3) **"Fresh" Rock**: Slightly weathered, well-fractured Franciscan sandstone with an occasional well-weathered (clayey) zone. Fractures are very tight. Seismic velocities of 8000 ft./sec. to 11,500 ft./sec.

Vert Scale 1"=100'
Hor'z scale 1"=50'

SCALE 1"= ~~100'~~ 50' (H+V)

BAILEY SCIENTIFIC

CROSS - SECTION
NORTH GUALALA WATER COMPANY
ELK PRAIRIE

Project No. 465 Date: 12-30-96

DFG EXHIBIT 16

STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources

in cooperation with
County of Sonoma

BULLETIN No. 118-4

EVALUATION OF GROUND WATER RESOURCES: SONOMA COUNTY

Volume I: GEOLOGIC AND HYDROLOGIC DATA

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Director
Department of Water Resources

Excerpts from Ford, R.S., 1975, Evaluation of Ground Water Resources: Sonoma County, Volume 1: Geologic and Hydrologic Data, DWR Bulletin 118-4, 177 pp.

Uplift of the Ohlson Ranch sediments occurred at about the same time as uplift and faulting of the Merced and Glen Ellen sediments. By the close of the Pliocene Epoch, the Kenwood and other synclines had been formed, and the structural feature that now is Sonoma Valley began to take shape. To the west, however, were still rolling hills leading down to the sea, and no evidence of the Santa Rosa Plain as yet could be seen.

During the Pleistocene Epoch, uplift and erosion continued, with much of the Ohlson Ranch, Merced, and Glen Ellen Formations being stripped off. Present drainage courses were established and Older Alluvium was deposited in many areas. Downwarping along the Windsor Syncline in the Santa Rosa Plain area caused the creation of a broad valley which sloped southward from Dry Creek all the way to what is now San Pablo Bay.

In the late part of the Pleistocene Epoch, sea level stood some 300 feet (91 m) lower than it does today. Streams draining the highlands cut deep valleys as they meandered southward toward the Golden Gate. Local uplift in the vicinity of the Washoe Anticline subsequently created a gentle arch in the vicinity of Penngrove. This formed the present drainage patterns and turned the Russian River westward to the sea. Since the beginning of the Holocene Epoch, Mark West Creek has changed its course slightly. This event has been coupled with rapid aggradation along the creek and minor subsidence along Laguna de Santa Rosa to the south, all of which helped to create the swamp and marsh condition found today along Laguna de Santa Rosa from near Sebastopol downstream toward Occidental Road.

Geologic Formations and Their Water-Bearing Properties

Nearly all geologic formations in Sonoma County yield some degree of water to wells. Well yields range from 1,000 gpm (3,780 l/m) in wells completed in coarse-grained Holocene deposits, to less than 1 gpm (3.78 l/m) in wells in the Jura-Cretaceous and Tertiary marine sediments. In general, the Jura-Cretaceous and Tertiary marine sediments, along with the granitic rocks and serpentine, yield less than 5 gpm (19 l/m). Mineral constituents, such as chloride, iron, manganese, and boron may be present in sufficient amounts to make ground water nonusable. In contrast, the Pliocene to Holocene materials are the principal water producers in the county; the water derived from these materials usually is of good to excellent quality, although some water quality problems also may be present.

Each of the various geologic formations occurring in Sonoma County is discussed below. Included in the discussion is a description of its general lithology, its water-yielding characteristics, and the general character of ground water produced.

Granitic Rocks

An area of intrusive granitic rocks is exposed along the western side of Bodega Head. Named the Bodega diorite by Johnson (1943), the rocks consist of deeply weathered, sheared, and faulted hornblende-biotitie-quartz diorite. Pegmatite, aplite, and lamprophyre dikes occasionally are present; some of the rock mass exhibits gneissose banding. Johnson correlated the Bodega diorite with similar rocks occurring in the Santa Lucia and Gabilan ranges to the south; it is considered to be of pre-Franciscan age.

A spring-fed pond is located at the abandoned site of the Bodega Nuclear Power Plant. The pond is formed from ground water entering the foundation excavation area. The water level in the pond stands about 20 feet (6 meters) above sea level, and there is a constant outflow from the pond into Bodega Bay of from 10 to 20 gpm (38 to 76 l/m). The water in this pond is an acceptable quality sodium chloride water.

There are no known wells in the granitic rocks of Bodega Head. Wells drilled into this rock mass may be able to produce limited quantities of potable ground water from fractures, shears, and deeply weathered zones.

Franciscan Formation and Great Valley Sequence, Undifferentiated

General Character. Much of the mountainous area in the northwestern and northeastern parts of the county is underlain by an assemblage of marine sediments with a stratigraphic thickness of at least 40,000 feet (12,000 meters) that has been identified as part of the Franciscan Formation and the Great Valley Sequence. Lesser exposures of these rocks also occur in the southwestern and southeastern parts of the county.

In the north coastal area, west of the San Andreas Fault, the rocks of this group have been identified by Huffman (1972) as being of Cretaceous age and have been named the Stewarts Point Strata and the Anchor Bay Strata. These rocks are massive sandstone, conglomerate, and mudstone, all of marine origin. Underlying the Stewarts Point Strata near Black Point is a complexly faulted mass of spilitic basalt.

The rocks east of the San Andreas Fault have been divided into two main groups, the Franciscan Formation and the Great Valley Sequence. Rocks of the Franciscan Formation predominate throughout most of the area. These rocks are of Jura-Cretaceous age and consist of three main rock types. The sedimentary sequence consists of interbedded graywacke and shale with minor amounts of greenstone, conglomerate, chert, and limestone. Much of the rock is highly shattered and commonly is veined with zeolite minerals. The metamorphic sequence contains metagraywacke with lesser amounts of weakly metamorphosed greenstone and chert; some glaucophane schist also is present.

The sheared sequence includes sheared sandstone and shale with discrete masses of serpentine and other rock types such as ultramafic, silicacarbonate rock, chert, greenstone, pillow lava, metabasalt, glaucophane schist, eclogite, and amphibolite. All of these rock types are intensely folded and faulted; zones of shearing and crushing are common. Rocks of the Great Valley Sequence are composed of well-bedded sandstone, shale, siltstone, and conglomerate. Included near the base of the Great Valley Sequence are masses of pillow lava, basalt breccia, diabase, gabbro, quartz diorite, and ultramafic rocks.

Water Quality. Only meager data are available on the quality of ground water contained in the fracture and shear zones of the Franciscan Formation and Great Valley Sequence. Excellent quality water is found at a number of cold springs which issue from these rocks. Thermal areas, such as The Geysers and Skaggs Springs, yield hot to boiling water with compositions ranging from highly mineralized sodium bicarbonate water to unpotable magnesium sulfate and ammonium sulfate water.

Water quality data are available for only one well tapping the rocks of the Franciscan Formation. This well Number 4N/7W-8R80, is located south of Petaluma and is 854 feet (260 meters) deep. The well produces an excellent quality sodium bicarbonate water that has a total hardness of only 5 mg/l. The water is used for both domestic purposes and dairy operations.

Well Yield. Ground water is present in the Franciscan and Great Valley Sequence rocks as indicated by the great number of springs in the areas of outcrop (see Figure 18). Ground water is not present in primary openings, as with the water-bearing materials, but rather in secondary openings such as joints, fractures, and shear zones. Wells drilled in these rocks frequently are completed as "hard rock" wells; that is, they usually are uncased. Well yields generally are low and range from less than 1 to at most 3 gpm (<4 to 12 l/m). These meager yields, however, may be sufficient for domestic purposes provided that water storage facilities of at least 1,000 gallons (3.78 (m^3) are available.

Well log data are available from 27 wells drilled into the Jura-Cretaceous rocks. These wells range in depth from 20 to 257 feet (6 to 78 meters); the range of yield of water is from 0.2 to

68 gpm (0.7 to 257 l/m), with the average being 18.4 gpm (70 l/m). Static water levels ranged from 2 feet to 160 feet (0.6 to 48.7 meters); one well was reported as flowing. An indication of the ability of a "hard rock" well to yield water is its discharge per unit of saturated rock. For wells in the Jura-Cretaceous rocks, this value ranged from 0.01 to 1.5 gpm per foot (0.1 to 18 l/m per meter); the average was 0.22 gpm per foot (2.7 l/m per meter).

Serpentine

Elongate masses of serpentine and related ultramafic rocks occur within the outcrop area of the Franciscan Formation. Major areas of this rock type have been identified on Plate 1. The rock areas so identified consist of blocks of greenish-black serpentinized periodotite enclosed in a bluish-green matrix of sheared serpentine. The weathered surface of these masses commonly is reddish-brown due to concentrations of iron oxides. Serpentine is not usually considered a reliable source of potable ground water. Mineral analyses are available from two springs in an area of serpentine (see Table 15). One spring yields a highly alkaline unpotable calcium hydroxide water; the other yields a magnesium bicarbonate water of acceptable potability.

Dry Creek Conglomerate

General Character. Although usually mapped as part of the Great Valley Sequence, the Dry Creek Conglomerate is considered a separate unit for ground water studies because of its ability to transmit and yield appreciable quantities of good-quality ground water to wells. The conglomerate is situated in the fold of the Geyserville Syncline which trends northwesterly from east of Fitch Mountain through Lytton to Pritchett Peaks, a distance of about 18 miles (29 kilometers). The surface exposure of the conglomerate ranges from one to two miles (1.6 to 3.2 kilometers) in width. The conglomerate consists of beds up to 100 feet (30 meters) thick of well-rounded cobbles and boulders of granodiorite, porphyry, chert, quartz, and greenstone; the matrix is an arkosic sandstone. The conglomerate is extremely massive; Gealey (1950 estimated its thickness at 5,000 feet (1,500 meters). Exposures of a similar conglomerate have been reported to the southeast in Napa County.

Water Quality. Ground water in the Dry Creek conglomerate is an excellent quality calcium bicarbonate water. Table 2 presents a summary of the quality characteristics of ground water in the Dry Creek conglomerate. No data have been gathered concerning

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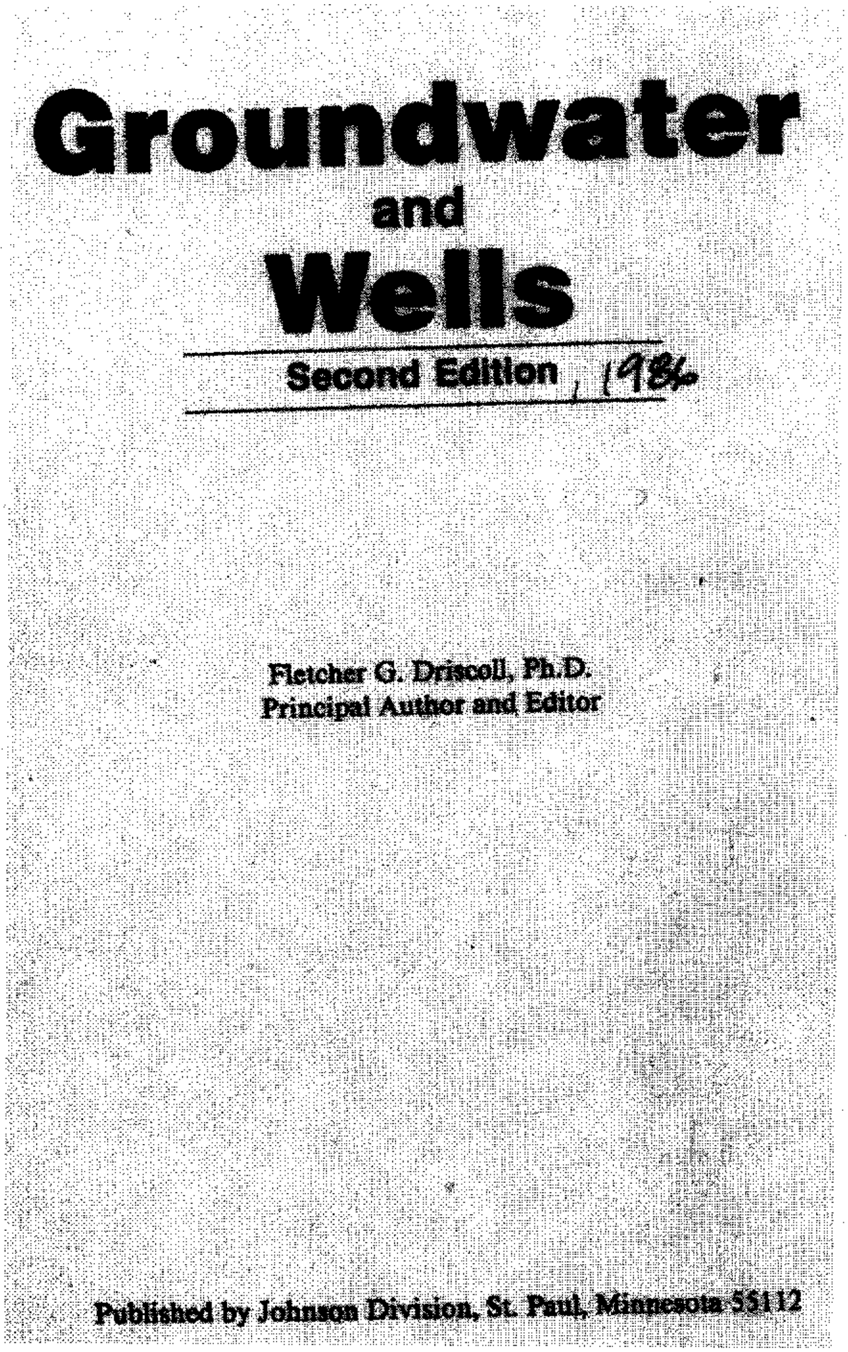


Groundwater and Wells

Second Edition, 1986

Fletcher G. Driscoll, Ph.D.
Principal Author and Editor

Published by Johnson Division, St. Paul, Minnesota 55112

Driscoll, F.G., 1986, Groundwater and Wells, page 1021 for estimating transmissivity from specific capacity.

APPENDIX 16.D.

Empirical Equations Used to Estimate Specific Capacity and Transmissivity

Two empirical equations have been developed from the modified nonequilibrium (Jacob) equation to estimate the potential specific capacity and transmissivity of a well. These equations are derived by assuming an average well diameter, average duration of pumping, and typical values for the applicable storage coefficient. The equations are useful for quickly checking the accuracy of values obtained for transmissivity and specific capacity during pumping tests.

Recall Jacob's equation (9.6):

$$s = \frac{264Q}{T} \log \frac{0.3Tt}{r^2S}$$

where
s = drawdown in the well, in ft
Q = yield of the well, in gpm
T = transmissivity of the well, in gpd/ft
t = time of pumping, in days
r = radius of the well, in ft
S = storage coefficient of the aquifer
This equation is based on the simplifying assumptions listed on page 218.

By rearranging terms, the specific capacity is:

$$\frac{Q}{s} = \frac{T}{264 \log \frac{0.3Tt}{r^2S}} \tag{1}$$

If typical values are assumed for the variables in the log function of the equation such as t = 1 day, r = 0.5 ft, T = 30,000 gpd/ft, and $S = 1 \times 10^{-3}$ for a confined aquifer and $S = 7.5 \times 10^{-2}$ for an unconfined aquifer, the specific capacity of the confined aquifer is given by:

$$\frac{Q}{s} = \frac{T}{2000} \tag{2}$$

The specific capacity for an unconfined aquifer is given by:

$$\frac{Q}{s} = \frac{T}{1500} \tag{3}$$

These empirical equations can be used to check the transmissivity of wells where the specific capacity is known, or the specific capacity where the transmissivity is known.

It may appear to be presumptuous to use an average transmissivity value or even to assume a transmissivity value at all before one is known. However, because it appears in the log term of Equation 1, its affect on the value of the divisor in either derivation is minimal. For example, if a transmissivity of 120,000 gpd/ft is assumed, the divisor increases from 2,000 to 2,133, a difference of less than 7 percent.

Estimates of Q/s using Equation 3 for unconfined aquifers will nearly always be optimistic because part of the aquifer is dewatered during pumping, resulting in a lower transmissivity as the saturated thickness decreases. Therefore, some estimates for unconfined aquifers may be more accurate if Equation 2 is used.

DFG EXHIBIT 18

Caspar Creek

Thornthwaite Potential Evapotranspiration
Water Years 1990 - 1995

MONTH	AIR TEMP (C)	Heat Index	Unadj PE	Lat Corr	Adj PET (mm)	Precip (mm)	P-PET (mm)
Aug	15.34	5.46	2.36	35.40	83.54	2.71	-80.83
Sep	14.29	4.90	2.16	31.20	67.39	9.10	-58.29
Oct	12.25	3.88	1.79	28.80	51.55	72.60	21.05
Nov	8.54	2.25	1.15	25.10	28.87	74.93	46.07
Dec	6.84	1.61	0.88	24.50	21.56	164.04	142.48
Jan	8.72	2.32	1.18	25.40	29.97	263.53	233.55
Feb	9.40	2.60	1.29	25.10	32.38	164.04	131.66
Mar	10.95	3.28	1.56	30.90	48.20	214.88	166.68
Apr	11.74	3.64	1.70	33.30	56.61	92.84	36.23
May	12.77	4.13	1.88	37.00	69.56	102.74	33.18
Jun	14.18	4.85	2.14	37.30	79.82	25.95	-53.87
Jul	15.56	5.58	2.40	37.90	90.96	0.93	-90.03
ANNUAL		**44.50**			**660.42**	**1188.30**	**527.88**
Measured North Fork Streamflow (mm)							503
Measured South Fork Streamflow (mm)							461

Last Updated on December 30, 1997, by Bob Ziemer

Five year Water balance for Caspar Creek, Jackson state Forest, by R.R. Ziemer, 1997, http://www.rsl.psw.fs.fed.us/projects/water/Thornthwaite.html. .

DFG EXHIBIT 19

United States
Department
of Agriculture

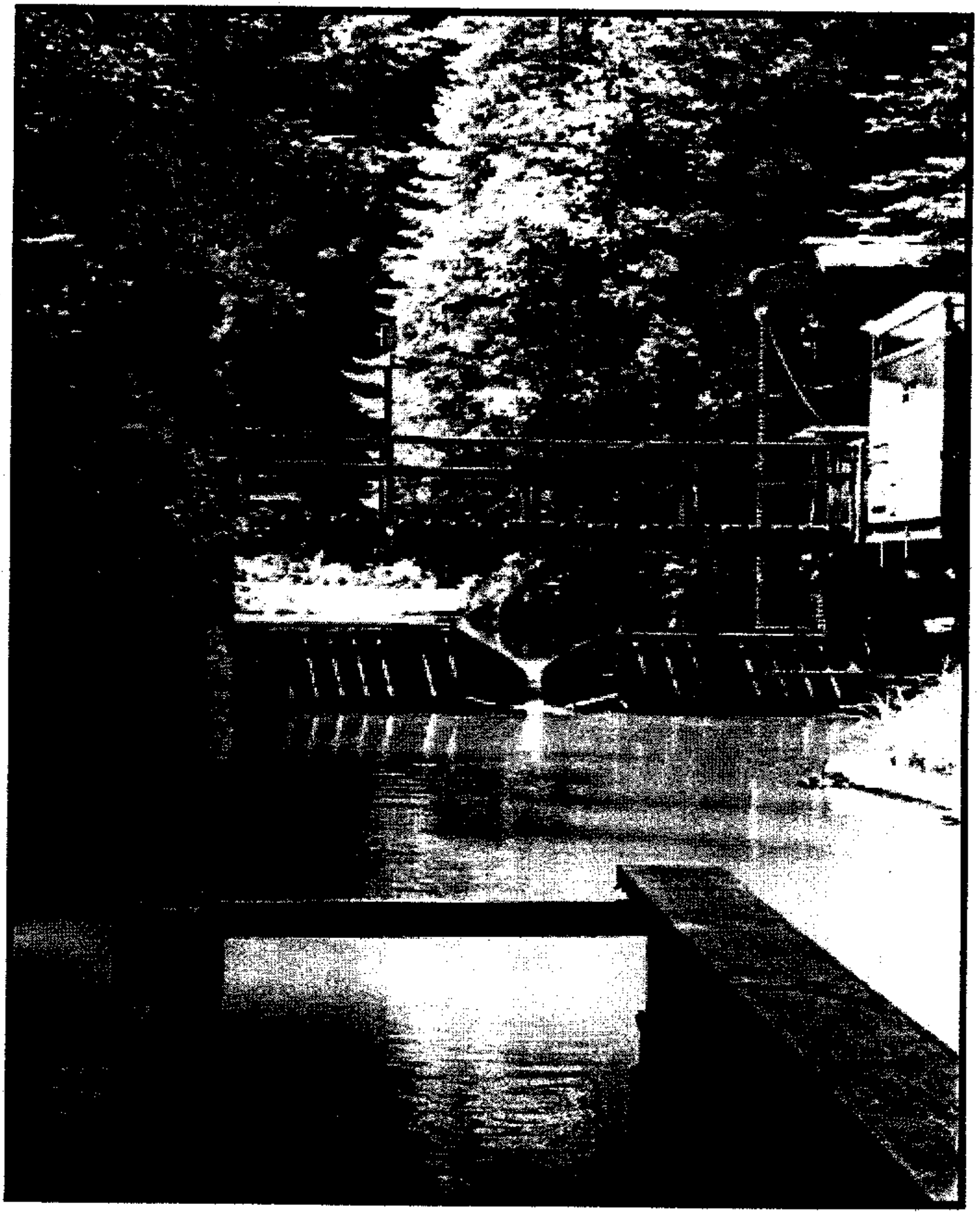
Forest Service

**Pacific Southwest
Research Station**

General Technical Report
PSW-GTR-168

Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story

May 6, 1998 Ukiah, California



Subsurface Drainage Processes and Management Impacts[1]

Elizabeth Keppeler[2] and David Brown[3]

Abstract: *Storm-induced streamflow in forested upland watersheds is linked to rainfall by transient, variably saturated flow through several different flow paths. In the absence of exposed bedrock, shallow flow-restrictive layers, or compacted soil surfaces, virtually all of the infiltrated rainfall reaches the stream as subsurface flow. Subsurface runoff can occur within micropores (voids between soil grains), various types of macropores (structural voids between aggregates, plant and animal-induced biopores), and through fractures in weathered and consolidated bedrock. In addition to generating flow through the subsurface, transient rain events can also cause large increases in fluid pressures within a hillslope. If pore pressures exceed stability limits of soils and shallow geologic materials, landslides and debris flows may result. Subsurface monitoring of pipeflows and pore pressures in unchanneled swales at North Fork Caspar Creek in the Jackson Demonstration State Forest began in 1985. Four sites have been established to investigate the effects of timber harvest (K1 and K2) and road building (E-road) for comparison with an unmanaged control drainage (M1). Flow through large soil pipes at these sites is highly transient in response to storm events, reaching peak discharges on the order of 100 to 1,000 L min^{-1}. Pore pressures at these sites also respond dynamically to transient rain events, but to date have not exceeded slope stability limits. Most soil pipes cease flowing in the dry summer period and hillslope soil moisture declines to far below saturation. The clearcut logging and skyline-cable yarding of the K2 site resulted in dramatic increases in soil pipeflow and subsurface pore pressures. During the first 4 years after timber harvest, pore pressures increased 9 to 35 percent for the mean peak storm event in the control M1 site. Peak soil pipeflow response was far greater, increasing 400 percent in the 4-year postlogging period. These results suggest that the soil pipes are a critical component of subsurface hillslope drainage, acting to moderate the pore pressure response. As the subsoil matrix becomes saturated and pore pressures build, soil pipes efficiently capture excess water and route it to the stream channel. This logging does not appear to have impaired the hillslope drainage function. Methods and results at the E-road site are quite different. Here, the mid-swale road construction and tractor yarding have resulted in large changes in the pore pressure response. Positive pore pressures were negligible in the upper portion of this instrumented swale before disturbance. Subsequent to the road construction in May 1990, there was little indication of immediate impacts. But, after the completion of felling and tractor yarding in late summer 1991, dramatic changes in pore pressure response were observed beginning in hydrologic year 1993 and continuing to date (1998). Largest pore pressure increases have occurred at sensor locations in and up-slope of the road prism. Below the road, the response is muted. These data support previous studies documenting the profound effects of roading and tractor logging on watersheds and provide special insight into these effects for this region.*

The hydrologic response of forested watersheds to rain events occurs through several interrelated flow processes. Soil surface conditions determine whether rainfall will run off as surface flow or whether it will infiltrate and travel through the subsurface. Infiltration capacities for soils in the coastal redwood region exceed maximum rainfall intensities common in the region. Exceptions occur in isolated areas where bedrock is exposed at the land surface. More widespread are infiltration limitations resulting from soil compaction associated with road building, landings, and other constructed surfaces. Over the great majority of forested landscapes, rainfall infiltrates into the soil and flows through the subsurface to streams, rivers, and lakes.

Subsurface flow may occur within soil horizons, regolith (weathered bedrock), or bedrock (*fig. 1*). The conductive and storage properties of a given earth material as well as the spatial relations of adjoining materials strongly influence the actual flow path through the subsurface. For example, water may flow within soil horizons through the matrix, a porous medium of individual grains. Pores on the individual grain scale transmit water very slowly, several orders of magnitude less than surface water flows. Larger pores (on the order of 1 mm in diameter or larger) are commonly referred to as macropores, and can conduct substantial quantities of water at rates approaching surface flow velocities. By virtue of their geometry, macropores can be shown to conduct water more rapidly under high moisture conditions than the "micropores" of the soil matrix. Macropore geometry and type varies with depth below the land surface arising from various biologic and soil-forming processes (*fig. 1*). Interconnected large macropores (on the order of 2 cm in diameter or larger) are often referred to as "soil pipes." These features are erosion pathways that extend within the shallow subsurface horizons as continuous or interconnected conduits forming complex branching networks (Albright 1992). An important hydrologic attribute of macropores is that the surrounding soils must be saturated before water can flow into these large pores. Thus, the antecedent moisture conditions in forest soils strongly control the importance of flow through macropores; and hence, the hydrologic response of a watershed to a precipitation event. Similarly, fractures in regolith or bedrock may dominate the flow response under saturated conditions, and thus define a significant flow path distinct from the soil matrix or macropores.

The movement of water into and through these flow paths has two consequences of both theoretical interest and practical application to the management of forestlands. First, surface runoff in streams is generated on two widely different time scales: (1) on a seasonal basis and (2) during individual precipitation events. Runoff volume, timing, and duration affect both water supply and flood propagation. Seasonal effects of subsurface flows are manifest in the storage properties of forest soils. During the summer, water

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[1] An abbreviated version of this paper was presented at the Conference on Coastal Watersheds: The Caspar Creek Story, May 6, 1998, Ukiah, California

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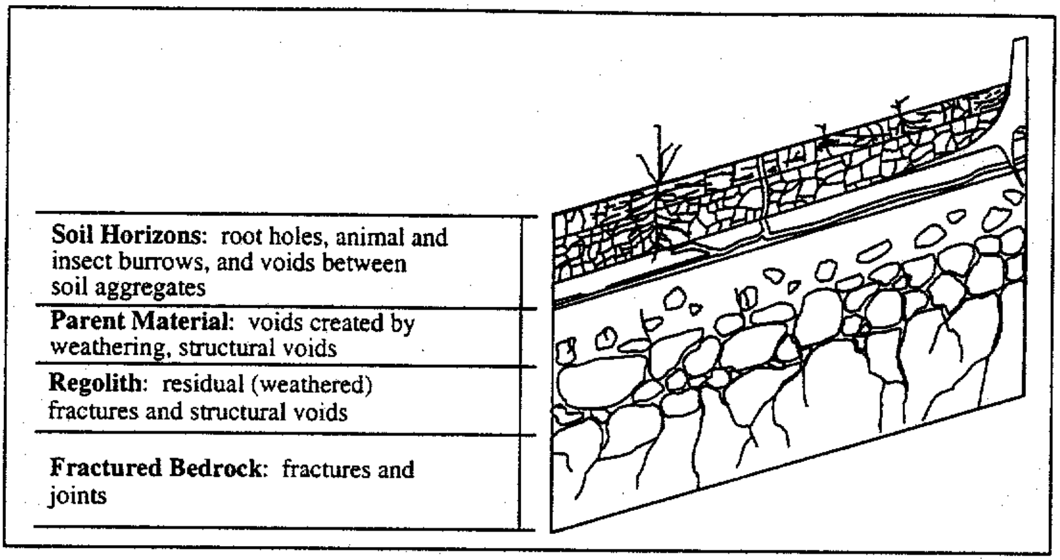


Figure 1—Hypothetical soil cross-section with characteristic voids and flow path variations.

drains from soils and supports perennial streamflow (baseflow). This drainage creates a water deficit in the soil that must be replenished before maximum flow through a hillslope can occur.

The second consequence of transient subsurface flow is directly related to the storm-driven evolution of pore pressures at the hillslope scale. Gravity is the primary force driving the flow of water in upland forested watersheds. However, if soil compaction closes pore spaces and prevents or reduces drainage through macropores, water pressure may increase such that the strength of the hillslope is lost and shallow landslides or debris flows may occur. Mass failures are a significant source of sediment reaching streams and are generated from background earth surface processes and from human activities such as road building. Dynamic interactions between pore pressures, drainage geometry, and the material properties of soil and bedrock can significantly influence the stability of slopes and channel heads, as well as sediment releases to streams (Dietrich and others 1986).

Research investigations at Caspar Creek have explored these hillslope and subsurface drainage processes with the dual objectives of identifying impacts associated with logging and road building and reducing the risk of mass failures associated with timber harvest activities in the redwood region.

Methods

Headwater swales were selected for monitoring in both a control (MUN) and two designated treatment sub-basins (KJE and EAG) of the North Fork experimental watershed (Preface, fig. 2, these proceedings). All study sites are moderately steep zero-order basins located in the North Fork watershed at an approximate elevation of 300 m (*fig. 2*). An almost 100-year-old second-growth forest occupied these sites at the initiation of these investigations (Henry, these proceedings). All study swales are drained by one or more soil pipes with outflow in evidence at the base of the swale axis. Pipeflow varies seasonally from less than 0.01 L min^{-1} to more than 1,000 L min^{-1} at individual soil pipes. Most soil pipes are intermittent or seasonally dry.

The vegetation community is a coniferous forest type with a

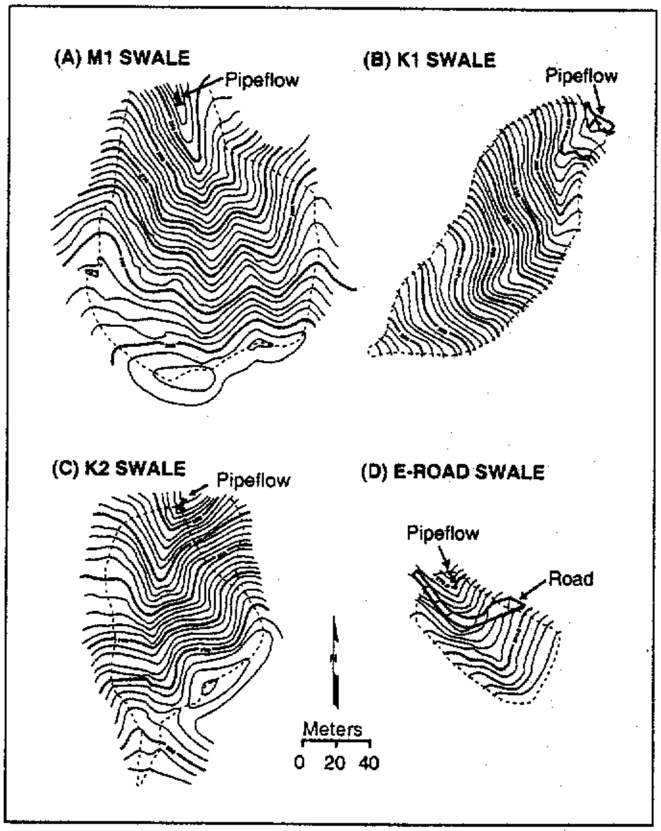


Figure 2—North Fork Caspar Creek study swales (2-m contour interval).

closed canopy consisting of coastal redwood (*Sequoia sempervirens* (D. Don) Endl.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) as the dominant tree species. Although not measured during this study, the diameter-at-breast height is estimated to range from approximately 0.3 m to 1.5 m. Forests in the Caspar Creek watersheds were clearcut and burned in the late 1800's (Tilley and Rice 1977; Napolitano, these proceedings), and are generally typical second-growth forests. Other tree species occurring at this site include grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and tanoak (*Lithocarpus densiflorus* (Hook. and Arn.) Rohn).

The soil at these sites has been classified as a clayey, mixed isomesic Typic Tropudult described as the Van Damme series (Huff and others 1985). Surface soils tend to have a loamy texture and increasing clay content with depth (Wosika 1981). Discontinuous argillic horizons have been observed in scattered soil pits (Dahlgren 1998). Soil thicknesses range from 1.0 m along the ridges to 1.5 m in the swales (Wosika 1981). The parent material below this depth range is a highly weathered layer of fractured regolith derived from the underlying graywacke sandstone of Cretaceous age known as the Franciscan Assemblage (Huff and others 1985). Geologically recent tectonic forces (1 my b.p.) acting along the San Andreas fault system just offshore have contributed to a gradual uplift of up to 200 m (Jenny 1980). Field estimates of hydraulic conductivities were made using slug tests in piezometers in EAG, KJE, and MUN swales. Saturated hydraulic conductivity estimates for the regolith above the hard bedrock contact range on the order of 10^{-8} to 10^{-4} m s^{-1}.

Local climate is heavily influenced by the site's proximity to the coast (approximately 10 km to the west). Like most of coastal California, the large majority of the rainfall occurs during late fall and winter months. The mean annual rainfall for this area is 1190 mm (46.85 in). Relatively little rainfall occurs between the months of April and October, but coastal fog may supply moisture to the soils via fog drip. Air temperatures range from a January mean of 7 °C to a high of about 15 °C in July.

M1 Site

The M1 site is the designated control site and thus retains continuous second-growth forest cover. This 1.7-ha swale (*fig. 2a*) is the largest subsurface study site. The terrain slope varies from 20 to 50 percent. One large and several small soil pipes drain the swale. These soil pipes were fitted for instrumentation in 1986 (Ziemer and Albright 1987). The large 80 cm (height) by 60 cm (width) pipe, M106, has discharged the highest pipeflow peak recorded in the North Fork watershed—1,700 L min^{-1} on January 20, 1993. This pipe occurs at the interface between the upper soil and an argillic horizon (Albright 1992). Two transects of piezometers, denoted A (three instruments) and C (four instruments), were installed to bedrock (at depths of up to approximately 6.0 m) on the side slopes above the piping gage station (Brown 1995). A nest of piezometers was installed at the confluence of the two subswales. Two piezometer nests were installed at the confluence of the subswales (piezometers B1 and B2) and just upslope of the swale at the bottom of the C transect (piezometers C1 and C2). Two additional piezometers were installed to bedrock, one in each of the two upper tributary swales (Brown 1995). On the basis of the soil borings excavated during piezometer installations, a geologic cross-section was prepared across the A-C transects (*fig. 3*). Soil horizons and regolith thicknesses were fairly uniform throughout both slopes.

K1 Site

A second pipeflow site, K1, was developed near the KJE stream gaging station in 1986 (Preface, fig. 2, these proceedings). This 1.0-ha swale (*fig. 2b*) is drained by several soil pipes within the upper 0.5 m of the soil with diameters ranging from 10 to 20 cm (Albright 1992). Most are flashy and ephemeral, yielding significant flows only during storm events. Pipeflow, surface flow, and matrix flow at the soil face were gaged at this second site, but no subsurface pore pressure measurements were made. The site was clearcut and skyline yarded from the ridge in 1989 as part of the Caspar East timber sale unit K (Henry, these proceedings). No slash burning or other site preparation was done in this unit after timber harvest.

K2 Site

This 0.8-ha zero-order swale (*fig. 2c*) was first instrumented for pipeflow measurements in 1986. Three soil pipes were gaged at this site. The largest soil pipe, K201, is 50 cm in diameter and emerges from the exposed soil face at a depth of less than 1.5 m from the ground surface (Albright 1992). In 1987, a network of piezometers and tensiometers was established along five hillslope transects (Keppeler and others 1994) that were aligned perpendicular to a west-facing K2 hillslope. To prevent excessive disturbance of this steep 70 percent slope, a system of ladders and catwalks was built before instrument installation. Hillslope installations include: 31 bedrock piezometers, 27 1.5-m-deep piezometers, and 25 tensiometers at depths of 30, 45, 60, 120, and 150 cm. Three of these instrument transects (A, B, C) are about 20 m in length and extend from near the swale axis to mid-slope positions. The other

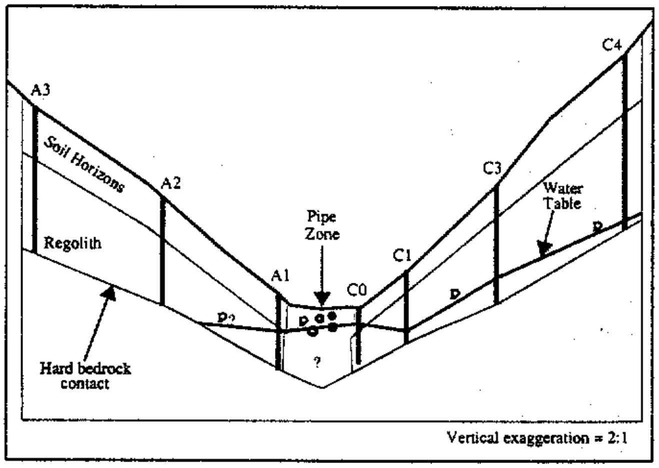


Figure 3—Cross-section of soils, geology, soil pipe, and piezometer installations at the M1 site.

two transects (D and E) extend nearly to the ridge. Two additional bedrock piezometers are installed in the swale axis. After two winters of data collection, the K2 site was clearcut and skyline yarded from the ridge during August 1989 (Henry, these proceedings). No slash burning or other site preparation was done in this unit following timber harvest.

E-Road Site

The smallest and most recent Caspar Creek subsurface monitoring site is the E-road swale. This 0.4-ha swale is located in the EAG subbasin and cutblock E of the North Fork (Preface, fig. 2, these proceedings). This north-facing swale is drained by two instrumented soil pipes. A single 44-m-long transect consisting of six bedrock and two shallower piezometer installations extends through the swale axis from the soil pipe excavation to a position 38 m from the ridge (*fig. 2d*). Piezometer depths range from < 1.5 m at the lower end of this transect to almost 8 m at the top. The terrain slope along this transect averages 35 percent. This site was instrumented in fall 1989 to evaluate the impacts of road construction on hillslope drainage processes. Predisturbance monitoring of pore pressures and pipeflow occurred during the winter 1990. In June 1990, a seasonal road was built across this swale to a yarder landing on the unit divide. The road centerline crosses the instrument transect at the R4P2 piezometer. The grade of this 30-m road segment averages 19 percent. The fill depth is 3 m at its maximum, 2 m at the centerline, 1.6 m at R3P2, and <1 m at R2P2 (near the base of the roadfill). This haul road was rocked for use during October and November of 1990 when a portion of the Unit E cutblock was harvested using a cable skyline yarder at the end of this spur. In late-summer 1991, the timber not cut during the road right-of-way felling was harvested using tractor yarding above and long-lining below the road. Broadcast burning of the unit occurred in late November. Because of the north-facing aspect of this swale, fuel consumption was incomplete.

Instrumentation

Field investigations were undertaken first to identify the most upslope occurrence of gullying or sinkholes associated with pipeflow outlets at each study swale. At these existing collapses, handcrews excavated a near-vertical soil face to facilitate the capture of pipeflow and soil matrix discharge. Soil pipes ranging in diameter from 2 to 60 cm and occurring within 2 m of the soil profile were instrumented. Flow from individual sources (pipes, overland flow, and soil matrix flow) was captured by first driving metal flashing collectors into the excavated soil profile, then connecting these collectors to PVC (polyvinyl chloride) pipe, and finally routing the flow into an upright PVC standpipe container. Drainage holes were drilled into these standpipe containers and a laboratory calibration was done to establish the relationship between stage in the container and discharge. Containers were designed with a variety of drain hole diameters and placements to accommodate a wide range of discharges. Using electronic pressure transducers and data loggers, container stages were recorded at 10-min intervals during the winter season and at 30-min intervals during the lowflow season. Frequent manual discharge measurements were made at these pipeflow sites to verify and refine the standpipe container calibrations (Ziemer and Albright 1987).

To measure the pore pressure response along selected transects in these study swales, piezometer wells were installed by hand-augering 10-cm-diameter holes through the soil profile. A PVC pipe (38 or 51 mm diameter) was then cut to extend from the base of the hole to several centimeters above the ground surface. The lower 15-cm length of this pipe was slotted with a hack saw. Plastic mesh screen was wrapped around the slotted portion of the pipe before the pipe was placed in the augered hole. The hole was backfilled first with pea gravel for about 25 cm of the depth, then 15 to 20 cm of bentonite, and finally, with natural soil. Hillslope instruments were assigned a transect identifier and numbered beginning with the base of the slope and progressing up the hill. P2 indicates a "bedrock" piezometer, and P1 indicates a shallower installation.

Bedrock installations were augered to the physical limit of the hand auger device. At some sites, rock fragments in the lower saprolite prevented the auger from reaching competent bedrock. Shallower piezometers were installed at certain sites where a low-permeability clay layer (argillic horizon) was encountered. Finally, a few piezometers were installed into competent bedrock using a rock drill. Water levels (pore pressures) were monitored using a combination of techniques. Manual measurements were made at all piezometers at least weekly using an electronic water surface detector. Electronic pressure transducers connected to a data logger sensed piezometer water levels at 15-min intervals during the winter and less frequently during the lowflow periods at the K2 and E-road swales (Keppeler and Cafferata 1991, Keppeler and others 1994). Accuracy of these measurements was generally within a 0.05-m tolerance. At the M1 site, a comparable transducer/data-logger combination provided water level heights with a design accuracy of approximately 0.01 m along three transects (A, B, and C). Only very rarely did the electronic data differ from hand measurements by more than 0.02 m. Pressure heads in the piezometers were logged at 15-min intervals during storm periods, and at 2-hr intervals between storms.

Soil tensiometers were installed at some sites to provide a measure of soil moisture in unsaturated conditions and to indicate when the shallower soil horizons became seasonally saturated. These devices are commonly used for assessing agricultural irrigation needs. Our tensiometers consist of a porous ceramic cup connected to a closed tube and a vacuum gage. The cup is buried in the soil and the tube is filled with water. As the soil moisture tension equilibrates with the water tension in the tube, a vacuum is created and indicated on the gage. At field capacity, this tension is 33 cb. As the soil drains, tensions exceeding 85 cb may be recorded. These gages were read manually at weekly intervals and, in some cases, connected to a data logger via a pressure transducer allowing for frequent readings and recordings. Keppeler (these proceedings) reports summer soil moisture changes at these sites.

Analyses

Ziemer (1992) evaluated changes in peak pipeflow after the logging of the K1 and K2 swales using data from hydrologic year 1987 through 1991. Regression analysis was used to develop a relationship between individual soil pipes at the K1 and K2 sites and the M1 site control, as well as total pipe discharge per site. A second set of regressions was developed using the postlogging pipeflow peaks. Chow's test (Chow 1960) was used to detect differences between these regression lines ($p < 0.05$). For this report, additional peak pipeflow data through hydrologic year 1993 from the K201 and M106 sources were analyzed using this regression approach. This analysis included 38 prelogging and 41 postlogging storm peak pairs from K201 and M106.

Keppeler and others (1994) evaluated the piezometric response to logging in the K2 site. Regression analysis was used to define the prelogging relationship between peak pore pressures along selected K2 transects and peak discharge ($\log_{10}$) at the M106 soil pipe. Postlogging regressions were then developed for storm peaks occurring during hydrologic years 1990-1993. Zar's test for comparing regression lines (Zar 1974) was used to detect differences between the calibration and postlogging relationships ($p < 0.05$). A similar procedure was applied to evaluate piezometric pressure heads during nonstorm periods.

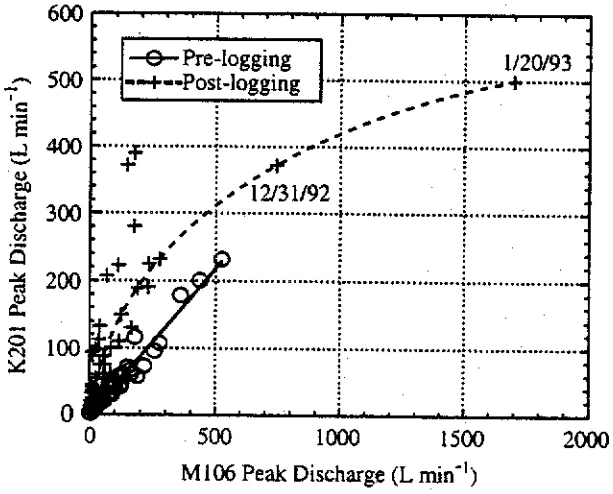
Initial analysis of the pore pressure response to road building was done nonstatistically by comparing E-road piezometric peaks and ranges before and after road construction and tractor logging. In addition, further analysis was attempted using E-road piezometer peaks regressed on peak discharge ($\log_{10}$) at the M106 soil pipe. Only preliminary screening of other factors relating to the E-road subsurface response has been performed.

Results and Discussion

Pipeflow

Increased peak pipeflow was detected at the fully clearcut K2 site during the first winter after logging (1990), but larger increases were observed one year later (Ziemer 1992). During 1990 and 1991, peak pipeflow at K2 (pipe K201) was 370 percent greater than predicted by the calibration relationship with M1 (pipe M106). Extending this analysis to include peak discharges through 1993 provides further insight into the pipeflow response to logging. With 38 peaks ranging up to 525 L min^{-1} (M106) in the prelogging data set, a linear regression provides a very good fit to the data ($r^2 = 0.96$) as evident in *figure 4b*. The postlogging data set contains 41 peaks, with all but two of the M106 peak discharges less than 300 L min^{-1}. Those two large peaks exceed the prelogging data by a substantial margin (*fig. 4a*), and present an interesting complication to evaluating treatment effects. The largest storm produced a peak at M106 of 1700 L min^{-1} on January 20, 1993, triple the size of the largest M106 peak in the prelogging data set. The return interval for this peak is approximately 8 years based on the 35-yr North Fork peakflow record. The postlogging relationship between M106 and K201 is much more variable than the prelogging relationship. Although pipe K201 yields maximum discharges of up to 500 L min^{-1}, it appears to be capable of unrestricted discharge only until about 250 L min^{-1}. The recurrence interval of the comparable North Fork streamflow peak is approximately 0.3 years. K201 discharge appears to be restricted by pipe capacity above a discharge of about 250 L min^{-1}, whereas M106 can pass discharges of at least 1,700 L min^{-1}. The other instrumented soil pipes also exhibit peak discharge restrictions at even lower discharges. In contrast to open channel conditions, pipeflow is limited by the physical capacity of the pipe. The cross-sectional area of pipe K201 is much less than M106; thus, discharge capacity at K201 is more limited than M106. Field observations indicate that upslope of the M1, K2, and K1 gaging sites; several ungaged pipe outlets produce significant discharge volumes during larger storm peaks. These "overflow" features provide further evidence of the hydraulic limitations of these main soil pipe pathways.

a) K201 (logged 1989) versus M106 (unlogged control)



b) M106 Discharge < 300 L min^{-1}

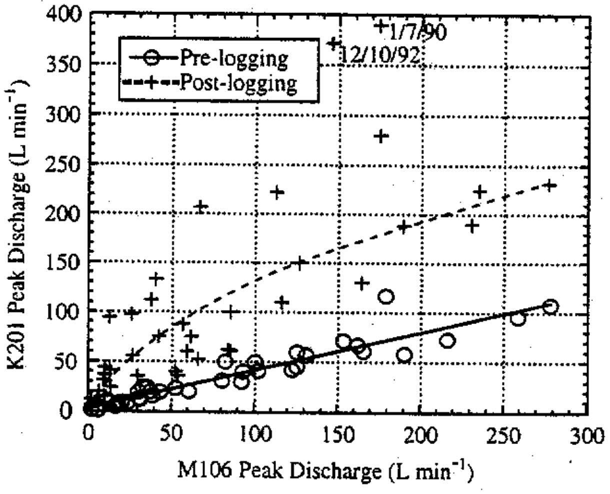


Figure 4—A comparison of the peak pipeflow response from M106 (unlogged control) and K201 (clearcut in 1989) and regression lines. The solid line is the linear fit to the prelogging data. The dashed line is the locally fitted regression of the postlogging data and is approximated by a second-order polynomial fit to a log-log relationship. Plot (a) includes all data. Plot (b) excludes the larger M106 peaks where K201 begins to exhibit capacity limitations.

Because of these physical limitations, a linear regression analysis of the postlogging K201 and M106 peakflow data is not appropriate for moderate to high peak discharges. However, it is clear that a substantial increase in K201 pipeflow occurred after logging (*fig. 4*). When the postlogging data are fit by a locally weighted regression (Cleveland 1993), it is evident that the greatest departures from pretreatment data occur at discharges of less than 200 L min^{-1} at M106. Above this level, K201 peaks begin to level off. When the M106 discharges exceed 500 L min^{-1}, it is not possible to detect any postlogging change in K201 discharge peaks. The prelogging regression equation predicts that at the mean M106 peak pipeflow of 118 L min^{-1} the expected K201 peak is 51 L min^{-1}, but the postlogging locally weighted regression predicts a peak of 143 L min^{-1} — a 280 percent increase (*fig. 4b*).

The maximum postlogging increase at K201 was more than 300 L min^{-1} for two moderate storm events that occurred January 7, 1990 and December 10, 1992 (*fig. 4b*). These storms produced discharges at North Fork Caspar with return intervals of 1.7 times per year. The largest proportionate increases in pipe peakflow occurred during two minor storms in February 1991, when winter rainfall totals had been far below normal. These were the first stormflow responses at M1 for that year indicating that antecedent soil moisture conditions were just reaching saturation, whereas K2 soils were more fully saturated. As previously explained, the soil in the vicinity of the pipe pathway must be saturated before water can flow through these conduits. Ziemer's evaluation of Caspar Creek streamflow peaks (these proceedings) states that the largest increases in peak discharges occur when the greatest differences in soil moisture exist between the logged and forested watersheds.

At K1, peakflow from instrumented soil pipes did not show a significant increase (Ziemer 1992). However, an additional pipe outlet located about 30 m upslope of the pipeflow gaging instrumentation began to discharge storm flows. This source flowed rarely before logging, but regularly during storm events after logging, suggesting that the capacity of the K1 soil pipes was quite limited in comparison to either K201 or M106. When the discharge from this source is added to that of the other instrumented K1 pipes, the K1 peakflow increase approximates the increase observed at K201 (Ziemer 1992).

Keppeler (these proceedings) reports increases in minimum summer pipeflow, as well. The duration of these postlogging increases has yet to be documented.

M1 Pore Pressures

The water table throughout the entire monitoring period was observed only along the regolith-hard bedrock interface. A typical water table profile across the A-C transects during late February 1994 is shown in *figure 3*. On the basis of field observations of the soil pipes emerging at the pipeflow gages, it appears that the pipes in the swale bottom occur at depths where the water table often fluctuates into and around the pipe zone. As the winter progressed, the piezometers responded more rapidly to larger rain events. This behavior supports the findings of Ziemer and Albright (1987) who observed a strong dependence of pipeflow on soil moisture conditions. Piezometric responses in undisturbed drainages will generally mirror pipeflow responses because both are dependent on flow through macropores. Soil pipes are simply the largest size-class of macropores. The peak piezometric response was noted for a mid-February 1994 storm with peak rainfall occurring over an 18-hr period (*fig. 5*). Piezometric responses on the two side-slope transects were fairly similar to each other. The lag between the rainfall and the peak piezometric response for A and C transects

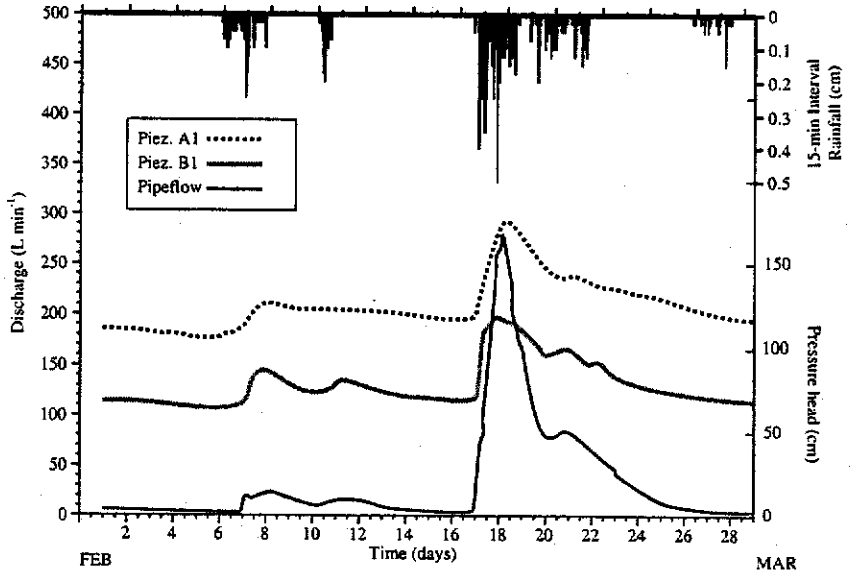


Figure 5—M1 pipeflow and piezometric response to a moderate storm event during February 1994. Note the similarity between pipe discharge and subsurface pore pressures responses to this discrete storm event.

generally exceeded the lag for the B-nest piezometers. The convergence of flow in the B subswales could explain the difference in lag times with the parallel side-slopes.

K2 Pore Pressures

The post-treatment response along two transects (C and E) has been evaluated through hydrologic year 1993. Regression analysis results indicate increased peak piezometric responses after logging. All six postlogging regressions were significantly different than the prelogging regressions ($p < 0.05$). The postlogging intercept terms were greater than the prelogging coefficients and, in some cases, the slopes of the postharvest regression lines were reduced (*fig. 6*). Unlike the stream discharge peaks (Ziemer, these proceedings) and the pipeflow peak response just described, increases in peak pore pressures were detectable for both large and small storms, as well as for antecedent moisture conditions ranging from a relatively dry to a fully saturated soil profile. Between storms, piezometric water levels remained higher in the postharvest period than before harvest. Sidle and Tsuboyama (1992) state that pore pressure responses tend to be less variable at the base of the hillslope than at upslope positions because of higher soil moisture content and the presence of preferential pathways in the saturated zone. These K2 data support that hypothesis. Greater variation and larger magnitude increases were observed in the upslope piezometers (C3P2 and the E transect). At the mean M106 peak discharge, pore pressures were 9 to 35 percent greater than those predicted by the preharvest relationship.

E-Road Pore Pressures

With only a single year of pretreatment data, regression analysis was only marginally successful in illuminating changes in pore pressure response at the E-road site. Before road construction, pore pressure responses at this site were minimal. Although the bore holes for the two most upslope piezometers were the deepest installations at this swale (5.7 and 7.7 m, respectively), positive pore pressures were not detected before road building and tractor logging. During the first winter after road building, these upslope piezometers remained dry; however, some changes were observed at the lower instrument sites (R1P2 and R2P2). There were brief spikes in pore pressures of less than 0.5 m, reflecting individual precipitation events superimposed on a more extended pore pressure response of about half that magnitude indicative of seasonal effects (*fig. 7*). Hydrologic year 1991 was also the second-driest year on record at Caspar Creek, with annual precipitation totaling only 716 mm. This lack of rainfall made first-year changes difficult to detect.

After tractor logging was completed late in 1991, a series of normal and above-normal rain years ensued. The event-driven pore pressure spikes continued at R1P2 during 1992 and 1993. The regression analyses of the predisturbance pore pressure peaks on the M106 peak pipeflows ($\log_{10}$) were fairly successful at explaining the variations in response at the downslope installations both before and after logging. The r^2 values for the prelogging regressions were greater than 0.80 for R2P2 and R3P1, and 0.49 for R1P2. Similar r^2 values resulted from the postlogging regressions of these piezometer peaks. The postlogging regressions indicate increased peak pore pressures at R1P2, R2P2, and R3P1 that are similar to those observed at the K2 site (*fig. 6*). However, there was no significant relationship between peak pipeflow at M106 and the pore pressure response at the upslope E-road piezometers. These results suggest the upslope E-road pore pressure response was quite different than

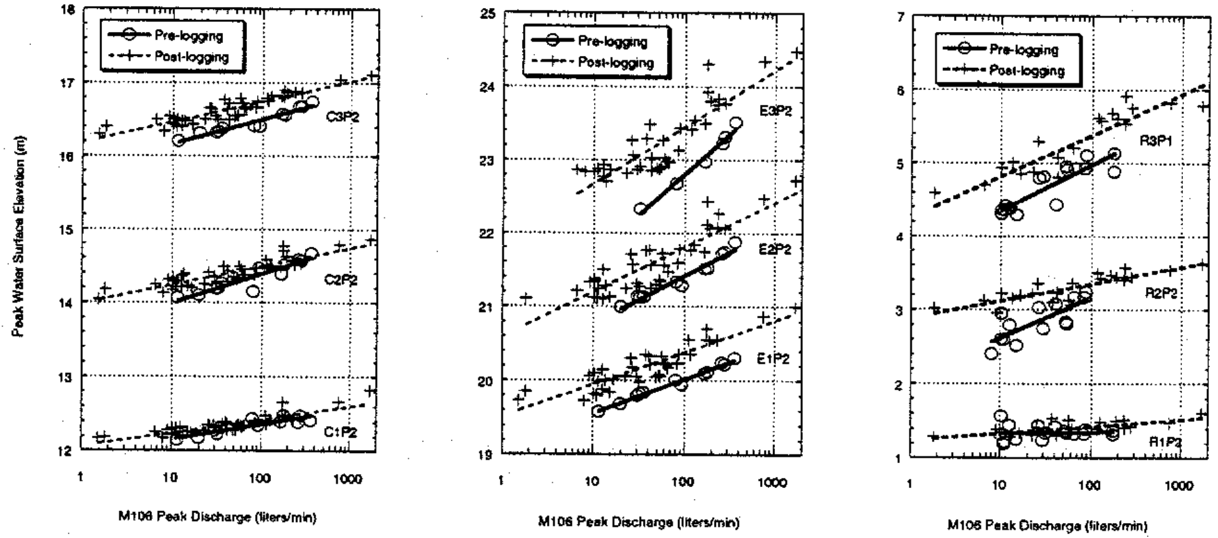


Figure 6—Regression comparisons of peak piezometric response at the K2 and E-road sites before and after clearcutting. C1P2, C2P2, and C3P2 are located in the lower portion of the K2 slope. E1P2, E2P2, and E3P2 are mid-slope K2 locations. R1P2, R2P2, and R3P1 are located along the E-road swale axis between pipeflow outlet and the new road. Elevations are relative to the pipeflow outlet at each swale.

the response below the road and the response in the undisturbed M1 swale.

However, after road construction and logging, a clear and dramatic increase in pore pressure response at the above-road installations is evident. Not only did peak pore pressures increase in response to a discrete storm event, but also there was a progressive increase in piezometric water levels related to cumulative seasonal precipitation (*fig. 8*). At R4P2, the dry-season recession was particularly slow. By late fall of 1994 and 1996, the pore pressure level remained higher than it had been at the onset of the preceding hydrologic year. Pore pressures at this bedrock installation located directly under the road centerline have yet to return to predisturbance levels. At this same location, a second piezometer, installed at the time of road construction at the interface between the fill and the original ground surface, never showed a positive pressure response. However, this pressure transducer failed in 1996 and was not replaced.

For all installations at the E-road site, the post-road construction and logging annual pore pressure peaks exceeded the predisturbance annual peak (*table 1*). To explore this difference, a variable reflecting the storm rank through all years (1990 to 1995) was evaluated. This regression was more significant in explaining the peak responses at R5P2 ($r^2 = 0.23$) and R6P2 ($r^2 = 0.61$), but not significant for the below-road installations. Above the road, the apparent trend in pore pressures levels is one of increased peak levels over time since logging (*fig. 9*). However, this may be a reflection of above-normal rainfall totals in 1993 and 1995, rather than the isolated impact of road construction in this swale. More work remains to be done to model the pore pressure response at this E-road site. Pipeflow data from this site has yet to be evaluated. This future analysis will provide an important indication of the integrity of the macropore flow mechanism at this site after road construction and tractor logging.

Conclusions

Subsurface flow is the dominant process by which rainfall is delivered to stream channels in the coastal redwood region. Several different flow paths exist within soils and bedrock, and they interact on both rain-event and seasonal time scales. As the soil and subsoil become saturated, the soil pipes play an extremely important role in hillslope drainage. The combined water storage and transmissive properties of shallow earth materials are such that headwater watersheds produce significant storm runoff and dynamic changes in fluid pressures that are an important factor in the stability of hillslopes. Management activities such as timber harvesting and road construction can alter the subsurface flow and pore pressure response to rain events. Increased subsurface flow from the loss of rainfall interception and transpiration after timber harvesting increases peak pipeflow and may accelerate scour erosion within the soil pipes. This form of subsurface erosion can lead to the expansion of discontinuous gullies within the unchanneled swales and increased sediment loading to surface channels such as has been observed in some of the Caspar Creek cutblocks (Ziemer 1992; Lewis, these proceedings). Further, subsurface drainage may be impeded by the felling and yarding of logs in these zero-order swales if matrix and macropore flows are reduced by soil compaction or shallow pipe collapses, thus accelerating gully erosion.

Timber harvesting increases peak pore pressures, but whether these fluid pressures pose significant risks to slope stability is highly

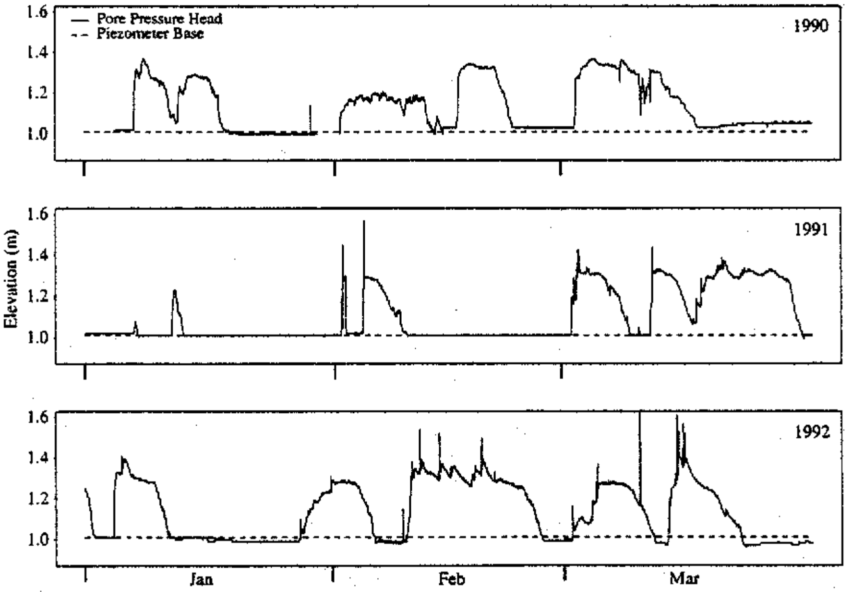


Figure 7—Piezometric response at the E-road site (between the base of the road fill and the pipeflow outlet) for three winter periods: 1990 (predisturbance), 1991 (post-roadbuilding) and 1992 (postlogging). Elevations are relative to the pipeflow outlet.

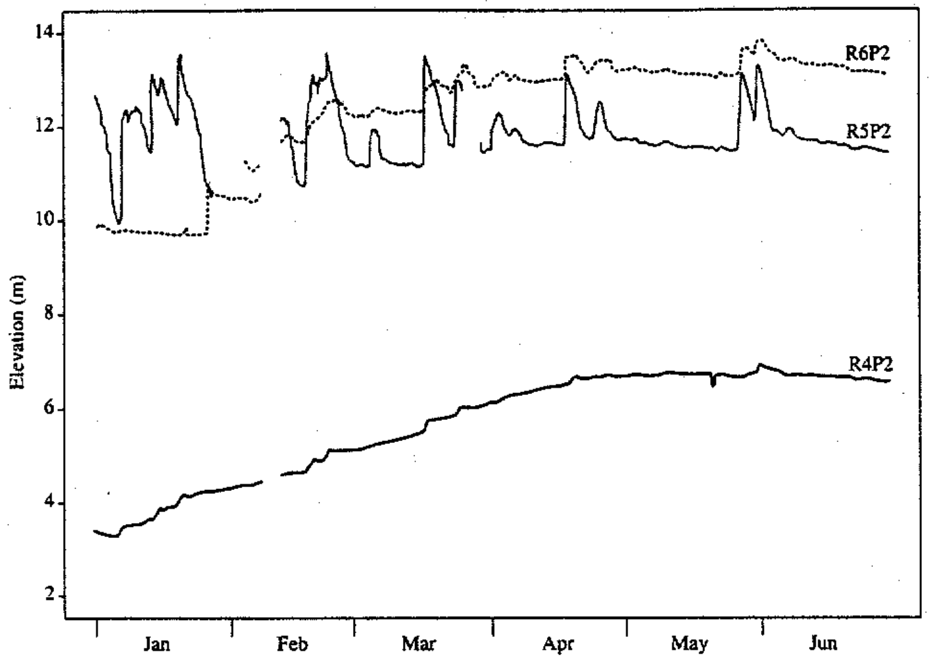


Figure 8—Upslope piezometric response at the E-road site after road construction and tractor logging. Note the seasonal increases in pore pressure heads as the rainy season progresses and the discrete storm response most evident at R5P2. Elevations are relative to the pipeflow outlet. Gaps in traces indicate missing data.

Table 1—Annual maximum pore pressures (m) at E-road piezometers. Road constructed in May 1990 with road centerline at R4P2. Tractor logging of swale occurred September through October 1991. "NR" indicates that no positive pressure head was observed during that year. Base elevation (m) is the bottom of piezometer well relative to the elevation of the pipeflow outlet. Maximum pore pressures for all years are shown in bold.

Hydrologic Year	**R1P2**	**R2P2**	**R3P1**	**R3P2**	**R4P2**	**R5P2**	**R6P2**
1990	0.37	1.31	0.89	2.11	0.77	NR	NR
1991	0.57	1.71	0.86	3.39	0.63	NR	NR
1992	**0.65**	1.91	1.37	**6.05**	**6.03**	2.97	6.45
1993	0.61	2.09	1.67	4.24	4.61	4.77	4.18
1994	0.42	**2.12**	1.65	4.29	3.89	3.97	6.56
1995	0.52	1.92	**1.84**	4.50	5.25	4.72	**7.49**
1996	0.46	1.88	1.81	4.49	4.69	4.84	6.76
1997	0.45	1.80	1.84	5.59	4.07	**4.93**	6.04
Maximum Pore Pressure (m)	**0.65**	**2.12**	**1.84**	**6.05**	**6.03**	**4.93**	**7.49**
Hole Depth (pre-road) (m)	1.37	2.59	1.96	4.80	7.66	5.69	7.83
Base Elevation (m)	1.00	1.53	4.25	1.57	2.29	8.79	9.64

dependent on local hillslope conditions. At those sites most prone to failure because of inherent geologic and soil conditions, timber harvest activities may tip the delicate balance of hillslope stability towards failure. However, such failures are expected only in response to relatively extreme rainfall events occurring at roughly 5-year return periods (Cafferata and Spittler, these proceedings). Thus far, the data from the North Fork phase of the Caspar Creek study suggest that the frequency of large landslides has not increased owing to the timber harvest activities between 1989 and 1991. The road location and design used in the North Fork logging demonstrate a tremendous improvement in the application of the principles of subsurface hydrology to minimize the risks of aggravating slope instabilities. However, it is too early in the post-harvest history to draw definitive conclusions concerning slope stability. Large landslides occur relatively infrequently; thus, it is necessary to evaluate failure rates over a long time. One caution suggested by the findings in the M1 swale and previous research is that convergent topography will amplify pore pressure responses and there should be special attention and analysis when planning operations in these areas. Designated crossings are an effective safeguard, provided that the designator understands the principles of subsurface hydrology as they relate to erosion control. Road construction can have a very significant impact on the timing and magnitude of pore pressure responses as exemplified by the E-road

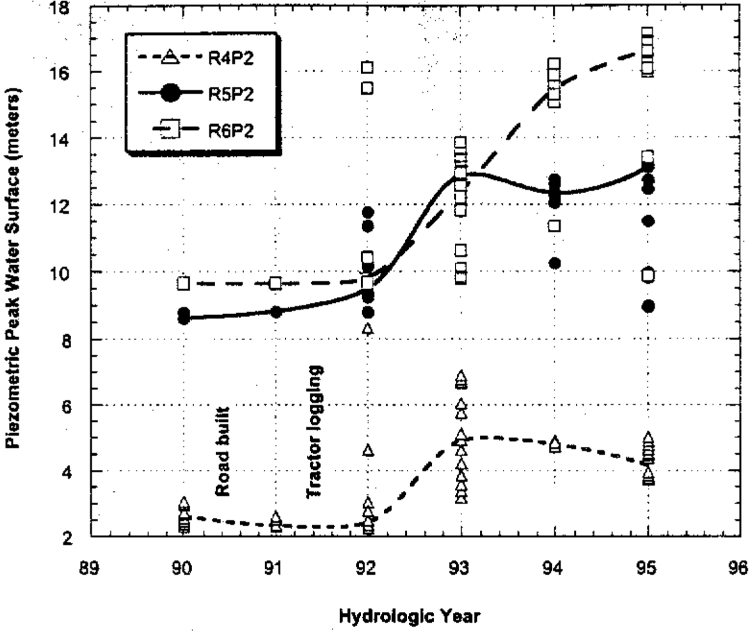


Figure 9—Peak pore pressure response upslope of the new road at the E-road site. Fitted lines connecting median pore pressure peaks suggest a trend of increased pore pressures over the 6-year period since road construction. Elevations are relative to the pipeflow outlet.

site. Additional work is needed to further elucidate more general relationships between road construction and pore pressure evolution, as well as to better understand site-specific subsurface conditions as they affect slope stability.

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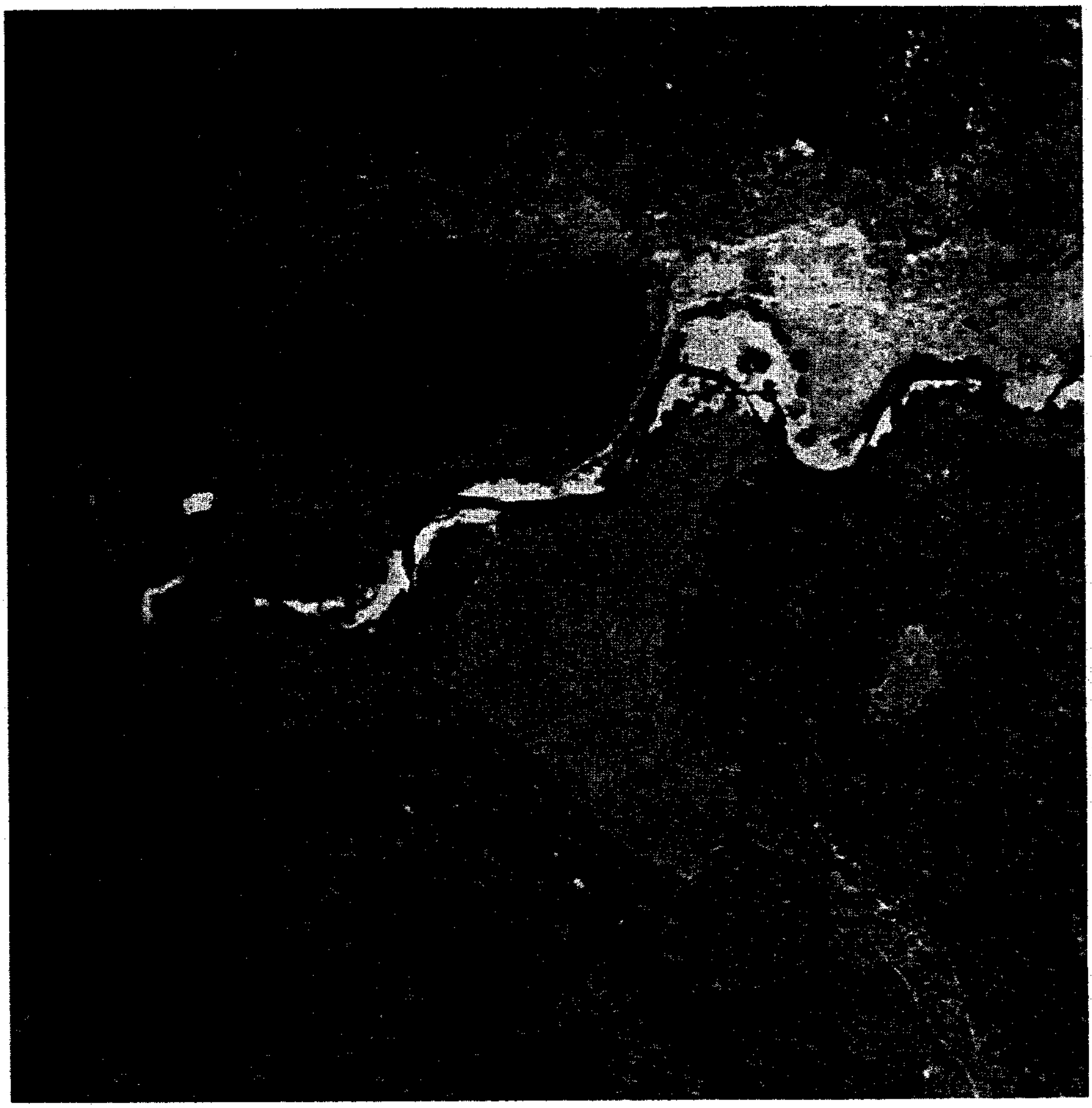
DFG EXHIBIT 20

1936 aerial photo of Elk Prairie



DFG EXHIBIT 21

USGS Digital Orthophoto quadrangle images of North Fork Gualala at Elk Prairie. Images 38123g44.tif and 38123g53.tif, taken July 12, 1993.

DFG EXHIBIT 22

Taber
Since 1954

MONITORING WELL LOG

Job No.: 102/596/38

Project Name: Elk Prarie Groundwater Basin

Client: Rau & Associates

WELL CASING: 2" Diameter PVC		FROM	53	TO	0	ft.
TYPE OF PERFORATION: .040" Machine slotted		FROM	48	TO	28	ft.
SIZE AND TYPE OF FILTER: #8 Sand		FROM	54	TO	25	ft.
TYPE OF SEAL	NO. 1 1/4" Bentonite pellets	FROM	25	TO	21	ft.
	NO. 2 Cement/bentonite slurry	FROM	21	TO	0	ft.
	NO. 3 Cement/bentonite grout	FROM	155	TO	53	ft.

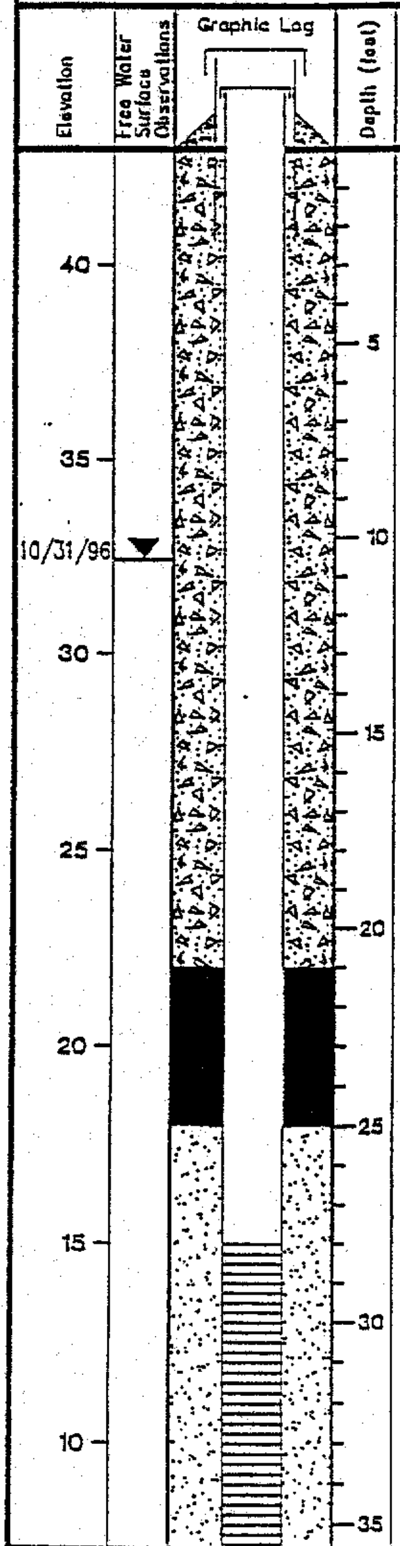
Well No. 5 | Location: See Plan

Elevation: 44.22* | Reference: Per Rau & Assoc

Drilling Equipment: Diedrich D120

Drilling Method: See Remarks

Notes: * Elev. at top of monument



REMARKS (drill rate, fluid loss, odor, etc.)

4" Auger

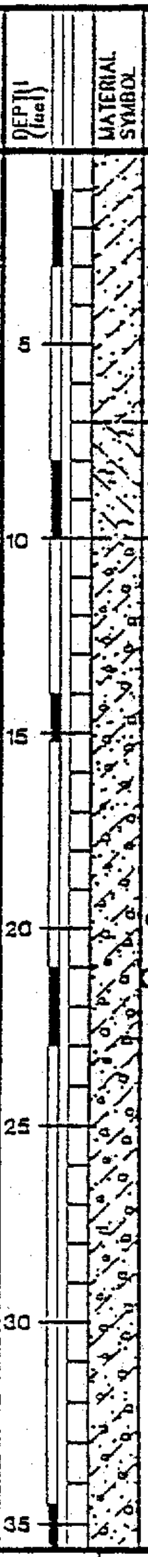
Smooth drilling

Boring drilled and logged 10/16-10/18/96. Boring backfilled 10/22/96. Well built in new hole 10/21/96, using 8" hollow stem auger. Set casing to 3ft. switched to 3" rotary wash

Hole caving poor circulation mixed mud

THE MONITOR WELL LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES

SOIL TESTS	BLOWS/FOOT 350 ft lb.	SAMPLE SIZE (inches)	SAMPLE No.
		Bag	5/1
		Bag	5/2
		Bag	5/3
		Bag	5/4



UNIFIED SOIL CLASSIFICATION	Material Description
ML	Loose light brown very fine SANDY SILT
SP	(Loose) brown very fine-medium SAND with SILT and WOOD fragments
GP / GW	(Compact)-dense brown very fine-coarse SANDY fine GRAVEL and fine-coarse GRAVEL with SILT

--CONTINUED--

LOGGED BY: T.A.K. | CHECKED BY: T.A.K. | DATE: 10-16-96

FIGURE 1

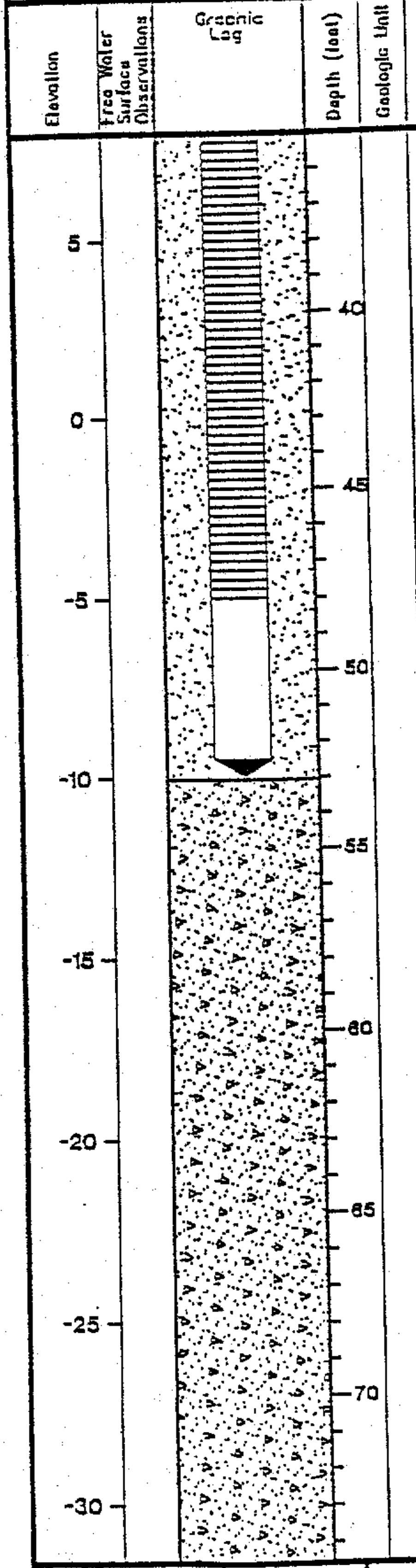
Taber
Since 1954

MONITORING WELL LOG

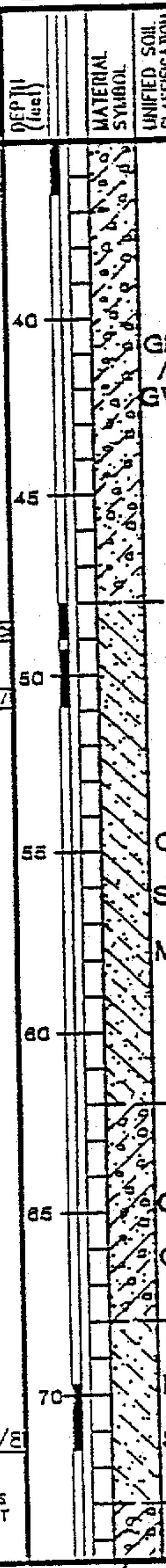
Job No.: 102/596/38

Project Name: Elk Prarie Groundwater Basin
Client: Rau & Associates

Well No. Scont.
Location: See Plan
Drilling Company/Equipment: Diedrich D120
Elevation: 44.22±
Reference: Per Rau & Assoc.



REMARKS (drill rate, fluid loss, odor, etc.)	SOIL TESTS	BLOWS/FOOT 350 ft lb.	SAMPLE SIZE (inches)	SAMPLE No.	UNIFIED SOIL CLASSIFICATION	Material Description
wet Drilled smooth good circulation		65	8aa	5/5	GP / GW	(Compact)—dense brown very fine—coarse SANDY fine GRAVEL and fine—coarse GRAVEL with SIL
			8aa	5/6	CL / SM / ML	(Stiff—very stiff) blue gray SILTY CLAY with thin SILTY very fine—fine SAND and SANDY SILT layers
wet		32	8aa	5/7		
End drilling 10/16/96.					GM / GC	(Very dense) blue gray and brown SILTY and CLAYEY SANDY fine GRAVEL
Drilled smooth good circulation		31	8aa	5/8	ML / SM	Compact blue gray very fine SANDY SILT and SILTY fine SAND
						See below for descripti



—CONTINUED—

THE MONITOR WELL LOGS SHOW SUBSURFACE CONDITIONS
AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT
WARRANTED THAT THEY ARE REPRESENTATIVE OF SUB-
SURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES

LOGGED BY: T.A.K.
CHECKED BY: T.A.K.
DATE: 10-16&17-96

FIGURE 1

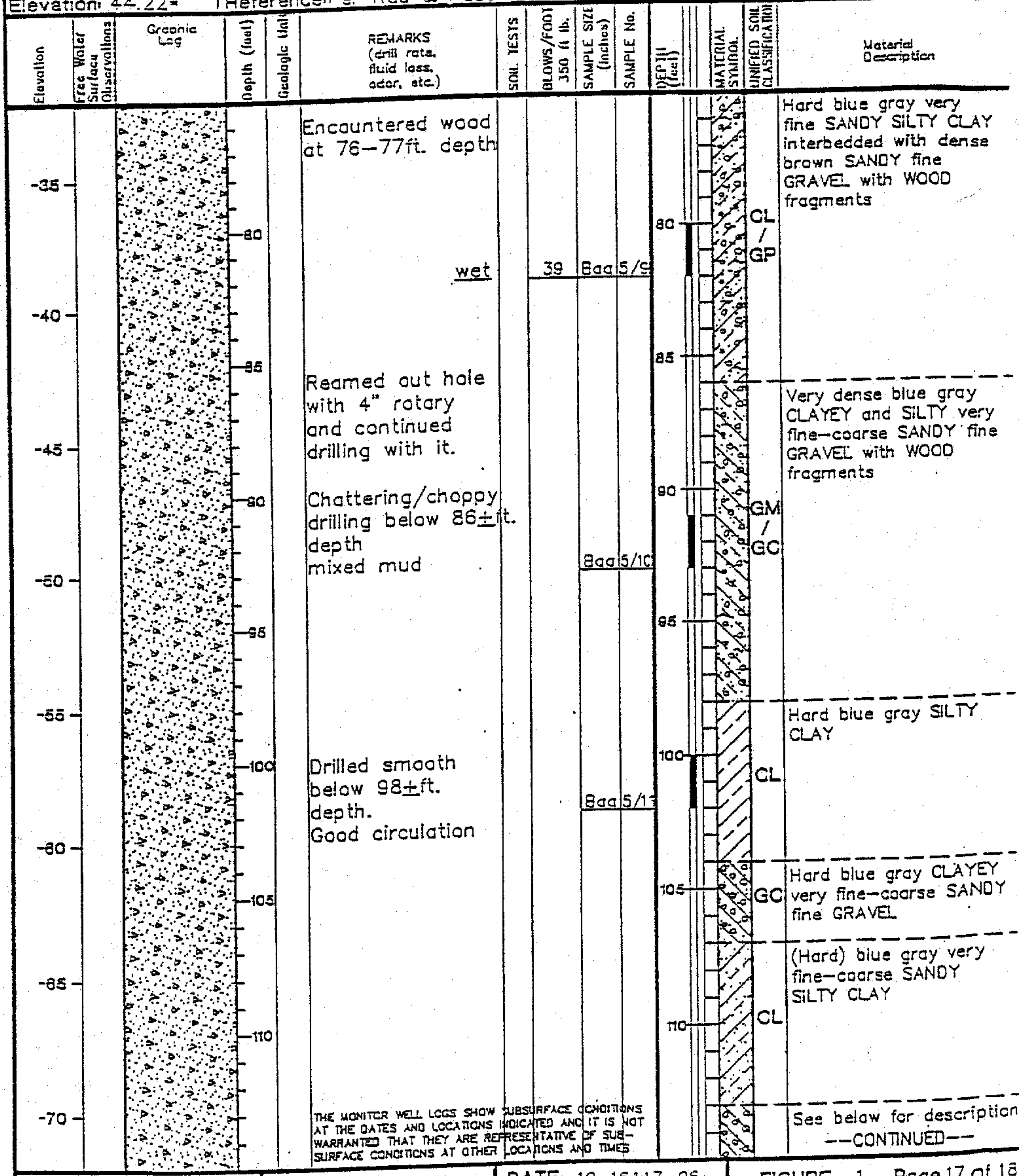
Taber
Since 1954

MONITORING WELL LOG

Job No.: 102/596/38

Project Name: Elk Prarie Groundwater Basin
Client: Rau & Associates

Well No. Scont.
Elevation: 44.22±
Location: See Plan
Reference: Per Rau & Assoc.
Drilling Company/Equipment: Diedrich D120



Encountered wood at 76–77ft. depth

wet — 39 — Bag — 5/9

Reamed out hole with 4" rotary and continued drilling with it.

Chattering/choppy drilling below 86±ft. depth
mixed mud

Bag — 5/10

Drilled smooth below 98±ft. depth.
Good circulation

Bag — 5/1

CL / GP — Hard blue gray very fine SANDY SILTY CLAY interbedded with dense brown SANDY fine GRAVEL with WOOD fragments

GM / GC — Very dense blue gray CLAYEY and SILTY very fine–coarse SANDY fine GRAVEL with WOOD fragments

CL — Hard blue gray SILTY CLAY

GC — Hard blue gray CLAYEY very fine–coarse SANDY fine GRAVEL

CL — (Hard) blue gray very fine–coarse SANDY SILTY CLAY

See below for description
——CONTINUED——

THE MONITOR WELL LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES

LOGGED BY: T.A.K.
CHECKED BY: T.A.K.
DATE: 10-16&17-96

Taber
Since 1954

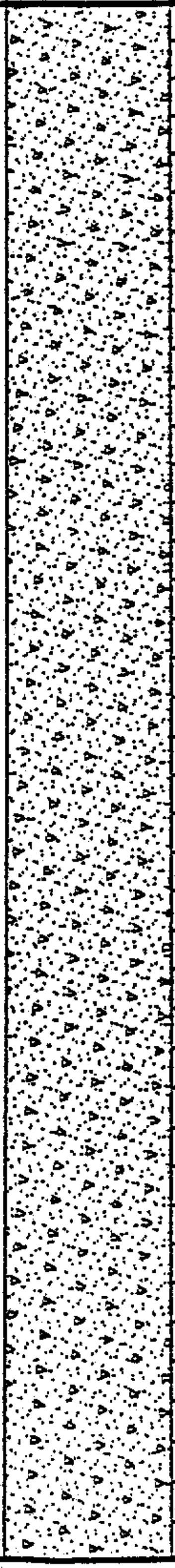
MONITORING WELL LOG

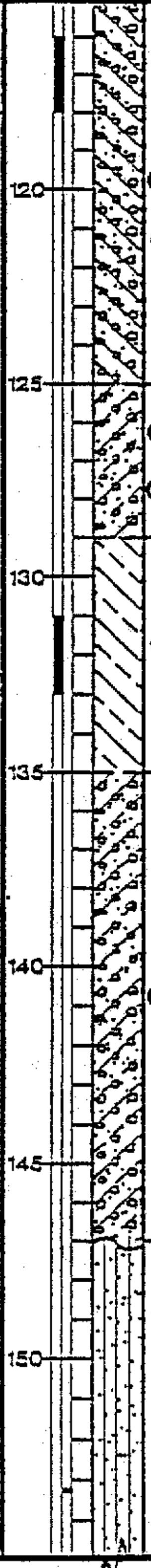
Job No.: 102/596/38

Project Name: Elk Prarie Groundwater Basin

Client: Rau & Associates

Well No. 5cont.	Location: See Plan	Drilling Company/Equipment:
Elevation: 44.22±	Reference: Per Rau & Assoc.	Diedrich D120





Elevation	Free Water Surface Observations	Depth (feet)	Geologic Unit	REMARKS (drill rate, fluid loss, odor, etc.)	SOIL TESTS	BLOWS/FOOT 350 ft lb.	SAMPLE SIZE (inches)	SAMPLE No.	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION	Material Description
-75 -80		120				77	Bag	5/12	120	GC / CL	(Very dense) blue gray CLAYEY SANDY fine GRAVEL with thin layers (very hard) blue gray very fine-fine SANDY SILTY CLAY
		125		Very hard/slow drilling/chattering below 125±ft. depth					125	GC / GM	(Very dense) blue gray CLAYEY and SILTY, SANDY fine-coarse GRAVEL
-85 -90		130		Drilled smooth below 129ft. depth			Bag	3/13	130	CL	(Very hard) light gray SILTY CLAY
-95 -100		135 140 145							135 140 145	GC	(Very dense) blue gray CLAYEY SILTY SANDY fine GRAVEL
-105 -110		150		Drilled very slow below 147ft. depth Refusal with 4" bit at 147±ft. End drilling 10/17/96 Start with 3" bit Grinding on coreable rock, very slow drilling		ref	bit	15	150		Very dense dark gray slightly weathered fine-medium grained sedimentary ROCK (SANDSTONE)

THE MONITOR WELL LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES

LOGGED BY: T.A.K. | CHECKED BY: T.A.K. | DATE: 10-17&18-96 | FIGURE 1

DFG EXHIBIT 23

Photos of North Fork Gualala at Elk Prairie and Little North Fork, taken by Kit Custis 4/8/2002.

STATE WATER RESOURCES
CONTROL BOARD

02 APR -3 PM 4:12

DIV. OF WATER RIGHTS
SACRAMENTO

NORTH GUALALA HEARING

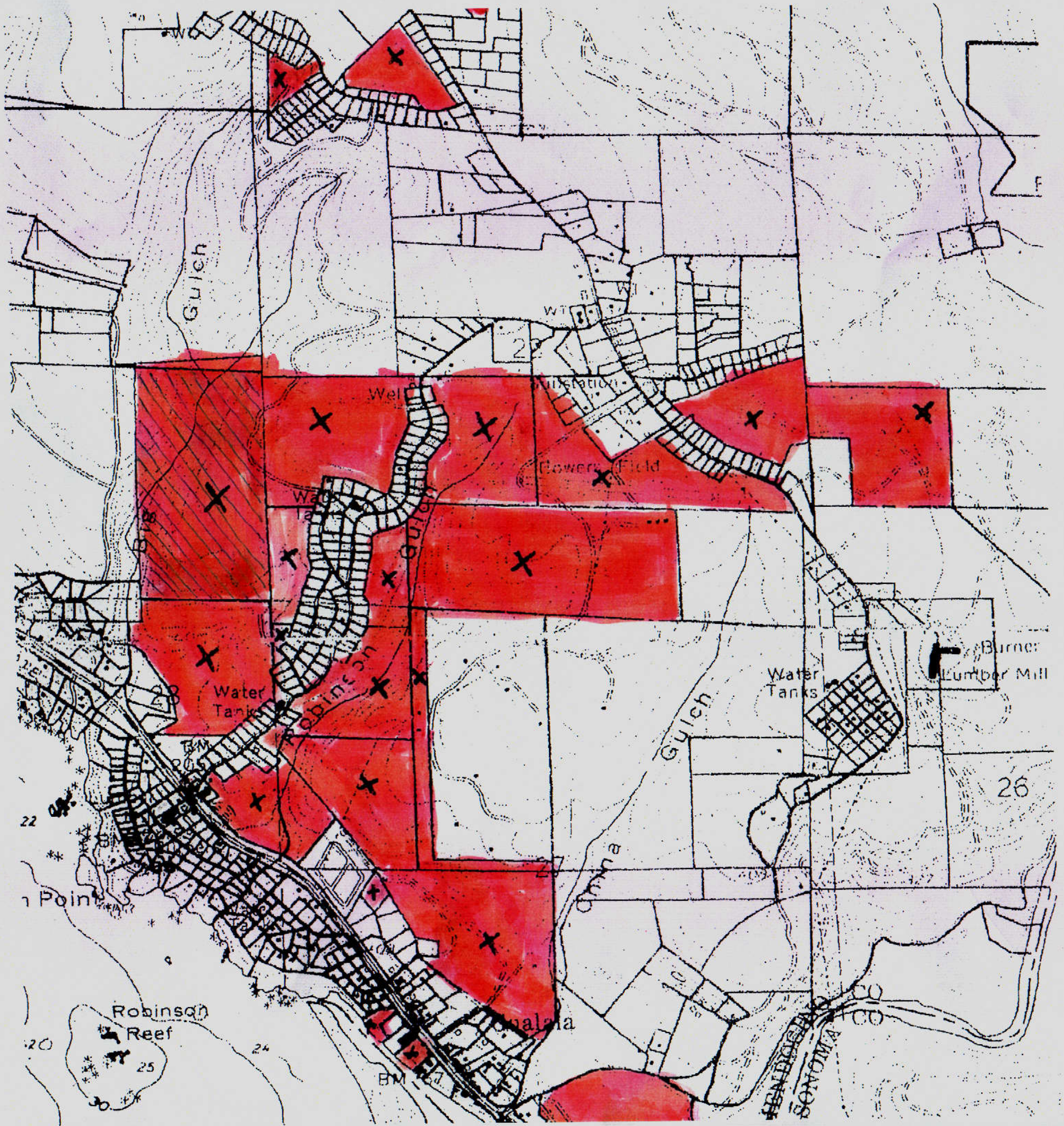
Page 1 of 1.

Exhibit Identification Index

DELIVERED PRIOR TO 4:00 LJM

Participant Jerome P. Lucey

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
1.	Plot map of Bower owned property color coded to identify parcels and within NGWC service area			
2.	Computer generated list of Bower owned property. Mendocino County Records.			
3.	D.W.R. letter - 12/9/97 - identifying Public funds that Gualala ratepayers are responsible for. (4 million dollars)			
4.	SWRCB letter - 12/5/97 - Delay			
5.	Mendo County Water Agency letter 11/6/97 regulated to NGWC paid study - delay tactic.			
6.	GMAC policy statement relating to minimum bypass flows			
7.	Coast Action Group letter to Ed Anton 2/29/96 Full letter in file - Request for E.I.R.			
8.	Copy of my water bill/with 0 usage. $39.54			
9	Fax letter to Ed Anton 9/20/01			
10	N.G.W.C. undated letter to protestants referring to P.U.C. Conflict Resolution Group under the auspices of Admin. Law Judge Steve Wiseman and Mendo. Co. Supervisor Charles Peterson.			
~~11~~	~~3 letters re: Requests for extensions for NGWC - from Juan Erickson 4/16/97 / 2/22 96 / 12/5/97~~			
11.	STATEMENT OF QUALIFICATIONS MR. DONALD McDONALD			


Gulch
Wel
Station
Bowers Field
Wa
Ta
Gulch
Water
Tanks
28
Robinson
Water
Tanks
Burner
Lumber Mill
Gulch
26
27
Point
Robinson
Reef
Gualala
BM
22
20
24
25
MENDOCINO CO
SONOMA CO

Bower Holdings

AP-145-191-17
AP-145-191-12
AP-145-191-10
AP-145-084-01
AP-145-200-13
AP-145-200-07
AP-145-200-06
AP-145-200-05
AP-145-133-01
AP-145-092-20
AP-145-092-19
141-240-25
145-105-14
145-110-03
145-030-12
145-030-16
145-030-09
145-030-04
145-030-03
145-081-01
145-070-02
145-170-03
145-166-13
145-101-01
141-270-05
144-256-13
145-192-01
144-253-05
145-11004
145-261-11
145-261-05
145-261-13

(6)

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

DEC 9 1997

Mr. Jerome P. Lucey
66 Manderly Road
San Rafael, California 94901

Dear Mr. Lucey:

Safe Drinking Water Bond Law of 1988, Loan Contract E51408
<u>North Gualala Water Company</u>

This is a follow-up to the issues discussed in our meeting of November 25, 1998. At that time you expressed a variety of concerns about North Gualala Water Company's water system improvement project, funded under the subject bond law.

The Department of Water Resources and California Department of Health Services jointly administer the Safe Drinking Water Bond Law Program. A project cannot be funded until DHS determines that it is the most cost effective method of correcting primary drinking water standard deficiencies. DWR assesses applicants' ability to repay loans and negotiates the terms and conditions of the funding contracts. Investor owned utilities, such as North Gualala, must also obtain the approval of the California Public Utilities Commission to impose the surcharge necessary to repay the loan before DWR will issue a contract. This process includes a public hearing to provide ratepayers and other interested parties a forum to express their opposition or support for the proposed project. This practice was followed for the North Gualala project.

DHS approved the project concept by a memorandum to DWR dated January 18, 1994. The cost of the project was estimated to be $2,935,179. On August 22, 1994, DWR issued a letter of commitment to North Gualala for a $2,935,179 loan. The PUC authorized North Gualala to enter into a loan contract with DWR by its Resolution No. F-645, dated January 24, 1996. In addition to the PUC hearing, North Gualala held a project feasibility meeting December 4, 1995, to provide an opportunity for public input on the proposed project. Subsequent to this comment and approval period, the loan contract was issued July 29, 1996 and signed by DWR on August 26, 1996.

During our discussion, you stated that North Gualala was guilty of a number of improprieties during project construction. While we understand and appreciate your concerns, the Department of Water Resources has neither the jurisdiction nor the authority to investigate these matters. Furthermore, these issues cannot be resolved by a single agency. The problem of declining fisheries resulting from project construction can best be addressed by the Department of Fish and Game. The matter of alleged illegal pumping of water from the river via wells adjacent to the waterway should be referred to the State Water Resources Control Board. The perceived construction irregularities associated with the project are the province of DHS. You may wish to contact these agencies to seek a resolution of your concerns. Enclosed is a list of contact people, including appropriate telephone numbers and mailing addresses, for your information.

As you are aware, North Gualala has requested additional funding in the amount of $1,507,342 to complete the final phases of its project. DWR cannot approve the increased loan amount until DHS concurs that the increased costs are appropriate and North Gualala applies for and receives PUC approval to impose a higher surcharge to repay the larger loan. As a part of this process, another public hearing will be scheduled. This hearing may provide an appropriate venue to bring your concerns to the attention of the agency responsible for regulation of utilities such as North Gualala. You may contact Fred Curry of the PUC at (415) 703-1739, to ensure you are notified of the date and time of the hearing once it is scheduled.

I hope this information is useful to you. If you have any questions, please contact me at (916) 653-9836, or Sarah Richey, in the Bond Financing and Administration Office at (916) 653-4763.

Sincerely,

Chester M. Winn

Chester M. Winn, Chief
Division of Fiscal Services

Enclosure

Cal/EPA

State Water Resources Control Board

Division of Water Rights

Mailing Address:
P.O. Box 2000
Sacramento, CA
95812-2000

901 P Street
Sacramento, CA
95814
(916) 657-1972
FAX (916) 657-1485

Pete Wilson
Governor

DECEMBER 05 1997

To: Interested Parties
(See Enclosed Mailing List)

Dear Sir or Madam:

RESCHEDULING OF FIELD INVESTIGATION REGARDING PETITIONS TO CHANGE NORTH GUALALA WATER COMPANY PERMITS 5431, 5432, 11535, AND 14853 (APPLICATIONS 9372, 9454, 10898 AND 21833, RESPECTIVELY), NORTH FORK GUALALA RIVER IN MENDOCINO COUNTY

We have been advised by the petitioner's engineer that the hydrology report will not be mailed until next week. This date does not allow sufficient time for the report to be reviewed before December 17, 1997, the scheduled date for the field investigation. For this reason, we are postponing the investigation until after the first of the year so that all parties will have sufficient time to review the report. Notice of the revised field investigation date will be provided to all parties after the investigation has been rescheduled. We will not reschedule the investigation until the report is filed with this office.

If you have any questions about the postponement, please telephone me at the above telephone number or Steven Herrera at (916) 653-0435.

Sincerely,

Katherine Mrowka

for Luann L. Erickson
Engineering Associate
Hearing Unit

Mendocino County Water Agency
Memorandum

To: Gary Pedroni, Planning Department November 6, 1997

From: Dennis Slota, MCWA

Subject: Elk Prairie Groundwater Investigation for the North Gualala Water Company

I received this document dated October 31, 1997 for review at 6:00 p.m. on November 5. This is inadequate time for proper review. However, I have reviewed this document and report that it is a summary document that states the results of a seismic and hydrological field study at Elk Prairie.

This document does not include any data to substantiate the stated conclusions. The **complete study** describing the materials used, methods employed, procedures followed and actual data need to be submitted for review. The necessary field data includes the following:

1. Groundwater monitoring data,
2. Stream flow data,
3. Stream gauge data.
4. Precipitation records,
5. Well bore logs,
6. Pump test field data including equations used and assumptions employed,
7. Full description and field data for the seismic study,
8. Description and actual results of the modeled pumping scenarios mentioned on page 5 of the report.

In addition, a peer review process was established before this study was prepared. However, it is my understanding that this peer review was not done. The agreement for a full peer review should be fulfilled. In conclusion, there is insufficient information provided with inadequate time for review for me to comment on the available water supply at this site.

I am doing scheduled field on November 6 and 7 but may be back in the office on the afternoon of the 7th. Please call me with any questions or concerns regarding these comments.

C:\DATA\WP\WATER REVIEW\NGWC.MEM

Goal and policy relating to water supply and fisheries habitat protection. Adopted by GMAC on February 28, 1996 (Goal: 4-yes, 1-n0, 1-abstention; Policy: 4-yes, 2-no).

Water Supply

Goal 2.5-3 To ensure that water extractions do not adversely affect fisheries habitat.

Protection of Environmental Resources

Policy 3.8-1 The County shall <u>encourage</u> and <u>support</u> the establishment and enforcement of minimum bypass flows and/or other mitigations measures to protect fishery habitat.

The words "encourage and support" limits the possibility of enforcement of protections to fishery resources. New wording should read.

> The County shall establish and enforce minimum bypass flows as a measure to protect fishery habitat.

There may be a reconsideration of the wording by the GMAC. The NGWC would like bypass flows removed as an option. This would leave the North Fork Gualala without any fishery protections.

COAST ACTION GROUP
P.O. BOX 215
POINT ARENA, CA 95468

February 29, 1996

Mr. Ed Anton
State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000

Subject: Environmental Impacts of Water Diversion - Little North Fork of the Gualala River
Additional Comments to be added to the Administrative Record

Included is reference to additional documents with evidence and arguments indicating that potential adverse impacts from water use on the North Fork Gualala River must be considered by a complete Environmental Impact Report. This is to be added to the record of existing evidence added to the file by Coast Action Group and Other sources.

Summary

There is in the file evidence from many sources that indicate:

- That there is hydraulic continuity between subsurface flows and instream flows in the North Fork Gualala River.
- That pumping water from the subsurface flow will affect instream flows during critical periods.
- That there are public trust issues to be addressed and protected.
- That recent proposed upgrading of North Gualala Water Company's facilities allows for increased delivery capacity and water use.
- That increased development potential as demonstrated in the Gualala Municipal Advisory Council (GMAC) recommendations (Proposed General Plan and Local Coastal Plan Amendment) indicates increased water demand from the North Fork Gualala River.
- That monitoring and controls to protect minimum low flows in the North Fork Gualala are not adequate or functional. And, that appropriate hydrologic and use analysis with discussion of alternative methods to protect this resource has not been completed.

There is sufficient evidence in the file, from several valid sources, to support the above statements. A complete Environmental Impact Report and hydrological study must address the

②

NORTH GUALALA WATER CO.
P.O. BOX 1000
GUALALA, CA 95445
707-884-3579

PRESORTED
FIRST-CLASS MAIL
U.S. POSTAGE PAID
GUALALA, CA 95445-1000
PERMIT NO. 45

ACCOUNT NO.	SERVICE FROM	SERVICE TO	DUE DATE
24610160	7/24	8/21	9/10/01

METER READING PREVIOUS	METER READING PRESENT	USED	AMOUNT
59970	59970		.00
TAX			.30
PREVIOUS BAL			.01-
METER S/C 5/8X3/4"			21.10
SDWBA 5/8X3/4"			18.15

JERRY LUCEY
CAROL LUCEY
66 MANDERLY RD
SAN RAFAEL, CA
94901-2459

REF. NO.	LAST BILLING - USAGE - LAST YEAR	
7/31	39.56	308

SERVICE ADDRESS	GROSS DUE AFTER DUE DATE	NET BILL DUE NOW
46820 PAC WDS	44.54	39.54

Use Chg:$3.03/100 CuFt Mailed:8/22

RETURN THIS STUB WITH PAYMENT

ACCOUNT NO.	DUE DATE
24610160	9/10/01

GROSS BILL	NET BILL
44.54	39.54

NORTH GUALALA WATER CO.
P.O. BOX 1000
GUALALA, CA 95445
707-884-3579

PRESORTED
FIRST-CLASS MAIL
U.S. POSTAGE PAID
GUALALA, CA 95445-1000
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ACCOUNT NO.	SERVICE FROM	SERVICE TO	DUE DATE
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METER READING PREVIOUS	METER READING PRESENT	USED	AMOUNT
59970	59970		.00
TAX			.30
PREVIOUS BAL			.01-
METER S/C 5/8X3/4"			21.10
SDWBA 5/8X3/4"			18.15

JERRY LUCEY
CAROL LUCEY
66 MANDERLY RD
SAN RAFAEL, CA
94901-2459

REF. NO.	LAST BILLING - USAGE - LAST YEAR	
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46820 PAC WDS	44.54	39.54

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RETURN THIS STUB WITH PAYMENT

ACCOUNT NO.	DUE DATE
24610160	9/10/01

GROSS BILL	NET BILL
44.54	39.54

THE PAPER TIGERS
Pacific Division
30 Railroad Avenue
Suite 3
Point Richmond, California 94801

Phone: (510) 215-0390
Fax: (510) 215-0806
papertigers.com

To: Mr. Ed Anton - Chief - Water Rights Div.
State Water Resources Control Board

From: Jerry Lucey

Re: North Gualala Water Co.
Illegal Diversion

Date: 09/20/01

Dear Mr. Anton: The U.S.G.S. flow-monitor is reporting a flow of 3 CFS in the area of the North Gualala Water Co.'s diversion/pumps. Their permit specifies that they must stop pumping at 4 CFS. The fine of $500 per day should be collected for every days infraction. I am aware of pending litigation but this litigation is only a continuation of over 20 years of delays and bad-faith dealings with the SWRCB. Please present this request to the "Board" for immediate attention. Thank you for your prompt response. Thank you - Jerry Lucey

Jerome P. Lucey
66 Manderly Rd.
San Rafael, CA 94901

RE: PETITION TO CHANGE PERMIT 14853 (APPLICATION 21883) OF NORTH GUALALA WATER COMPANY, NORTH FORK GUALALA RIVER IN MENDOCINO COUNTY

To All Protestants:

North Gualala Water Company (NGWC) has been given until April 15, 1996, to conduct negotiations with all Protestants to the "Change in Point of Diversion" referred-to above.

Under the auspices of Steven Weisman, Administrative Law Judge for the California Public Utilities Commission and Charles Petersen, 5th District Supervisor for Mendocino County, NGWC opened negotiations at an informal meeting of interested parties on February 23, 1996. It was agreed to continue those on March 15, 1996.

Since progress appearss to have been made with the California Department of Fish and Game and others in the first meeting, and since most of the Protestants' interest is in the protection and/or enchancement of the fishery resource, it is an appropriate time to invite you to this second meeting. If you are not able to attend, you are encouraged to contact another Protestant on the attached list so that your concerns can be considered.

If additional information is desired, please call John Bower at (707) 884-3579 or George Rau at (707) 462-6536. The agenda and list of Protestants is attached.

5/2/02

JEROME P. LUCEY

MR. PAUL MURPHEY
HEARING COORDINATOR
State WATER RESOURCES CONTROL BOARD
P.O. BOX 2000
SACRAMENTO, CALIF. 95812-2000

DEAR MR. MURPHEY: RE: WATER Rights Hearing - North Gualala WATER CO.

Statement of Qualification of Witness

MR. DONALD McDONALD
14535 LAKE VISTA DRIVE
SONORA, CALIFORNIA 95370

EDUCATION - UNIVERSITY of CALIFORNIA - BERKELEY
B.S. DEGREE 1951
FORESTRY / wildlife MANAGEMENT

EXPERIENCE - UNITED States FOREST SERVICE
RANGER - 1948 thru 1951

GUALALA RIVER Steelhead PROJECT
HATCHERY PROJECT MANAGER - 1979-1985

GUALALA RIVER Steelhead HABITAT OBSERVATION AND FISHERMAN - 1960-2002

66 Manderly Road, San Rafael, California 94901

NORTH GUALALA HEARING **Page ____ of ____.**

Exhibit Identification Index

Participant Division of Water Rights, Permitting Team

Exhibit No.	Description	Status as Evidence		
		Introduced	Accepted	By Official Notice
1	Written testimony of Charles Nesmith, Associate Engineering Geologist, Division of Water Rights			
2	Statement of Qualifications of Charles Nesmith			
3	Application 21883 and Permit 14853 issued thereon			
4	SWRCB Order WR 99-09-DWR (Aug. 27, 1999)			
5	Exhibit by reference: SWRCB, Division of Water Right file 21883, cat. 2, vol. 1, "Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie," Luhdorff & Scalmanini, January 1998. Excerpts provided as identified below in Exhibits 5a-5g.			
5a	Figure 2-3: Geologic Cross-Section B-B'			
5b	Figure 4-4: Ground-Water Elevation Contours			
5c	Appendix B: Water Well Drillers Reports for North Gualala Water Company Wells 4 and 5			
5d	Page 8			
5e	Pages 42-43			
5f	Pages 13-14 (including Tables 4-1 and 4-2)			
5g	Page 39			
6	SWRCB Decision 1639 (June 17, 1999)			
7	Letter, dated May 4, 1998, to Alan Lilly, Bartkiewicz, Kronick & Shanahan, from Edward C. Anton, Chief, Division of Water Rights			
8	Letter, dated June 1, 1998, to John H. Bower, North Gualala Water Company, from Joseph C. Scalminini, Luhdorff & Scalminini			
9	Excerpts from "Ground Water and Wells," Fletcher Driscoll, 1986.			
10	"Mendocino County Coastal Ground Water Study," Department of Water Resources, June 1982, Table 6			
11	Water Well Drillers Reports for North Gualala Water Company Wells 1, 2, and 3			
12	SWRCB Order WR 95-10 (July 6, 1995)			

IN THE MATTER OF PERMIT 14853 (APPLICATION 21883) OF NORTH GUALALA WATER COMPANY REGARDING LEGAL CLASSIFICATION OF GROUNDWATER APPROPRIATED UNDER THIS WATER RIGHT

TESTIMONY OF CHARLES NESMITH, ASSOCIATE ENGINEERING GEOLOGIST, REGARDING THE LEGAL JURISDICTION OF GROUND WATER EXTRACTED BY THE NORTH GUALALA WATER IN THE VICINITY OF THE NORTH FORK OF THE GUALALA RIVER, MENDOCINO COUNTY, CALIFORNIA

1.0 QUALIFICATIONS

I am an Associate Engineering Geologist with the State Water Resources Control Board's (State Water Board or Board) Division of Water Rights (Division). I have a B.S. degree in Geology, and have taken several graduate level courses, including a course in hydrogeology. My ground water related professional work began as a graduate student assistant with the California Department of Water Resources where my key work projects included evaluating the impacts of evaporation ponds on ground water in the San Joaquin Valley and studying the extent of Radon in ground water in the Sierra Nevada Foothills.

I began full time work with the State of California in 1988 with the Regional Water Quality Control Board (Regional Water Board). I worked for two Regional Water Board Offices, the San Francisco Bay Region and the Colorado River Basin Region. The bulk of my work with the Regional Water Boards consisted of oversight of leaking underground storage tank site investigations. In this capacity I was responsible for oversight of several dozen leaking underground storage tank sites.

I began work with the State Water Board in 1991 and have worked in several different capacities with the State Water Board. These include the underground storage tank cleanup fund, the landfill unit, the Department of Defense/Department of Energy Unit, the underground storage tank program support unit, and the underground storage tank engineering unit. Most of this work included ground water issues. While working in these various capacities I was asked to provide my geologic and hydrogeologic expertise regarding several controversial petitions to the State Water Board. This usually consisted of a technical report and in some cases a technical presentation at a Board meeting.

I transferred to the Division's Complaint Unit approximately one year ago. My work with the Division has included evaluation of the jurisdiction of ground water contested in several complaints, including Deep Creek in San Bernardino County, Laguna Creek in Santa Cruz County, Hare Creek in Sonoma County, and an unnamed in Lake County. A more detailed description of my qualifications is included in Exhibit 2.

This written testimony is based primarily on a review of the Division's water right files for Permit 14853 of the North Gualala Water Company (Permittee), a report by Ludhorff and Scalmanini, January 1998, entitled "Investigation of Groundwater Occurrence and Pumping Impacts at Elk Prairie," State Water Board Decision 1639 (Garrapata Water Company), and Order 95-10 (Carmel River). I also referred to "Ground Water and Wells," Fletcher Driscoll, 1986, for general well and hydrogeology information and I visited the site on March 14 and April 8, 2002.

Exhibit 3 is the water right application and permit (Permit 14853) for the North Gualala Water Company and Exhibit 4 is the Order approving Permittee's petition to add points of diversion that are identified in the Order as offset wells (Permittee's Wells 4 and 5).

2.0 GEOLOGY

The Gualala River (River) is a southwesterly flowing coastal stream located just north of the boundary between Mendocino and Sonoma Counties (Figure 1). The River is situated in a meandering alluvial channel deeply incised into mostly Coastal Franciscan marine sandstone (Figure 2). The alluvial channel ranges in width from less than 200 feet in the upper reaches of the River to about 1500 feet at Elk Prairie where the Permittee has installed its currently active wells. The depth of the alluvial channel is unknown in the upper reaches of the River; however, based on the geologic information obtained from the boreholes for the Permittee's supply wells and exploratory wells drilled by Ludhorff and Scalmani (Exhibit 5), the depth of the alluvium in the area of Elk Prairie is at least 150 feet (Exhibit 5a).

The major structural feature in the area is the northwest trending San Andreas Fault Zone. Activity along the fault has created an area of weak crushed rock that controls the flow direction of the lower reaches of the Gualala River.

3.0 APPLICATION OF CRITERIA FOR DETERMINING THE LEGAL CLASSIFICATION OF GROUNDWATER EXTRACTED FROM PERMITTEE'S WELLS 4 AND 5

According to Water Code sections 1200 and 1201, the State Water Board has permitting authority over subterranean streams flowing in known and definite channels. The hearing notice asks the participants to provide evidence that supports any tests a participant advocates the State Water Board use in determining the classification of groundwater that is extracted by Permittee's Wells 4 and 5. Due to the Permitting Team's limited role in this proceeding, I am not going to advocate a particular test, but instead will provide technical testimony and recommendations regarding the possible criteria that would be used under the tests that may be proposed.

Figure 1. Location map for the Gualala River

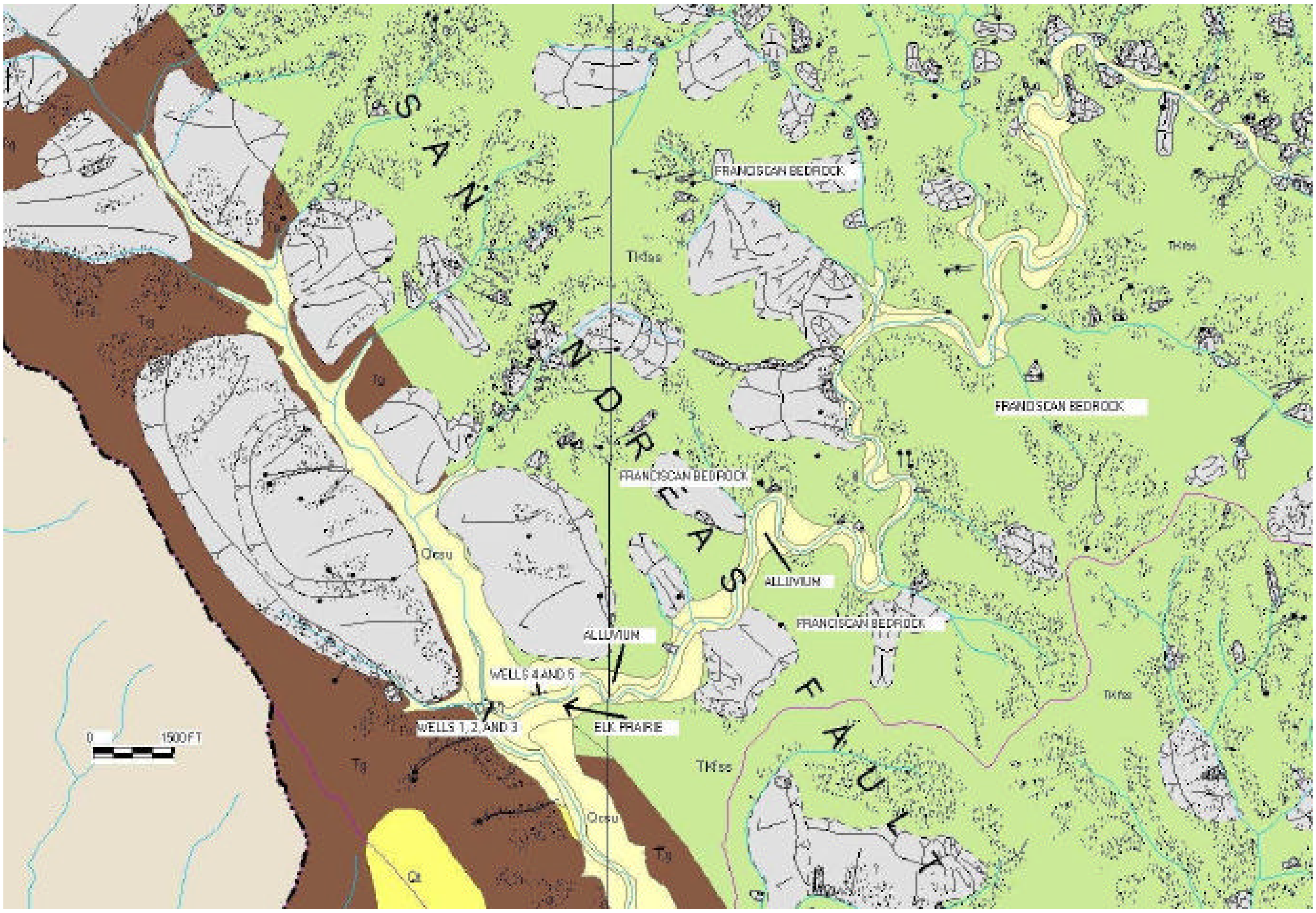

FIGURE 2. Excerpt from a California Division of Mines and Geology map of landslides near the Gualala River. The alluvium (yellow) is bounded by Franciscan Bedrock (light green). The Elk Prairie area and the location of Permittee's supply wells are also noted. Landslides are shown in grey.

3.1 The Garrapata Test

State Water Board Decision 1639 (Decision) regarding Garrapata Creek in Monterey County (Exhibit 6) is the most recent Board decision relating to subterranean streams. In its decision, the Board identified four factors that must exist for ground water to be classified as a subterranean stream (the "Garrapata test"):

1. A subsurface channel must be present;

2. The channel must have relatively impermeable bed and banks;

3. The course of the channel must be known or capable of being determined by reasonable inference, and;

4. Groundwater must be flowing in the channel.

The Board also stated on page 6 of the Decision that a subterranean stream need not be interconnected with a surface stream. Like a surface stream, a subterranean stream is merely the flow of water in a defined channel that may or may not daylight above the ground to create surface flow. As such, the Board determined in the Decision that the expert testimony provided by the Applicant (Garrapata Water Company) concerning the interconnection of the ground water in the alluvium with the surface flow of Garrapata Creek was immaterial to the legal classification of ground water. Interconnection with surface water as a possible factor is discussed in the "Other Proposed Criteria" section, below.

3.2 Applying the Garrapata test to the North Fork of the Gualala River

Of the four components of the Garrapata test, three of them are interrelated. That is, in the context of subterranean streams, a channel is a geologic feature identifiable in the field or on a map (known and definite) whereby water flows preferentially through the channel rather than the rock units (the bed and banks) bounding the channel.

Figure 2 above shows the alluvium (in yellow) associated with North Fork of the Gualala River bounded by marine sandstone (in green) of the Franciscan Formation. The results of short term pumping tests from wells installed in bedrock and wells installed in the alluvium (discussed below) indicate a significant difference in permeability between the two rock units. This difference in permeability between the bedrock and the alluvium creates a subsurface channel of preferential ground water flow. The course of the subsurface channel is known by the trace of the bedrock/alluvium contact shown on the map in Figure 2.

The subject points of diversion are located in the Elk Prairie area of the North Fork of the Gualala River (see Figure 2). Exhibit 5b is a ground water contour map prepared by Ludhorff and Scalmanini showing a southwesterly gradient for the ground water located in the alluvium where the subject wells are installed. The presence of the gradient indicates that groundwater is flowing in the subsurface channel at the points of diversion.

The above discussion shows that three of the four components of the Garrapata test are present at the North Fork of the Gualala River, i.e., ground water is flowing in a known and definite subsurface channel. The remaining factor requires an evaluation of whether or not the bed and banks are relatively impermeable such that a subterranean stream is formed.

Although this appears at face value to be a simple concept, the permit record indicates otherwise. During the events that led to this hearing, the Division and the Permittee debated a qualitative evaluation of the permeability of the pertinent rock units (i.e., whether or not the units are "water bearing") rather than a comparison of the actual permeabilities. A 1998 exchange of correspondence between the Division and the Permittee (Exhibits 7 and 8) included a discussion as to whether or not the bedrock in the area forms the bed and banks of a subterranean stream. In this exchange, while citing the same well performance data, the Division asserted that the bedrock in the area was not water bearing and the Permittee asserted that it was water bearing.

The underlying assumption of both parties was that the "water bearingness" of the bedrock bore directly on the issue of bed and banks.

However, saying whether or not a rock is water bearing, without strictly defining the term, is meaningless. Most subsurface rock materials contain water and, where saturated, will release some of that water under stress (i.e., gravity or pumping). Some rocks will readily yield much more of that water at a faster rate than other rocks, and this ability largely relates to the primary (pore space between grains) or secondary (joints and fractures) permeability. Permeability is simply a measure of the interconnectedness of the pore space in the rock. The total amount of water that may be released by a rock is mostly dependent on its permeability and the volume of pore space that contains water. These are the major components of a rock's "coefficient of storage," often known as its "storativity" or "storage capacity."

A rock may store a large volume of water but not have the permeability to release that water sufficiently to meet the demand for that water. Clays typically range in porosity of 45% to 55% compared to 10% to 35% for sand and gravel (alluvium). (Exhibit 9, p. 67, Table 5.1.) Clay layers, however, because of their low permeability, typically form the aquitards that divide confined and unconfined ground water or act as horizontal ground water barriers between unconfined aquifers. In fact, saturated clays may form the boundary of an alluvial channel and theoretically could be considered the bed and banks of a subterranean stream (under the Garrapata test) if the permeability of the clay was sufficiently less than the channel alluvium. This would be true despite the fact that the clay actually contains much more water than the alluvium.

The qualitative debate between the Division and the Permittee regarding "water bearingness" mostly revolved around the issue of whether or not the Franciscan sandstone could yield enough water to meet demand. Division staff apparently did not consider the ability of the bedrock to meet domestic supply demand (i.e., a few gallons per minute) sufficient to label the rock as "water bearing" and the Permittee disagreed.

This brings us to the crux of the debate regarding the comparison of permeability between the bed and banks and channel materials. Some people argue that the bed and banks should be sufficiently impermeable, and thus sufficiently non-water bearing, to not even yield enough water for a domestic supply. Others argue that the bed and banks and the channel material should only <u>differ</u> enough in permeability to form a subterranean stream.

The Garrapata decision rested on the latter "relatively impermeable" approach. The fractured granitic bedrock at Garrapata was considered by the Board to be sufficiently impermeable, compared to the alluvium, to form the bed and banks of a subterranean stream. Yet, based on specific capacity (discussed below) data, most of the wells installed in the bedrock were capable of providing a domestic supply, i.e., about 75 gallons per day per person, or 300 gallons per day for a family of four. A well only has to be continuously pumped at 0.3 gallons per minute to meet this demand.

In considering the North Fork of the Gualala River, I have taken a quantitative approach that is based on a comparison of the specific capacities of wells installed in the bedrock and wells installed in the alluvium. The ability of a rock to release water, i.e., its "water bearingness," is reflected in the specific capacity of a well installed in the rock. The specific capacity of a well is defined in Driscoll as its yield per unit of drawdown. (Exhibit 9, p. 207.) For example, if a well is pumped at 250 gallons per minute and the water level in the well drops 10 feet at this pumping rate, the specific capacity of the well is 250 gpm / 10 ft or 25 gpm per foot. If pumped at the same rate and the water level drops 100 ft, then the specific capacity is 2.5 gpm per foot, an order of magnitude difference. The second example represents an aquifer with significantly less permeability than the first.

As noted by staff and acknowledged by Permittee (Exhibits 7 and 8), a 1982 Department of Water Resources report entitled "Mendocino County Coastal Ground Water Study" indicated that the mean specific capacity of wells screened in Franciscan Bedrock (near Elk Prairie) is 0.265 gpm per foot (Exhibit 10). The Permittee has installed five production wells in the alluvium within 200 feet of the North Fork of the Gualala River, with the first three wells now inactive and Well 5 only used as a backup. The logs for these wells are shown in Exhibits 5c and 11. For each well, the driller conducted a short-term (1 to 3 hours) pumping test noting drawdown and pumping rate. Long term pumping tests (80 and 24 hrs) of Well 4 were conducted by Ludhorff and Scalmanini for the Elk Prairie investigation. Based on the information in the well logs, the pumping tests revealed the following:

Well 1 had 15 ft of drawdown at 60 gpm = 4.0 specific capacity

Well 2 had 5 ft of drawdown at 50 gpm = 10.0 specific capacity

Well 3 had 2 ft of draw down at 50 gpm = 25.0 specific capacity

Well 4 had 0.0 ft drawdown at 60 gpm = greater than 60.0 specific capacity

Well 5 had 20.7 ft of drawdown at 700 gpm = 33.8 specific capacity

Using these specific capacities calculated from short term[1] tests, the mean specific capacity for the alluvium is:

4 + 10 + 25 + 60 + 33.8 / 5 = 26.56 gpm per foot

Comparing 26.56 to 0.265 shows exactly 2 orders of magnitude difference between the mean specific capacity of wells installed in the alluvium to wells installed in the bedrock.

This is consistent with the findings regarding permeability included in the Ludhorff and Scalmanini report and in subsequent correspondence regarding the report as indicated by the following statements:

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[1] The long term (80 hour) pumping test for well 4 for indicated 1.9 feet of drawdown at 258 gpm giving a specific capacity of 136 gpm per foot. The lower number for the short term test was used in the calculation because the other tests were also short term, and the lower number is more conservative for the purpose of comparing specific capacities.

- "**The consolidated Franciscan Complex has a much lower permeability** but is sufficiently porous to store large volumes of precipitated water which slowly drains to maintain stream base flows throughout the season." (Exhibit 5d.)

- **"The relatively lower permeability of the Coastal Franciscan when compared to the alluvium is not disputed**, but this difference does not address the water storage possibility within the Coastal Franciscan." (Exhibit 8, p.2.)

In these statements, while acknowledging the significant difference in permeability between the pertinent rock units, Ludhorff and Scalmanini appear to claim that the ability of the Franciscan bedrock to store and slowly release a large volume of water to the alluvium overrides this difference in permeability. However, as discussed above, the Garrapata decision can be construed to acknowledge that the granitic "bed and banks" were sufficiently permeable to supply water for domestic use. Under the right conditions, i.e., where a deep alluvial channel exists, even bedrock of this limited permeability may slowly release a significant volume of water into the alluvial channel, yet the determination of "bed and banks" and thus the finding of the presence of a subterranean stream remains valid.

The minimum magnitude of the difference in permeability (Pmin) between the pertinent rock units that is sufficient to establish the bed and banks of a subterranean stream has not yet been established. The SWRCB's selection of the Pmin is the single most important factor that will ultimately determine the number of subterranean streams that are found in California under the Garrapata test.

Nearly all streams in California in areas of high relief (mountains and foothills) consist of alluvium (that has eroded from the bedrock) bounded by the bedrock. This bedrock may consist of igneous rocks formed by interlocking crystals, sedimentary rocks formed by consolidation of sediments, or metamorphic rocks formed by altering igneous and sedimentary rocks via intense pressures and temperatures over a long period of time. The permeability of these rocks varies considerably, and consists of both primary permeability and secondary permeability.

My opinion, which is based on theoretical values (Exhibit 9, p. 75, Figure 5.14) and actual permeability values gleaned from my experience in the Complaint Unit, is that nearly 95% of the alluvial channels surrounding streams in areas of high relief would be considered subterranean streams if the Pmin is set at one order of magnitude difference between the alluvium and bedrock. At two orders of magnitude, as is the case for the North Fork of the Gualala River, the number of subterranean streams would be reduced to about 70%. At three orders of magnitude, the number would be reduced to about 10% (i.e., rare). Above that (i.e., several orders of magnitude), I believe that it is likely that only limestone caverns and lava tubes could qualify as subterranean streams, thus making the subterranean stream extremely rare.

In the Carmel River Decision (Exhibit 12), the State Water Board concluded that the relatively impermeable rocks formed the bed and banks of a subterranean stream. A calculation of the specific capacities indicates that the specific capacity for the alluvium was 60 gpm/foot and the bedrock ranged from 0.1 to 0.0001 gpm/foot. This amounts to a magnitude of difference in permeability of about 2.5 to 4.5. If the Pmin was set at 3 orders of magnitude in the Carmel

River proceeding, it is possible that the State Water Board may not have determined that the bed and banks were relatively impermeable and may not have found the subsurface flow of the river to be a subterranean stream.

My recommendation is to set the Pmin at one order of magnitude. An order of magnitude difference is significant. It means that water has a 10/1 preference for flowing through the channel rather than its bed and banks. It also means that a well installed completely in the bedrock will have 10 times less the performance than a well installed in the channel, and thus will have a significantly reduced potential impact on the nearby stream compared to a well installed in the channel.

If the Pmin higher is set higher than one order of magnitude, fewer subsurface flows will be found to be subterranean streams subject to the Board's permitting authority. This will result in unregulated ground water extraction from the alluvium associated with a large number of California streams and potential negative impacts from these uncontrolled ground water diversions. Additionally, there may be no State Water Board protection for currently permitted ground water purveyors against new wells installed near their points of diversion. Because of the limited size of alluvial channels in narrow canyons, additional pumping in the area is more likely to have an impact on existing wells than in areas with larger basins.

If the Pmin is set at one or two orders of magnitude, the bed and banks of the North Fork of the Gualala River are sufficiently impermeable to qualify as the relatively impermeable bed and banks of a subterranean stream.

Applying the four criteria of the Garrapata test to the North Fork of the Gualala River, as discussed above, I conclude that Permittee's Wells 4 and 5 are extracting water from a subterranean stream flowing in a known and definite channel.

3.3 Other Proposed Criteria

3.3.1 *Pumping Impact Test, Ground Water Flow Direction, and Aquifer Recharge*

After the Permittee submitted a change petition to the Division to add Wells 4 and 5 to the authorized points of diversion for Permit 14853, several protests were lodged against the proposed changes. These protests primarily focused on the potential impacts of the Permittee's pumping on streamflow and fish in the North Fork Gualala River. In response, the Permittee hired Ludhorff and Scalmanini to prepare the 1998 report referred to above (Exhibit 5). The Permittee directed them to analyze the occurrence of ground water in the area, its relationship to the River, and the direct impacts of Permittee's proposed pumping on streamflow. Ludhorff and Scalmanini subsequently installed monitoring wells in the Elk Prairie area and conducted a long term pumping test on Well 4.

Based on the results of ground water level monitoring and the pumping test, Ludhorff and Scalmanini concluded that ground water beneath Elk Prairie does not occur in a subterranean stream, nor does it occur as underflow, because:

1. There is a perennial ground water gradient toward, and discharge into, the North Fork of the Gualala River;

2. There is no “channelized” ground water flow parallel to the River at Elk Prairie; and

3. The ground water is not recharged by influent stream seepage from the Gualala River.

Conclusions (1) and (2) relate, in part, to Ludhorff and Scalmanini’s premise that no significant seepage from the bedrock into the alluvium should be occurring where the permeability difference between the alluvium and bedrock is sufficient to form a subterranean stream. Ludhorff and Scalmanini assert that Conclusion (1) indicates that significant seepage is occurring from the bedrock into the alluvium and that this shows that the bedrock is not sufficiently impermeable, as compared to the alluvium, to form the bed and banks of a subterranean stream.

However, as discussed above, the bed and banks of a subterranean stream are established at the North Fork of the Gualala River by comparing the permeability of the pertinent rock units as indicated by the <u>specific capacities</u> of wells installed in those rocks (using a standard of one or two orders of magnitude). The Garrapata Decision can be construed to allow the bedrock to have sufficient permeability to supply domestic wells while still being classified as the bed and banks of a subterranean stream. At this level of permeability, one would expect some ground water to flow between the alluvium (including the surface stream) and the bedrock. If this ground water flow is seeping from the bedrock into the alluvium, it may cause the ground water gradient to incline toward the stream (influent stream).

The above discussion shows that it is possible for bedrock to be sufficiently impermeable, as compared to the alluvium, to form the bed and banks of a subterranean stream and still allow enough bedrock seepage of ground water into the alluvium to cause the ground water gradient to incline toward the stream. Furthermore, a review of the testimony provided by the Permitting Team in the Garrapata case demonstrates that a ground water gradient inclined toward the stream does not necessarily mean that there is significant seepage from the bedrock into the alluvium. Such a gradient could be caused by slow inflow of ground water into the alluvium along the soil/bedrock interface rather than the bedrock.

Conclusion (2) essentially rests on the same arguments as Conclusion (1), i.e., “channelized” ground water flow is not indicated if the ground water gradient is inclined toward the stream (i.e., at a high angle to the stream), and can be dismissed accordingly.

Based on their analysis of the results of the Well 4 pumping test, Ludorff and Scalmanini appear to assert another premise regarding ground water gradient—the concept of “once percolating ground water, always percolating ground water.” Under this premise, in the case of an effluent stream, the ground water in question was once part of the stream (i.e., was once clearly jurisdictional water), and thus remains jurisdictional. Similarly, in the case of an influent stream, the ground water was percolating ground water before it entered the alluvial channel, and thus remains percolating ground water provided that it is not pumped at such a rate that the stream becomes an effluent stream drawing jurisdictional water. This brings us to Conclusion (3).

According to their investigation, Ludhorff and Scalmanini concluded that the ground water gradient remains toward the Gualala River (influent stream) during pumping, and thus, the ground water beneath Elk Prairie does not occur in a subterranean stream. (Exhibit 5e.)

There are two problems with this conclusion. First, under the Garrapata test, it does not matter which direction the ground water is flowing (e.g., from bedrock to alluvium), or whether a stream is influent or effluent, because the subterranean stream is the alluvial channel bounded by the bedrock "bed and banks." As such, <u>all</u> ground water flowing in the channel is subject to the State Water Board's permitting authority regardless of the ground water's purported original character.

Second, this premise is flawed even with respect to evaluating the potential impacts of ground water pumping on the stream. Pumping from Well 4 clearly prevents ground water that would have contributed to the recharge of the River, sans pumping, from contributing to that recharge. Just because the pumping isn't sufficient enough to reverse the ground water gradient does not mean that the stream will not be significantly impacted by reduced recharge.

3.3.2 *Interconnection With a Surface Stream*

It has been suggested that interconnection with a surface stream should be a factor in determining whether a subterranean stream exists. Interconnectedness is not part of the Garrapata test. If interconnectedness with surface water was required for a subterranean stream to exist, even the classic examples of limestone caverns and lava tubes would not be considered to be subterranean streams.

Even if interconnectedness was incorporated as a criterion in this proceeding, it is clear that the Gualala River would meet that criterion. Ludhorff and Scalmanini go to great lengths to show the interconnectedness of the alluvial aquifer with the Gualala River to support their contention that the Gualala River is a gaining stream (Exhibit 5f).

3.3.3 *Water Quality*

It has been suggested that there should be some strong similarities between the quality of the surface water and that of its underflow. The suggestion has also been made that in the case of a subterranean stream, groundwater quality needs to be uniquely and consistently indicative of highly channelized conditions, i.e., constant in a downgradient direction and not randomly responding (changing) to a range of varying inputs (recharge, subsurface inflow, etc.)

A requirement that surface and groundwater chemistry be identical is not a component of the Garrapata test and should not be added as a component. Although water chemistry may be relevant in terms of locating the bed and banks where well logs have been lost or are unavailable, there is no reason to expect that ground water and surface water chemistry need to be of similar character. Ground water is typically higher in total dissolved solids because it spends much more time in contact (residence time) with earth materials than surface water. Additionally, surface water is typically recharged by several different sources, e.g., direct rainfall, surface runoff, ground water, and tributaries to the river. These multiple sources may create surface water of a different chemical nature than nearby ground water that is either recharged by the river or recharges the river.

Assuming, hypothetically, that water quality is considered as a criterion, Ludhorff and Scalmanini acknowledge that "there are similarities in surface-water quality and ground-water quality" (Exhibit 5g). Consequently, the subsurface flow would meet that additional criterion..

3.3.4 *The Recharge Zone Impact Test*

Another proposed test is what I characterize as the *Recharge Zone Impact Test.* Essentially, this test uses presumptions to determine jurisdiction and establishes a series of findings, including the following first two findings:

1. A well situated within 1000 feet of a surface stream recharge area is presumptively within the Board's jurisdiction if either (a) a substantial percentage of the well's annual flow is extracted from the stream recharge area, or; (b) the well produces substantial stream depletion determined as of the period of the most critical flows of the stream system it impacts.

2. The presumption shall be rebutted if either (a) the well is screened below a clay layer of such thickness, and where conditions denote lateral continuity, that indicates lack of well impact on the stream, or (b) the well does not create a measurable drawdown at the edge of the stream recharge area, indicating a lack of hydraulic influence from the stream.

Assuming, hypothetically, that this test is used to determine whether a subterranean stream exists, Exhibit 5b shows that wells 4 and 5 are located within 200 feet of the North Fork of the Gualala River. My own field investigation verified this. A stream recharge area, which could be calculated by connecting the nodes of stream meanders, is by definition larger than the stream itself.

As indicated by the extensive pumping tests of well 4, virtually all five monitoring wells showed some drawdown during the test. This means that the cone of depression extended at least out to these wells. Figure 3 indicates the calculated stream recharge area. Wells 4 and 5 are within this recharge area and a substantial portion of the cone of depression created during the pumping test of well 4 is located within this recharge zone. Therefore, Well 4, and nearby Well 5 (a similar performing well), draw a substantial portion of their annual flow from the stream recharge area. Accordingly, Wells 4 and 5 meet the first component of presumptive jurisdiction, based on the Elk Prairie investigation.

This presumption of jurisdiction cannot be rebutted under this test because (1) the well logs for Wells 4 and 5 do not indicate a significant clay layer above the well screen; and (2) as noted above, the wells create a measurable drawdown at the edge of the stream recharge area.

4.0 ADDITIONAL WELLS

The hearing notice asks if the Permittee will extract groundwater that is subject to the laws governing surface water rights if it installs and pumps groundwater from new wells on its property in the Elk Prairie area, but the notice doesn't identify where these new wells may be located.

If the Garrapata test is used, any well that Permittee installs in the alluvium of the North Fork of the Gualala River will be installed in a subterranean stream. This is also the case under the other proposed tests that relate to the characteristics of the bedrock versus the characteristics of the alluvium (e.g., water quality and ground water gradient related to seepage from bedrock).

Under the Recharge Zone Impact Test, there is some jurisdictional leeway with respect to distance of the proposed wells from the River. However, the further from the River, the closer to the bedrock. The Permittee has already installed wells near the bedrock (Wells 1, 2, and 3) and they eventually drew poor quality water and had to be abandoned. Any useable new well would likely fall within the jurisdiction of Division under the Recharge Zone Impact Test.

5.0 CONCLUSION

Under the Garrapata test, the Permittee's Wells 4 and 5, and any new wells installed in the alluvium, extract groundwater from a subterranean stream flowing in a known and definite channel and are subject to the State Water Board's permitting authority.

Under the Recharge Zone Impact Test, the Permittee's Wells 4 and 5, and likely any new wells installed in the alluvium, extract ground water from a subterranean stream flowing in a known and definite channel and are subject to the State Water Board's permitting authority.

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OCTOBER 1991 - PRESENT: STATE WATER RESOURCES CONTROL BOARD

ASSOCIATE ENGINEERING GEOLOGIST

DIVISION OF WATER RIGHTS

Complaint Unit
(1 year)

Responsible for investigating and resolving water rights complaints. Typically this involves reviewing the evidence presented by the Complainant and the Respondent, inspecting the site and meeting with all interested parties, and preparation of an investigation report with recommendations.

DIVISION OF CLEAN WATER PROGRAMS

Underground Storage Tank Engineering Unit
(4 years)

Most of this work involved leading the State Water Resources Control Board (SWRCB) effort to write regulations to implement, interpret, and make specific underground storage tank statutes enacted through Senate Bill 989. These regulations were adopted by the Board in May 2001.

Previous work in this unit included revising regulations, review of local agency underground tank programs, auditing Regional Water Quality Control Board underground tank programs, technical reviews of proposed underground storage tank equipment, and answering questions from the public and local agencies.

**Permitting Team
Exhibit 2**

Underground Storage Tank Petition Review Unit
(2 years)

This work involved analysis of the technical issues raised by an aggrieved party responsible for remediation of an unauthorized release from a petroleum underground storage tank. The analysis required a full understanding of UST regulations and how they relate to the geologic and hydrogeologic conditions at the site, and to the fate and transport characteristics of the constituents of concern. Findings were put in a technical report to SWRCB attorneys, and if necessary, a technical presentation was made before the Board.

Agreement in Principle Program
(1.5 years)

This program involved coordinating oversight efforts with the Department of Health Services for two US Dept. of Energy (DOE) groundwater cleanup sites -- Stanford Linear Accelerator Center and Lawrence Berkeley Laboratory. Duties included review of hydrogeologic reports prepared by the DOE, development of site investigation strategies, and conducting pumping tests.

Solid Waste Assessment Test Program
(2 years)

This program involved the compilation and analysis of chemical and hydrogeologic data collected by landfill owners in response to the Calderon Solid Waste Assessment Test Act. Work activity included evaluation of site specific geology and hydrogeology, and types of wastes deposited in the landfill, in relation to the nature of any soil and groundwater pollution found at the site. The results of this work were used to support the development of new regulations for the construction and operation of Class 3 landfills.

Underground Storage Tank Cleanup Fund Program
(1 year)

This work involved the development of plain English guidelines for helping tank owners understand the site remediation process and thus facilitate cost-effective decisions regarding the nature and extent of investigations at their site. Additional duties included evaluating site-specific underground tank investigations as they related to the cost-effectiveness standards of Article 11 of the California Underground Storage Tank Regulations.

JUNE 1989 - OCTOBER 1991: REGIONAL WATER QUALITY CONTROL BOARD, PALM DESERT, CA.

ENGINEERING GEOLOGIST

Program manager for the Regional Water Board underground storage tank unit from June 1990 to October 1991. Managing this program included review and comment on site investigation reports, development of site investigation strategies, preparation of enforcement orders, budgeting, prioritizing activities, response to complaints, and supervision of staff also involved in the program.

Previous duties involved oversight of a hazardous waste facility in Westmoreland, Ca. This included preparation and/or amendment of waste discharge requirements, conducting compliance inspections, review and evaluation of groundwater monitoring reports with respect to the leak detection statistical analysis approved for the facility, and oversight of the construction of two hazardous waste units.

Miscellaneous duties included preparation of waste discharge requirements for an aquaculture facility at the Salton Sea, and preparation of a general national pollutant discharge elimination system (NPDES) permit to facilitate timely cleanup of leaking underground storage tank sites.

OCTOBER 1988 - JUNE 1989: REGIONAL WATER QUALITY CONTROL BOARD, OAKLAND, CA.

ENGINEERING GEOLOGIST

Duties here included working in the Well Investigation Program determining the source of pollution of municipal wells. Activities included surveys of potential sources near a well, analysis of local geology and hydrogeology, soil-gas surveys, and sampling of wells.

[For full information concerning the filling out of this form refer to Article 4 of Rules and Regulations Pertaining to Appropriation of Water]

STATE OF CALIFORNIA—STATE WATER RIGHTS BOARD

Application No. 21883 **Filed** August 26, 1964, **at** 3:40 **P.M.**
(Applicant must not fill in the above blanks)

APPLICATION TO APPROPRIATE UNAPPROPRIATED WATER

I, John J. Bower dba North Gualala Water Company
Name of applicant or applicants

of Gualala County of Mendocino
Address

State of California, do hereby make application for a permit to appropriate the following described unappropriated waters of the State of California, *SUBJECT TO VESTED RIGHTS:*

Source, Amount, Use and Location of Diversion Works

1. **The source** of the proposed appropriation is North Fork of Gualala River
Give name of stream, lake, etc., if named; if unnamed state nature of source and that it is unnamed

located in Mendocino County, tributary to Gualala River

2. **The amount of water** which applicant desires to appropriate under this application is as follows:

(a) For diversion to be directly applied to beneficial use 2 cubic feet per
1 cubic foot per second equals 40 statute miner's inches or 646,317 gallons per day

second, to be diverted from January 1 to December 31 of each year.
Beginning date — Closing date

(b) For diversion to be stored and later applied to beneficial use acre-feet
1 acre-foot equals 325,851 gallons

per annum, to be collected between and of each season.
Beginning date — Closing date

NOTE.—Answer (*a*) or (*b*) or both (*a*) and (*b*) as may be necessary. If amount under (*a*) is less than .025 cubic foot per second, state in gallons per day. Neither the amount nor the season may be increased after application is filed. If underground storage is proposed a special supplemental form will be supplied by the State Water Rights Board upon request.

3. **The use** to which the water is to be applied is municipal
Domestic, irrigation, power, municipal, mining, industrial, recreational

purposes.

4. **The point of diversion** is to be located confluence of Little North Fork and North Fork of
State bearing and distance or coordinate distances from section or quarter section corner

Gualala River S 1100' and E 1750' from NW corner of Section 23

being within the NE$\frac{1}{4}$ of NW$\frac{1}{4}$
State 40-acre subdivision of public land survey or projection thereof

of Section 23, T. 11N, R. 15W, M.D. B. & M., in the County of Mendocino

5. **The main conduit terminates** in NE$\frac{1}{4}$ of NW$\frac{1}{4}$ of Sec. 22, T. 11N, R. 15W, M.D. B. & M.
State 40-acre subdivision of U. S. Government survey or projection thereof

Description of Diversion Works

NOTE.—An application cannot be approved for an amount grossly in excess of the estimated capacity of the diversion works.

6. **Intake or Headworks** (fill only those blanks which apply)

(a) Diversion will be made by pumping from offset well
Sump, offset well, unobstructed channel, etc.

(b) Diversion will be by gravity, the diverting dam being 3 feet in height (stream bed to level of overflow); 50 feet long on top; and constructed of earth
Concrete, earth, brush, etc.

(c) The storage dam will be feet in height (stream bed to spillway level); feet long on top; have a freeboard of feet, and be constructed of
Concrete, earth, etc.

7. **Storage Reservoir** North Gualala Water Company concrete storage tanks
Name

The storage reservoir will flood lands in none
Indicate section or sections, also 40-acre subdivisions unless shown upon map

It will have a surface area of acres, and a capacity of acre-feet. If reservoir has a capacity of 25 acre-feet or more fill in the following: Diameter of outlet pipe inches; length feet; difference in elevation from spillway level to highest point of outlet pipe feet; fall in pipe feet.

☛ In case of insufficient space for answers in form, attach extra sheets at top of page 3 and cross reference.

FORM 1

Permitting Team
Exhibit 3

The size of the nozzle to be used is............ inches.

The water will be returned to [illegible] in............ of

15. **Municipal Use.** This application is made for the purpose of serving Gualala, California
Name city or cities, town or towns. Urban areas only
.... having a present population of 1500

The estimated average daily consumption during the month of maximum use at the end of each five-year period until the full amount applied for is put to beneficial use is as follows:

1965 112,500 gallons per day

1970 500,000 gallons per day

1975 1,200,000 gallons per day

16. **Mining Use.** The name of the mining property to be served is............
Name of claim
.... and the nature of the mines is............
Gold placer, quartz, etc.

The method of utilizing the water is............

It is estimated that the ultimate water requirement for this project will be............
Cubic feet per second, gallons per minute. State basis of estimate

The water will / will not be polluted by chemicals or otherwise............
Explain nature of pollution, if any

and it will / will not be returned to............ in............ - .... of
Name stream — State 40-acre subdivision

Sec............., T............., R............., ... B. & M.

17. **Other Uses.** The nature of the use proposed is domestic
Industrial, recreational, domestic, stockwatering, fish culture, etc.

State basis of determination of amount needed. 5000 residences average 3 persons per residence using
Number of persons, residences, area of domestic lawns and gardens, number and kind of stock, type
average of 75 gallons per day per person (15,000 persons) = 1,125,000 gallons per day.
industrial use, and unit requirements

General

18. Are the maps as required by the Rules and Regulations filed with Application? yes . If not,
Yes or No
state specifically the time required for filing same............

19. Does the applicant own the land at the proposed point of diversion? no . If not, give name and
Yes or No
address of owner and state what steps have been taken to secure right of access thereto Gualala Redwoods, Gualala, California negotiations underway to purchase necessary rights.

20. What is the name of the post office most used by those living near the proposed point of diversion?

Gualala, California

21. What are the names and addresses of claimants of water from the source of supply below the proposed point of diversion? None

[Signature of Applicant] /s/ John J. Bower
DBA NORTH GUALALA WATER CO.
A PUBLIC UTILITY

8. **Conduit System** (describe main conduits only)

(a) Canal, ditch, flume: Width on top (at water line) ______ feet; width at bottom ______
Cross out two not used

feet; depth of water ______ feet; length ______ feet; grade ______ feet per 1,000 feet; materials

of construction ______
Earth, rock, timber, etc.

(b) Pipe line: Diameter 6 inches; length 4500 feet; grade ______ feet per

1,000 feet; total ~~fall~~ lift from intake to outlet 900 feet; kind steel and asbestos cement
Riveted steel, concrete, wood-stave, etc.

NOTE.—If a combination of different sizes or kinds of conduit is to be used, attach extra sheets with complete description, also show location of each clearly on map.

9. **The estimated capacity** of the diversion conduit or pumping plant proposed is 400 gallons per minute peak demand
State cubic feet per second or gallons per minute

The estimated cost of the diversion works proposed is $25,000.
Give only cost of intake, or headworks, pumps, storage reservoirs and main conduits described herein

Completion Schedule

10. **Construction work** will begin on or before September 1, 1964

Construction work will be completed on or before July 1, 1965

The water will be completely applied to the proposed use on or before 1975

Description of Proposed Use

11. Place of Use. Sections 21, 22, 23, 27, 28, 16 and 17 of T11N, R15W, MDB&M.
State 40-acre subdivisions of the public land survey. If area is unsurveyed indicate the location as if lines of the public land survey were projected. In the case of irrigation use state the number of acres to be irrigated in each 40-acre tract, if space permits. If space does not permit listing of all 40-acre tracts, describe area in a general way and show detail upon map.

Do(es) applicant(s) own the land whereon use of water will be made? SOME Jointly? ______
Yes or No Yes or No

All joint owners should include their names as applicants and sign application at bottom of third page.

If applicant does not own land whereon use of water will be made, give name and address of owner and state what arrangements have been made with him.

12. **Other Rights.** Describe all rights except those on file with the State Water Rights Board under which water is served to the above named lands.

Nature of Right (riparian, appropriative, purchased water, etc.)	**Year of First Use**	**Use made in recent years** including amount if known	**Season of Use**	**Source of Other Supply**
1.				
2.				
3.				
4.				

Attach supplement at top of page 3 if necessary.

13. **Irrigation Use.** The area to be irrigated is ______ acres.
State net acreage to be irrigated

The segregation of acreage as to crops is as follows: Rice ______ acres; alfalfa ______ acres;

orchard ______ acres; general crops ______ acres; pasture ______ acres.

NOTE.—Care should be taken that the various statements as to acreage are consistent with each other, with the statement in Paragraph 11, and with the map.

The irrigation season will begin about ______ and end about ______
Beginning date Closing date

14. **Power Use.** The total fall to be utilized is ______ feet.
Difference between nozzle or draft tube water level and first free water surface above

The maximum amount of water to be used through the penstock is ______ cubic feet per second.

The maximum theoretical horsepower capable of being generated by the works is ______ horsepower.
Second feet × fall ÷ 8.8

The use to which the power is to be applied is ______
For distribution and sale or private use, etc.

The nature of the works by means of which power is to be developed is ______
Turbine, Pelton wheel, etc.

The size of the nozzle to be used is ______ inches.

in ______ of

APPLICANT MUST NOT FILL IN BLANKS BELOW

PERMIT No. 14853

This is to certify that the application of which the foregoing is a true and correct copy has been considered and approved by the State Water Rights Board SUBJECT TO VESTED RIGHTS and the following limitations and conditions:

1. The amount of water appropriated shall be limited to the amount which can be beneficially used, and shall not exceed 2 cubic feet per second by direct diversion to be diverted from January 1 to December 31 of each year. (0000005)

2. The maximum amount herein stated may be reduced in the license if investigation warrants. (0000006)

3. Actual construction work shall begin on or before December 1, 1965, and shall thereafter be prosecuted with reasonable diligence, and if not so commenced and prosecuted this permit may be revoked. (000[illegible]1)

4. Said construction work shall be completed on or before December 1, 1967. (000000[illegible])

5. Complete application of the water to the proposed use shall be made on or before December 1, 1968. (00[illegible])

6. Progress reports shall be filed promptly by permittee on forms which will be provided annually by the State Water Rights Board until license is issued. (0000010)

7. All rights and privileges under this permit including method of diversion, method of use and quantity of water diverted are subject to the continuing authority of the State Water Rights Board in accordance with law and in the interest of the public welfare to prevent waste, unreasonable use, unreasonable method of use or unreasonable method of diversion of said water. (0000012)
[illegible] 7-25-37

8. Permittee shall allow representatives of the State Water Rights Board and other parties, as may be authorized from time to time by said Board, reasonable access to project works to determine compliance with the terms of this permit.

9. Permittee shall at all times bypass a minimum of 5 cfs or the natural flow of the stream if less than 5 cubic feet per second from November 1 of each year to June 1 of the following year, and 1 cubic foot per second or the natural flow if less than 1 cubic foot per second from June 1 to November 1 of each year, at the points of diversion to maintain fishlife. (0140060)
([illegible] 12-13-[illegible])

This permit is issued and permittee takes it subject to the following provisions of the Water Code:

Section 1390. A permit shall be effective for such time as the water actually appropriated under it is used for a useful and beneficial purpose in conformity with this division (of the Water Code), but no longer.

Section 1391. Every permit shall include the enumeration of conditions therein which in substance shall include all of the provisions of this article and the statement that any appropriator of water to whom a permit is issued takes it subject to the conditions therein expressed.

Section 1392. Every permittee, if he accepts a permit, does so under the conditions precedent that no value whatsoever in excess of the actual amount paid to the State therefor shall at any time be assigned to or claimed for any permit granted or issued under the provisions of this division (of the Water Code), or for any rights granted or acquired under the provisions of this division (of the Water Code), in respect to the regulation by any competent public authority of the services or the price of the services to be rendered by any permittee or by the holder of any rights granted or acquired under the provisions of this division (of the Water Code) or in respect to any valuation for purposes of sale to or purchase, whether through condemnation proceedings or otherwise, by the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State, of the rights and property of any permittee, or the possessor of any rights granted, issued, or acquired under the provisions of this division (of the Water Code).

14853

Dated: SEP 3 1965

STATE WATER RIGHTS BOARD

L. K. Hill

L. K. Hill
Executive Officer

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER RIGHTS

ORDER WR-99-09-DWR

In the Matter of Minor Protested Petition
to Change Permits 5431, 5432, 11535, and 14853
NORTH GUALALA WATER COMPANY
(Applications 9372, 9454, 18098, and 21883, respectively).

SOURCES: North Fork Gualala River; Robinson Gulch; Big Gulch; and Fish Rock Creek

COUNTY: Mendocino

PROTESTANTS: California Department of Fish and Game, California Trout, Jerome P. Lucey, et al.

ORDER APPROVING PETITION TO ADD POINTS OF DIVERSION TO PERMIT 14853 AND PETITION TO ADD TO THE PLACE OF USE FOR PERMITS 5431, 5432, 11535, AND 14853

BY THE DIVISION OF WATER RIGHTS

1.0 INTRODUCTION

The State Water Resources Control Board (SWRCB) issued permits to North Gualala Water Company (Company) authorizing diversion of water from various streams tributary to the Pacific Ocean in Mendocino County.

On November 4, 1994, the Division of Water Rights (Division) received a second petition from the Company to add two vertical wells to Permit 14853, and on December 26, 1995, the Division received a petition to add 13 parcels to the place of use for Permits 5431, 5432, 11535, and 14853. The petitions were protested, and the Division conducted a minor petition field investigation to gather information pursuant to Water Code section 1704.1. After consideration of all available information, the Division finds (1) the petition to add points of diversion to Permit 14853 should be approved subject to conditions; and (2) the petition to add 13 parcels (as shown on the map accompanying the petition) to the place of use for Permits 5431, 5432, 11535, and 14853 should also be approved subject to conditions.

Permitting Team
Exhibit 4

2.0 BACKGROUND – PETITION TO ADD POINTS OF DIVERSION TO PERMIT 14853

Permit 14853 was issued September 3, 1965 for 2.0 cfs for municipal use to be diverted year-round from an offset well located at the confluence of the Little North Fork and the North Fork of the Gualala River approximately two miles east of the Town of Gualala in Mendocino County (See Figure 1). In response to a petition submitted by the permittee, the SWRCB issued an order in 1978 which changed the place of use, added three new terms to the permit, including a measuring device requirement to measure bypass flows, and amended the existing Term 9 to read:

> For the protection of fish and wildlife, permittee shall during the period: (a) from November 15 through February 29, bypass a minimum of 40 cubic feet per second; (b) from March 1 through May 31, bypass a minimum of 20 cubic feet per second; (c) from June 1 through November 14, bypass a minimum of 4 cubic feet per second. The total streamflow shall be bypassed whenever it is less than the designated amount for that period.

The above term was developed by the Department of Fish and Game (DFG) as a means to resolve their protest and was accepted by the Company.

Permit 14853 is one of four permits that are held by the Company to cover water diversions to the community of Gualala. The combined rate of diversion for Permits 5431, 5432, 11535, and 14853 is 4.16 cfs with a maximum annual limitation of 1,730 acre-feet per annum.

Due to concerns regarding the drinking water quality from the offset wells near the confluence of the Little North Fork Gualala River, the Company decided to abandon the original point of diversion under Permit 14853 and in 1989 drilled Well No. 4, a 142-foot-deep vertical well. The Company contends that this well pumps percolating groundwater, but Division staff's evaluation of available evidence leads to the conclusion that the water pumped from Well No. 4 flows in a subterranean stream and, therefore, is under the SWRCB's permitting authority. Although the Company did not concede that the water is pumped from a subterranean stream, the Company filed a petition with the Division in November 1994 to add points of diversion to cover Wells Nos. 4 and 5 and delete the original point of diversion.

Well No. 4, the primary source of water for the place of use, has a maximum output of approximately 250-260 gpm (0.55 – 0.58 cfs). The water from the well meets the State of California's safe drinking water standards with minimal treatment. Typical demand for Well No. 4 is 180,000 to 200,000 gpd. Well No. 5 will be used as a back-up supply in the event of a problem with Well No. 4. The Company also has observation and water quality sampling wells (Nos. 1, 2, and 3), but these wells will not be used for municipal water production. The Company has not specified whether the maximum output of Well No. 4 can be expanded to 2.0 cfs (the amount stated on Permit 14853). The Company has indicated that at full build-out the demand will be at or near 1.0 cfs as described in the Gualala Town Plan.

A controversy has existed for many years surrounding the measuring device for the bypass flow. Division engineering staff has inspected the diversion site several times over the years, and each time the permittee has been in compliance with the permit. However, there is a possibility in most years that flows in the river will be less than the bypass requirements prior to the onset of winter rains as well as during the winter and spring months of most drought years. Since Well No. 4 is the Company's primary water supply, it is highly unlikely that the Company would be able to shut down this point of diversion when flows in the river are less than the required minimums, without generating potential health and safety problems, unless the Company takes other actions to prevent these problems.

2.1 Protests Submitted Against Petition to Change Permit 14853

Protests were received from the following parties:

Salmon Unlimited
H. L. Joseph
The Sea Ranch Association
Donald McDonald
S. W. Kelly

Jerome P. Lucey
California Trout
Trout Unlimited of California/
Anglers of California
California Department of Fish and Game

The above protests were based on environmental concerns, primarily adverse impacts to spawning and rearing habitat for anadromous fish and compliance with the bypass amounts required by the permit.

2.2 Comments on the Draft Order and Initial Study / Draft Negative Declaration

A draft copy of this Order and the Initial Study/Draft Negative Declaration were circulated for 35 days beginning on May 12, 1999 for review and comment. Twenty-three copies were mailed directly to federal and state governmental agencies and interested parties that had expressed interest in reviewing these documents. Eleven copies were circulated by the California Governor's Office of Planning and Research to various state agencies. With the exception of the response from the Coast Action Group all of the comments were submitted within the specified review period.

Comments were received from:

Alan B. Lilly, North Gualala Water Company
Don McDonald—Fisheries Advocate
Brian Hunter, Regional Manager, California Department of Fish and Game, Central Coast Region
Jim Edmondson, Conservation Director, California Trout
Alan LeVine, Coast Action Group.

Following is a summary of the comments received:

- The North Gualala Water Company requests clarification of the wording in Terms 3 and 6 of the Order. Because Terms 3 and 6 of the Order supercede Term 10 of Permit 14853, the Company requests Term 10 be deleted. In addition, the Company reserves its rights to assert in subsequent proceedings that the water that is pumped from the Company's Well No. 4 and Well No. 5 is percolating groundwater that is not subject to the SWRCB's water right permitting authority.

- Don McDonald requests that the State Water Resources Control Board order North Gualala Water Company and the Gualala Redwoods Co. to undertake a "Baseline Fishery Study" at no cost to North Gualala Water Company ratepayers. Mr. McDonald also submitted a memorandum dated January 15,1998 regarding the need for continuous stream flow measurements in the North Fork of the Gualala River.

- The Department of Fish and Game requests that the flow measurement schedule proposed in the Order be modified to require daily flow measurements whenever the recorded stream flow is 4.5 cfs or less. The Department also requests that the Gualala Water Company be restricted to the current level of diversion until an alternative water source has been developed.

- California Trout requests that the SWRCB be required to prepare an Environmental Impact Report because the Steelhead Trout and Coho Salmon are listed under the federal Endangered Species Act.

- The Coast Action Group requests that the SWRCB prepare a "full EIR, or provide additional mitigations that will provide adequate protections for this resource" because there is no assurance that the terms and conditions described in the Draft Order will be enforced.

Based upon consideration of the comments received on the Draft Order and Initial Study/ Draft Negative Declaration and the Company's responses to the comments, the Division modified the Order where appropriate.

3.0 BACKGROUND—PETITION TO ADD TO THE PLACE OF USE FOR PERMITS 5431, 5432, 11535, AND 14853

Permits 5431 and 5432 were both issued November 3, 1939 for diversion from Robinson Gulch and Big Gulch of 1.0 cubic foot per second (cfs) each, year-round. Permit 11535 was issued September 4, 1958 for diversion from Fish Rock Creek for 0.16 cfs year-round, and Permit 14853 was issued September 3, 1965 for diversion from North Fork Gualala River for 2.0 cfs year-round. These permits have received numerous extensions of time over the years to allow the Company to fully develop its use of water. On September 21, 1993, Division staff conducted a compliance field investigation. During the investigation, staff discovered that the Company's current service area was larger than the place of use shown for the Company's water right permits. In response, the Company filed a petition to add 13 parcels to its authorized place of use (See Figure 1). Protests were received from Coast Action Group and Don McDonald. Both protests were based on environmental considerations and assert that additional hookups will further exacerbate low flow conditions on the North Fork Gualala River. However, the Company has not indicated that the expansion of its place of use will require any additional water above what it is already authorized under its existing water right permit.

4.0 MINOR PETITION FIELD INVESTIGATION

Division staff conducted a field investigation on October 7, 1998 to gather information on the Company's petitions. Approximately 30 interested persons attended the investigation, including the petitioner John Bower, president of the Company. The following protestants were represented:

California Department of Fish and Game
Coast Action Group
Jerome P. Lucey
Don McDonald
California Trout

5.0 ISSUES

The SWRCB's primary considerations when deciding whether a petition to change a permit should be granted are: (1) whether the proposed change will in effect initiate a new right, or (2) whether the proposed change will cause injury to any other legal user of water or to the environment. The protests received are primarily concerned with the effect of the change on the environment. Consideration of a petition to change is limited to the effect of the change and not other issues related to the effects of the underlying water right.

5.1 Proposed Change in Point of Diversion

The issue regarding the change in point of diversion is whether moving the point of diversion upstream from the previously permitted location to offset Wells Nos. 4 and 5 will have adverse impacts on the environment.

5.1.1 Riparian Habitat

The protestants raised the issue that the relocation of the point of diversion to Wells Nos. 4 and 5 will cause adverse impacts to the adjacent riparian vegetation on the North Fork Gualala River. Well No. 4 was installed in 1992 and has been in operation since that time. Division staff has visited the site on several occasions over the past six years. At the October 7, 1998 field investigation, staff viewed the original point of diversion, Wells Nos. 4 and 5, and the riparian corridor from the confluence of the Little North Fork Gualala

River to a point directly above Well No. 4. During each of these visits, staff noted that the riparian vegetation appeared to be well developed and healthy. Based upon staff's observations and review of the available information, there is no evidence to suggest that the installation and operation of Wells Nos. 4 and 5 has caused any significant adverse impacts to the riparian vegetation in the vicinity of the wells.

5.1.2 Fishery Resources

Although the effect of the Company's diversion on anadromous fish is the primary concern of protestants, no information was presented to indicate that moving the point of diversion upstream from the previously permitted location to Wells Nos. 4 and 5 would have adverse impacts to the fishery. However, many protestants were concerned that the Company may not be meeting the bypass flows required by the permit. This concern is amplified by the Company's reliance on Well No. 4 as the major source of its water supply and its inability to meet demand should it be required to reduce diversion from Well No. 4 to meet bypass flow requirements.

The Division's most recent compliance investigation was made September 21, 1993. The inspecting engineer reported that the conditions for measuring flows in the area of the diversion are generally poor. The stream has a considerable amount of sand and gravel in the channel. Low flows move from one backwater pool to the next. Free flow usually exists only in short reaches between pools. These reaches are often braided and very shallow, making streamflow measurement extremely difficult. No bedrock formations are apparent in the channel. The Division concluded that it is impossible to establish an adequate stage/flow relationship without constructing an artificial control structure and measuring device. Permit 14853 is for a relatively small amount of water from a large saturated channel of sand and gravel through which the underflow of the river passes. The impacts of these diversions on the surface flow are most likely spread over a prolonged period of time. At present, the maximum pumping capacity of Well No. 4 is 0.55 cfs to 0.58 cfs. The total amount authorized for diversion under Permit 14853 from the North Fork Gualala River is 2.0 cfs. Observations and measurements taken to date are therefore based upon the effects of the diversion of approximately 29 percent of the total permitted amount. Consequently, these observations and measurements do not reflect the potential effects of the diversion of the maximum amount authorized.

During the October 7, 1998 field investigation, several protestants stated that the Company should be required to install and maintain a device capable of continuously measuring the surface flow of the North Fork Gualala River. There was a mixed response regarding the problems associated with the installation and maintenance of a continuous, flow-measuring device. The DFG representative acknowledged the problems associated with the installation and maintenance of such a device, but reiterated that some type of instream flow-measuring device should be required to determine compliance with the surface flow bypass requirements. DFG also indicated that the permittee should provide advance notice and access to interested parties to observe the measurements as they are taken. The Company was generally in agreement with this approach.

Division staff suggested that due to the difficulties associated with installing and maintaining a continuous, instream flow-measuring device, the Company should periodically take manual flow measurements and report the results to DFG and the Division, and make the results available to the public upon request. In response, the representative from DFG stated that low-flow periods, which may in some years extend into December, are of particular concern. Surface flow should be measured regularly during low flows, but measurement is not necessary during the high winter flows. The Company's representative responded that he was not opposed to this approach. He also agreed that the Company could provide advance notice of the measuring schedule and invited DFG personnel to observe and participate.

Division Staff further suggested that the Company prepare a plan to measure the surface flow of North Fork Gualala River. This plan should include, but not be limited to a description of measurement locations and the type of equipment to be used. The objective of the plan is to demonstrate compliance with Permit Term 9 (see section 2.0 above) and the amount of water diverted for use. The plan should be submitted to the Chief of the Division of Water Rights for approval.

5.2 Will addition of the 13 designated parcels cause injury to any legal user of water or to the environment?

The petition to change the place of use proposed the addition of 13 parcels located on either side of Highway 1, between Triplett Gulch and Roseman Creek, approximately 6 to 6.5 miles north of the Town of Gualala as shown on a map on file with the SWRCB. Eleven of the thirteen parcels are already developed. The expansion of the service area was accomplished with approval from the County under a Coast Development Use Permit 34-92 dated April 15, 1993. Protestants expressed concern that such an addition would lead to increased diversions from the North Fork Gualala River. However, the Company has stipulated in the petition that the increase in the place of use will not require any additional water above the amount the Company was allotted in Permit 14853.

6.0 COMPLIANCE WITH CALIFORNIA ENVIRONMENTAL QUALITY ACT

The SWRCB is Lead Agency with respect to the pending petitions to change the water right permits held by the Company pursuant to the California Environmental Quality Act (CEQA) and is therefore responsible for the preparation and circulation of the appropriate CEQA documentation. CEQA requires the SWRCB to determine whether approval of these petitions will have a significant effect upon the environment. The Division has conducted a preliminary review for these petitions pursuant to CEQA.

The County of Mendocino prepared and circulated an Initial Study and a Draft Negative Declaration for the installation of a 6,000-linear-foot extension of a 6-inch water main. The purpose of this extension was to provide water service to 60 additional parcels including the 13 parcels described in the petition to expand the place of use. The State Office of Planning and Research circulated the Initial Study and Draft Negative

Declaration for review by governmental agencies in March of 1987. Mendocino County concurrently circulated these documents for public review. The Mendocino County Board of Supervisors adopted the Negative Declaration on July 23, 1987.

The protestants have asserted that the SWRCB must prepare and circulate a cumulative Environmental Impact Report (EIR) for these petitions. Cumulative effects of a proposed project are defined by CEQA [California Code of Regulations, Title 14, § 15065 (c)] as "the incremental effects of an individual project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects." Moving the point of diversion and adding 13 single-family residences to the authorized place of use does not constitute a cumulative impact to the physical environment. The protestants have not presented any evidence nor have they cited any persuasive authority in support of their assertion.

The existence of public controversy over the environmental effects of a project does not require preparation of an EIR if there is no substantial evidence before the Lead Agency that the project may have a significant effect upon the environment [Calif. Code of Regulations, Title 14, § 15064 (g)(5)]. There is no substantial evidence in the record nor have the protestants presented any substantial evidence that approval of the change petitions will have any significant effect upon the environment. As a result of the preliminary review, the Division prepared and circulated an Initial Study and a proposed Negative Declaration on May 12, 1999. The Division recommends that the SWRCB adopt the Negative Declaration after modification to reflect the terms contained in this Order.

7.0 CONCLUSION

After consideration of all available information, the Division finds:

(1) The petition to delete the onstream diversion point and add points of diversion for Wells Nos. 4 and 5 to Permit 14853 should be approved subject to conditions; and

(2) The petition to add 13 parcels (as shown on the map accompanying the petition) to the place of use for Permits 5431, 5432, 11535, and 14853 should be approved subject to conditions.

(3) Term 9 of Permit 14853 requiring bypass flows for the protection of fish and wildlife should remain as amended by the December 13, 1978 Water Right Order.

(4) The development by the Company of a surface flow measuring plan is necessary to comply with the measuring device requirement of Term 10 of Permit 14853.

ORDER AMENDING PERMIT

IT IS HEREBY ORDERED that:

(1) The following point of diversion identified in Water Right Permit 14853 be deleted:

> S 1,100 feet and E 1,750 feet from the NW corner of Section 23, being within the NE ¼ of the NW ¼, Section 23, T11N, R15W, MDB&M

And the following points added:

> Point 1 (Well No. 4): California Coordinate Zone 2, N 413,200; E 1,571,000, within the NW ¼ of NE ¼, Section 23, T11N, R15W, MDB&M
>
> Point 2 (Well No. 5): California Coordinate Zone 2, N 413,250; E 1,571,350, within the NW ¼ of NE ¼, Section 23, T11N, R15W, MDB&M

(2) The place of use for Water Right Permits 5431, 5432, 11535, and 14835 be amended to read as follows:

> Within the service area of the North Gualala Water Company, being within Sections 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 20, 21, 22, 23, 26, 27, 28, and 34, T11N, R15W, MDB&M and Sections 12 and 13, T11N, R16W, MDB&M, as shown on the map dated December 26, 1995 on file with the State Water Resources Control Board

(3) Permittee shall measure the flow of the North Fork Gualala River pursuant to the measurement plan described in Term 6 of this Order on June 1, July 1, and August 1, and weekly thereafter until December 15 of each year. If during the period of June 1 through November 14, any recorded flow is less than 4.5 cfs, and during the period of November 15 through December 15 any recorded flow is less than 40 cfs, measurements shall be taken on a daily basis to determine whether diversion is permitted. If during the period November 1 through December 15, Permittee finds that flows are consistently above 40 cfs, Permittee may choose to visually estimate flows. The specifics of this requirement shall be addressed in the surface flow measurement plan required by Term 6 of this Order. Permittee shall notify the Department of Fish and Game and other interested parties of the times stream measurements will be taken to allow a representative to be present. Permittee shall provide a copy of the flow measurement data to the Division of Water Rights and the Department of Fish and Game, and make a copy available for public review by January 1 of each year. Such annual measurements shall commence October 1, 1999.

(4) Permittee shall allow representatives of the State Water Resources Control Board and the California Department of Fish and Game reasonable access to the project works to determine compliance with the terms of this permit.

(5) Should any buried archeological materials be uncovered during project activities, such activities shall cease within 100 feet of the find. The Chief of the Division of Water Rights shall be notified of the discovery, and a professional archeologist shall be retained by the applicant to evaluate the find and recommend appropriate mitigation. Construction activities in the area of the find shall resume only after the completion of the recommended mitigation, as approved by the Chief of the Division of Water Rights.

(6) Permittee shall, in consultation with staff of the Division of Water Rights, prepare a surface flow measurement plan which shall describe the proposed method to measure the surface flow of the North Fork Gualala River below the influence of the Company's diversion to ensure compliance with the bypass amounts required in Term 9 of the permit. This plan shall be submitted in writing to the Chief of the Division of Water Rights for approval within 60 days of the date of this Order.

(7) Term 10 of Permit 14853 is superceded by Terms 3 and 6 of this Order and is therefore deleted from Permit 14853.

(8) The permit does not authorize any act which results in the taking of a threatened or endangered species or any act which is now prohibited, or becomes prohibited in the future, under either the California Endangered Species Act (Fish and Game Code sections 2050 to 2097) or the federal Endangered Species Act (16 U.S.C.A section 1531 to 1544). If a "take" will result from any act authorized under this water right, the permittee shall obtain an incidental take permit prior to construction or operation. Permittee shall be responsible for meeting all requirements of the applicable Endangered Species Act for the project authorized under this permit.

Gerald E. Johns

For Harry M. Schueller, Chief
Division of Water Rights

Dated: 8/27/99

and

Pumping Impacts at

Elk Prairie

prepared for

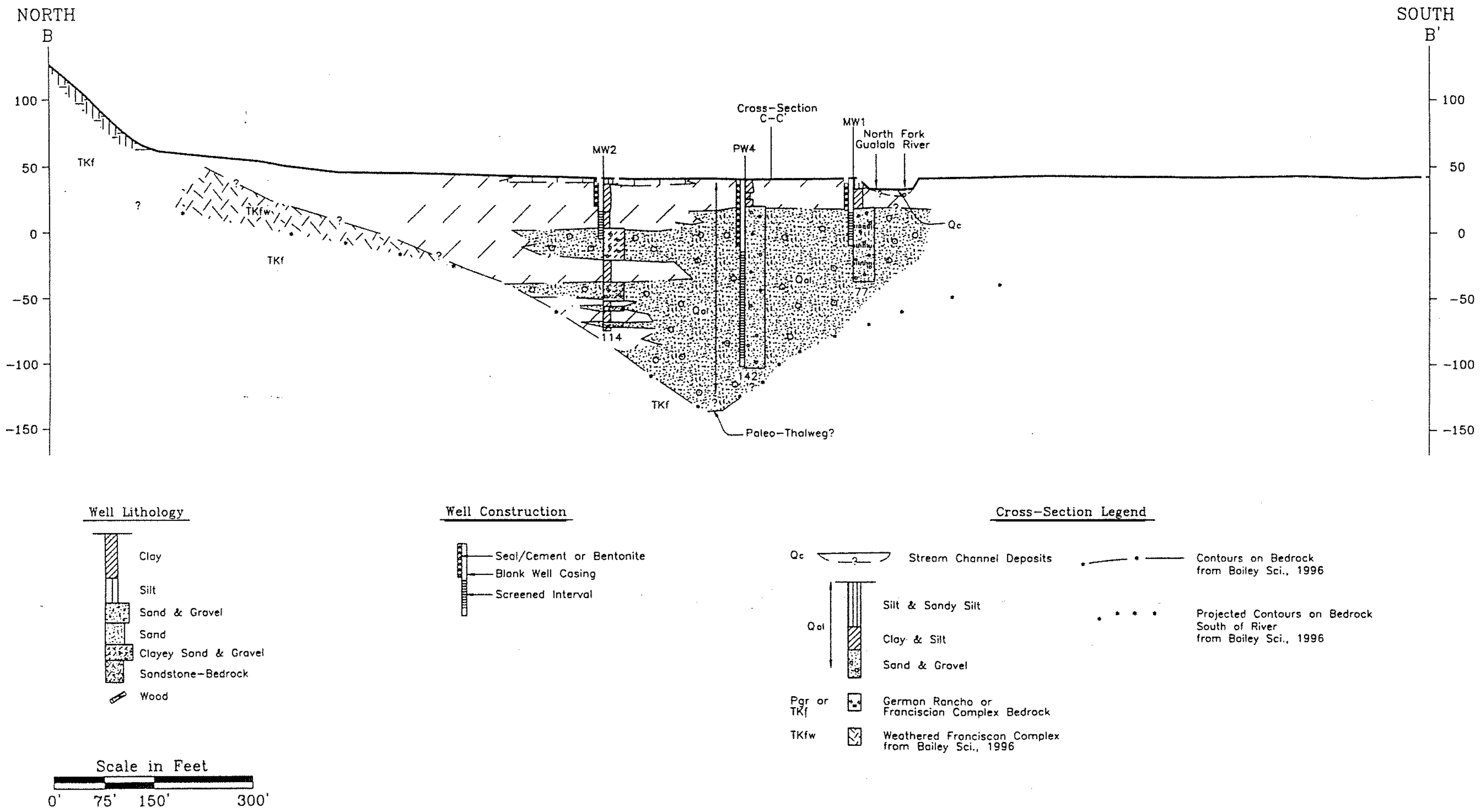
North Gualala Water Company

January 1998

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

FILE: 21883
CAT: 2 VOL 1
FXH ___ ITEM ___

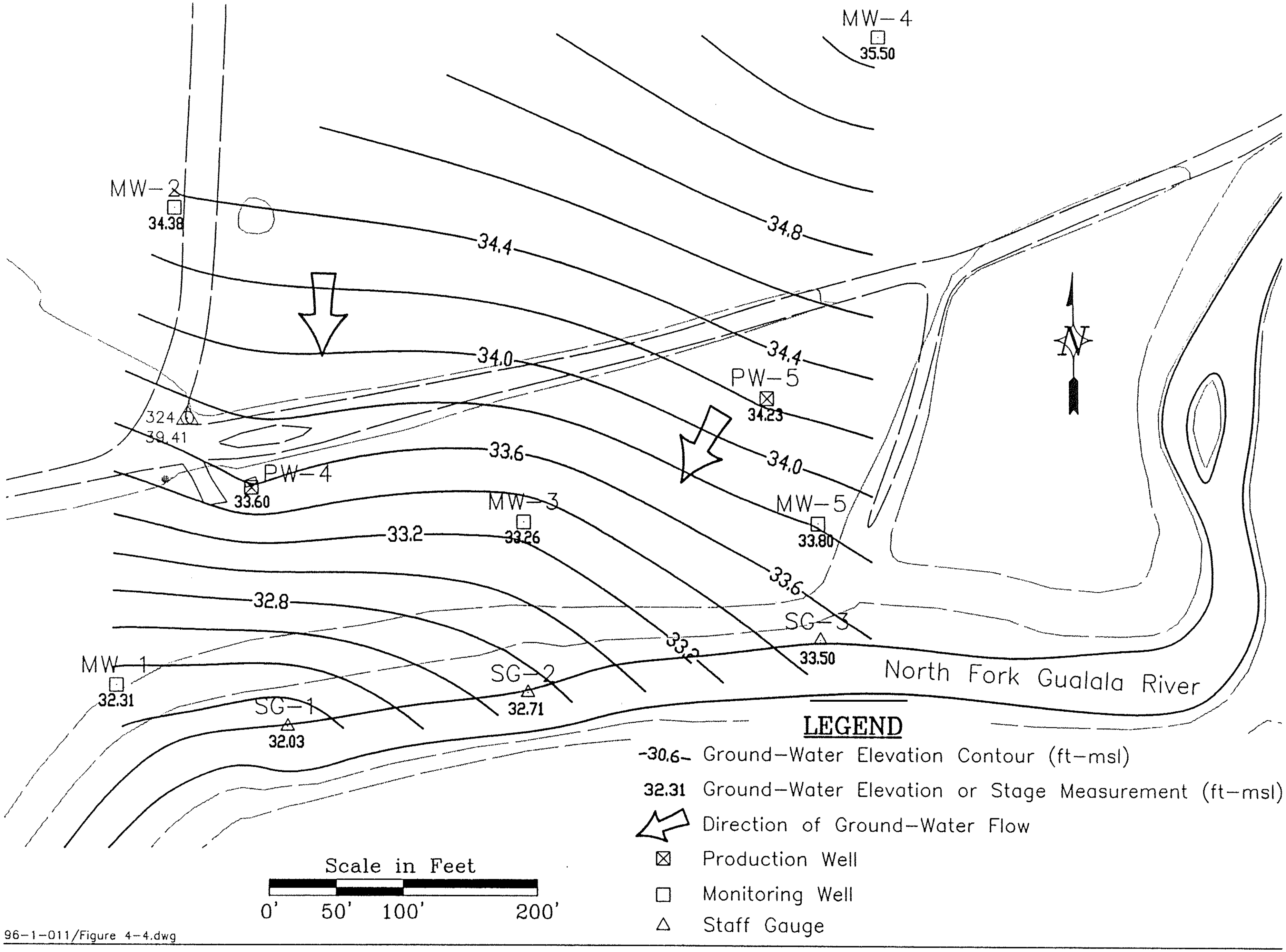
Permitting Team
Exhibit 5a



Gualala/96-1-011/Figure 2-3.dwg

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure 2-3
Geologic Cross-Section B-B'



LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure 4-4
Ground-Water Elevation Contours: 1/7/97
(High Streamflow Conditions)

Permitting Team
Exhibit 5b

TRIPLICATE
Owner's Copy

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 211074

N of Intent No.
L Permit No. or Date 5654

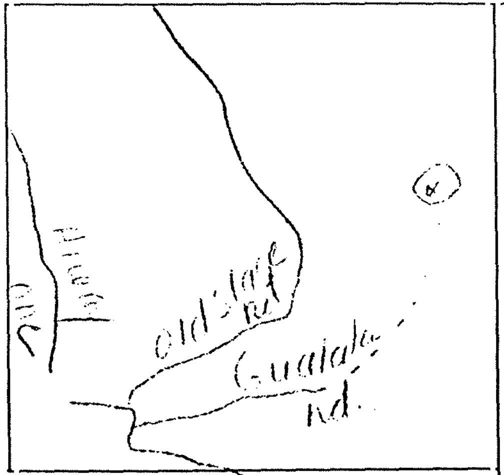
State Well No.
Other Well No.

(1) OWNER:

Name NORTH GUALALA WATER COMPANY
Address P.O. Box 1000
City Gualala, California Zip 95445

(2) LOCATION OF WELL (See instructions):

County MENDOCINO Owner's Well Number
Well address if different from above
Township 11N Range 15W Section 23
Distance from cities, roads, railroads, fences, etc.
44320 Gualala Road
Gualala
A.P. # 141-270-05



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☒
Other ☐

(5) EQUIPMENT:

Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size pea
Diameter of bore $13\frac{1}{2}$"
Packed from 50 to 142 ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen micro

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	141	8"	CL200	56	134	.030

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing concrete on gravel pack

(10) WATER LEVELS:

Depth of first water, if known ft.
Standing level after well completion 10 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Weeks
Type of test Pump ☐ Bailer ☒ Air lift ☐
Depth to water at start of test 10 ft. At end of test 10 ft
Discharge 60+ gal/min after $1\frac{1}{2}$ hours Water temperature cool
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:

Total depth 142 ft. Depth of completed well 141 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
		WELL # ~~3~~4
0	10	Brown clay
10	15	Roots
15	21	Sandy clay
21	142	Sand and gravels

Work started 8-2 1989 Completed 8-4 1989

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED Ward Thompson By: Don Sinclair
(Well Driller)

NAME WEEKS DRILLING AND PUMP COMPANY
(Person, firm, or corporation) (Typed or printed)
Address P.O. Box 176-6100 Sebastopol Road
City Sebastopol, California Zip 95472
License No. C57-177681 Date of this report August 14,198

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Permitting Team
Exhibit 5c

TRIPLICATE
Owner's Copy
Page 1 of 1

PW #5

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 442395

— DWR USE ONLY — DO NOT FILL IN —
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

Owner's Well No. ____
Date Work Began 11-8-96 Ended 11-13-96
Local Permit Agency MENDOCINO COUNTY HEALTH DEPARTMENT
Permit No. 11351P Permit Date 11-4-96

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER ____ (Ft) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	17	Brown sandy clay
17	40	Sand and gravel
40	41	Brown sandy clay
41	67	Sand and gravel
67	85	Sand and gravel with a trace of brown clay
85	88	Blue sandy silty clay and wood
88	97	Sand and gravel
97	122	Sand and gravel with streaks of blue sandy clay
122	129	Multicolored rock and blue and gray sandy clay
129	137	Blue sandy rock and blue clay

TOTAL DEPTH OF BORING 137 (Feet)
TOTAL DEPTH OF COMPLETED WELL 97 (Feet)

WELL OWNER

Name NORTH GUALALA WATER COMPANY
Mailing Address P.O. Box 1000
Gualala, California 95445
CITY STATE ZIP

WELL LOCATION

Address 44320 Gualala Road
City Gualala
County MENDOCINO
APN Book 141 Page 270 Parcel 05
Township ____ Range ____ Section ____
Latitude ____ NORTH Longitude ____ WEST
DEG. MIN. SEC.

LOCATION SKETCH

NORTH
WEST
EAST
SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
X Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD MUD ROTARY FLUID Poly Jel

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 13 (Ft.) & DATE MEASURED 11-14-96
ESTIMATED YIELD* 700+ (GPM) & TEST TYPE ____
TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 20'7" (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	137	13 3/4								
+2	97		X				PVC/F480	8"	CL200	
55	92			X						.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	50	X			
50	137			X	pea grav

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ____
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

NAME WEEKS DRILLING AND PUMP COMPANY
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P.O. Box 176 Sebastopol, California 95473
ADDRESS CITY STATE ZIP

Signed WARD THOMPSON By: Thurman Adams 11-19-96 17768
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

To the northwest along the fault valley, topographic expression suggests that alluvium may extend up the Little North Fork to near Log Cabin Creek. Again, thickness of the alluvium is not known but both the areal and vertical extent also appear to be smaller than the Elk Prairie, with thinning gradually to the north. Alluvium also appears to extend downstream along the fault valley to at least the junction with the South Fork Gualala River, again with apparently smaller areal extent than Elk Prairie.

Both the alluvium and the underlying Franciscan Complex in the Elk Prairie area are water bearing, although they have very different properties. The unconsolidated alluvium is dominated by coarse-grain sediments (sand and gravel) and is, therefore, highly permeable. This permeability is both horizontally and vertically heterogenous due in part to the stratigraphic complexity discussed above. The deeper portion of the alluvial formation appears to be somewhat less permeable due to a higher percentage of fine-grain sediments (silts and clays). Where these materials occur as distinct beds, the vertical permeability is much lower and the ground water in the aquifer tends to become more confined.

The consolidated Franciscan Complex has a much lower permeability but is sufficiently porous to store large volumes of precipitated water which slowly drains to maintain stream base flows throughout the dry season. High water storage is evidenced by perennial seeps and springs, both natural and on manmade cutslopes, and shallow depths to saturated soils and weathered bedrock. The high water content is also seen in the propensity of shallow and deep-seated landsliding occurring on slopes underlain by the Franciscan Complex. The permeability of the Franciscan Complex is highly dependent on fracture density, which tends to be higher near seismically active areas such as Elk Prairie.

Permitting Team
Exhibit 5d

Prairie were analyzed; including alternating pumpage between PW-4 and 5, increasing the pumping capacity of PW-4, and constructing additional wells at the site. Two additional production well locations and total capacities of 250 to 750 gpm were evaluated using an analytical model. Simulations based on measured aquifer characteristics at the site indicate that four of the 16 scenarios analyzed would cause a reversal of gradient between the aquifer and the River, including pumping of PW-4 and 5 simultaneously at their current capacities. The remaining 12 scenarios did not cause a simulated gradient reversal, including one scenario at 375 gpm, six scenarios at 500 gpm, two scenarios at 625 gpm, and one scenario at 750 gpm.

Based on the various components of the Elk Prairie exploration, monitoring, and testing, it can be concluded that NGWC can continue to operate well PW-4 at its design capacity, with extended pumping cycles to meet daily and seasonal fluctuations in water demand, and not cause any induced infiltration from the North Fork Gualala River. Similarly, NGWC can permanently equip backup well PW-5 with similar permanent pumping equipment and operate that well on intermittent pumping cycles without causing any induced infiltration from the river as long as both wells are not pumped at the same time. However, if PW-5 were equipped with a smaller capacity pump and PW-4 with a larger capacity pump, these wells could be pumped simultaneously at a combined capacity of up to 500 gpm. Finally, as water demand in the system increases in the future, NGWC could install one or two additional production wells at Elk Prairie, located a similar or greater distance from the River and equipped at a similar capacity, and operate them in a similar manner without causing any induced infiltration from the River. The addition of that source capacity would provide sufficient supply to meet increased water demand based on the Town's General Plan over the next 20 years.

Finally, the results of the overall Elk Prairie ground-water investigation show a perennial gradient for ground-water flow toward, and discharge into, the North Fork Gualala River from beneath Elk Prairie. There is no "channelized" ground-water flow parallel to the River at Elk Prairie. These conditions and the response of the aquifer to precipitation, to pumping, and to dry season lack of rainfall recharge all show that ground water is not recharged by influent stream seepage. Ground water is maintained by some combination of deep percolation of precipitation

Permitting Team
Exhibit 5e

and subsurface flow from the basement complex. Similarities in surface and ground-water quality are not the result of recharge from the North Fork Gualala River because ground water discharges to the River under both static and pumping conditions regardless of stream stage. Consequently, ground water beneath Elk Prairie does not occur in a subterranean stream, nor does it occur as underflow of the River.

IV. Water-Level Monitoring and Aquifer Testing

River Stage and Ground-Water Monitoring

Regular monitoring of Elk Prairie ground-water elevations and North Fork Gualala River stage began in March 1996. Water levels in PW-4 and stage at SG-1 were measured on a weekly basis between March 1996 and October 1996. In October and November 1996, the water-level monitoring network was expanded to include the second production well and five monitoring wells discussed above. Two additional surveyed control points for measuring River stage (identified as "staff gauges" SG-2 and 3) were also added to the monitoring network at that time. The current water-level monitoring network at Elk Prairie is shown on Figure 4-1 and summarized on Table 4-1. Beginning with the completion of the monitoring wells, and continuing through the present, ground-water levels and River stage have been measured biweekly at all monitoring locations except for SG-4, which was not added to the network until October 1997. The historical ground-water elevation and stage data are summarized on Table 4-2.

Prior to the construction of the monitoring wells, when ground-water and River stage measurements were limited to PW-4 and SG-1, there was a notable positive hydraulic head difference between PW-4 and SG-1, i.e. the static ground-water elevation at PW-4 was always higher than the stream elevation at SG-1. The head difference between the two points was about 1.4 feet throughout the monitored period beginning in March 1996. This head difference was generally independent of hydraulic conditions: ground-water elevation and stream stage increased together in wet periods, and declined together in dry periods. Those observations indicate that ground water was continuously discharging to the stream in the vicinity of NGWC's only Elk Prairie well at the time, PW-4.

Permitting Team
Exhibit 5f

Table 4-1
Elk Prairie Water-Level Monitoring Network

Name	Date of Installation	Reference Point Elevation (ft, msl)	Total Well Depth (ft)	Perforated Interval (ft)	Approx. Distance from North Fork (ft)	Distance from PW-4 (ft)	Start of Water-Level Monitoring
PW-4	08/04/89	45.95	141	56-134	180	---	03/21/96
PW-5	11/13/96	44.93	87	57-82	190	392	12/19/96
MW-1	10/23/96	44.01	50	25-45	50	179	10/28/96
MW-2	10/23/96	43.28	44	24-44	390	213	10/28/96
MW-3	10/20/96	42.35	48	23-43	125	205	10/28/96
MW-4	10/23/96	44.82	75	54-74	330	578	10/28/96
MW-5	10/21/96	43.87	53	28-48	90	425	10/28/96
SG-1	3/96	31.51	NA	NA	NA	181	03/21/96
SG-2	10/96	32.48	NA	NA	NA	257	10/28/96
SG-3	10/96	33.27	NA	NA	NA	441	10/28/96
SG-4	10/97	48.13	NA	NA	NA	3,388	10/07/97

Table 4-2
Elk Prairie Ground-Water Elevation and Stage Measurements (ft msl)

Date	PW-4 (Elev. 45.95)	PW-5 (Elev. 44.93)	MW-1 (Elev. 44.01)	MW-2 (Elev. 43.28)	MW-3 (Elev. 42.35)	MW-4 (Elev. 44.82)	MW-5 (Elev. 43.87)	SG-1 (Elev. 31.51)	SG-2 (Elev. 32.48)	SG-3 (Elev. 33.27)
03/21/96	32.85							30.50		
03/29/96	32.58							31.18		
04/04/96	32.74							31.39		
04/11/96	32.47							31.05		
04/17/96	32.51							31.09		
04/18/96	32.87							31.59		
04/25/96	32.87							31.59		
05/02/96	32.47							31.13		
05/09/96	32.33							30.90		
05/20/96	32.66							31.31		
05/24/96	32.97							31.52		
05/30/96	32.53							31.20		
06/06/96	32.32							31.03		
06/13/96	32.23							30.93		
06/20/96	32.13							30.84		
06/27/96	32.10							30.80		
07/05/96	32.03							30.72		
07/11/96	32.00							30.68		
07/17/96	31.97							30.66		
07/26/96	31.91							30.60		
08/01/96	31.93							30.56		
08/08/96	31.91							30.54		
08/15/96	31.85							30.50		
08/22/96	31.83							30.49		
08/29/96	31.85							30.48		
09/12/96	31.80							30.46		
09/19/96	31.82							30.46		
09/29/96	31.81							30.46		
10/04/96	31.85							30.46		
10/10/96	31.81							30.43		
10/18/96	31.78							30.52		
10/23/96	31.84							30.44		
10/28/96			31.08	31.84	31.50	33.25	33.09	30.45	30.74	32.18
10/29/96								30.53	30.91	

Table 4-2 (continued)

Date	PW-4 (Elev. 45.95)	PW-5 (Elev. 44.93)	MW-1 (Elev. 44.01)	MW-2 (Elev. 43.28)	MW-3 (Elev. 42.35)	MW-4 (Elev. 44.82)	MW-5 (Elev. 43.87)	SG-1 (Elev. 31.51)	SG-2 (Elev. 32.48)	SG-3 (Elev. 33.27)
10/31/96	31.89		31.01	31.70	31.50	33.53	32.05	30.53	30.79	32.20
11/04/96			30.80	31.64	31.57	33.32	32.07	30.48	30.76	32.19
11/12/96			30.80	31.71	31.53	33.52	32.03	30.47	30.84	32.18
11/14/96			30.87	31.82	31.55	33.51	32.12	30.47	30.84	32.23
11/20/96			31.73	32.29	32.51	34.55	33.01	31.59	31.74	32.85
11/27/96			31.21	32.66	31.89	31.84	32.40	30.89	31.05	32.44
12/06/96			32.64	34.09	33.16	35.16	33.70	32.18	32.75	33.51
12/19/96	32.72	33.26	31.61	31.36	32.44	34.40	32.94	31.09	31.78	32.78
01/07/97	33.60	34.23	32.31	34.38	33.26	35.50	33.80	32.03	32.71	33.50
01/24/97	34.15	34.70	32.84	34.44	33.78	35.99	34.17	34.33	33.04	33.79
02/06/97	32.98	33.55	31.83	33.21	32.60	34.77	33.07	31.10	32.12	32.87
02/19/97	32.59	33.01	31.44	32.73	32.25	34.34	32.72	30.67	31.66	32.51
03/06/97	32.48	33.02	31.29	32.88	32.13	34.19	32.62	30.52	31.56	32.39
03/21/97	32.83	33.36	31.60	32.82	32.44	34.56	32.96	31.05	31.82	32.72
04/03/97	32.34	32.90	31.17	32.33	31.98	34.10	32.51	30.48	31.39	32.21
04/18/97	32.15	32.70	30.96	32.08	31.66	33.90	32.27	30.35	31.26	32.10
05/02/97	32.12	32.71	31.00	31.73	31.77	33.65	32.25	30.31	31.23	32.07
05/16/97	32.01	32.38	30.77	31.83	31.51	33.75	32.14	30.20	31.12	31.95
05/29/97	31.96	32.39	30.83	31.78	31.52	33.70	32.12	30.17	31.09	31.92
06/12/97	31.94	32.29	30.78	31.73	31.57	33.51	32.05	30.12	31.03	31.88
06/23/97	31.87	32.19	30.71	31.68	31.51	33.40	32.02	30.05	30.97	31.82
07/03/97	31.83	32.14	30.66	31.65	31.47	33.36	31.99	30.03	30.94	31.80
07/18/97	31.71	32.12	30.55	31.39	31.37	33.33	31.92	29.97	30.89	31.76
07/31/97	31.70	32.28	30.38	31.16	31.20	33.51	31.87	29.94	30.88	31.82
08/15/97	31.70	32.18	30.61	31.79	31.36	33.45	31.89	29.90	30.85	31.71
08/29/97	31.74	32.10	30.55	31.78	31.38	33.28	31.88	29.93	30.87	31.73
09/15/97	31.87	32.40	30.70	31.86	31.48	33.63	31.95	29.98		
10/02/97								29.96	30.89	31.76
10/07/97	31.76	32.32	30.59	31.66	31.39	33.52	31.86	29.90		
10/09/97	32.69	33.24	31.62	32.18	32.35	34.32	32.80	30.97	31.72	32.58
10/24/97	31.80	32.16	30.69	31.89	31.45	33.56	31.98	29.98	30.88	31.74
11/08/97	31.82	32.36	30.66	31.99	31.45	33.64	32.00	30.00	30.92	31.76
11/21/97	32.50	33.00	31.42	32.74	32.10	34.26	32.62	30.80	31.59	32.44
12/03/97	32.86	33.40	31.70	33.09	32.50	34.67	33.04	31.10	31.76	32.81

After installation of the five monitoring wells and the second production well (PW-5) in late 1996, the regular measurement of water levels in all those wells and at three stream gauges further delineated the same picture: there was a perennial gradient for ground-water discharge from beneath Elk Prairie to the North Fork Gualala River; those conditions prevailed throughout wet and dry periods, and through regular pumping of PW-4 for water supply, since focused monitoring began in March 1996. The relative elevations of ground water at PW-4 and the River stage at SG-1 are illustrated in Figure 4-2.

The hydrographs of ground-water elevation and River stage shown on Figure 4-2 have almost identical shapes, which indicates significant hydraulic connection between the aquifer and the River. In 1996, water-level measurements began after the highest water levels in the winter, and levels gradually declined to a seasonal low by August. As noted above, the head difference between PW-4 and the River was approximately 1.4 feet during most of 1996. When stage and ground-water elevations reached their annual peak in January 1997, the head difference was 1.6 feet. During the remainder of the year, stage and ground-water elevations were both lower than in 1996, and the head difference between PW-4 and SG-1 increased to about 1.8 feet.

Upstream of SG-1, the gradient between the aquifer and River is not as steep. Ground-water elevations at PW-5 and stage at SG-3 are plotted on Figure 4-3. These hydrographs also have similar shapes, but the head difference between the well and the River was only about 0.5 feet during most of the year. The hydrographs of MW-3 and SG-2 show a similar pattern, and the head difference is also approximately 0.5 feet at this location (see Appendix C). Long-term hydrographs of the other four monitoring wells are also contained in Appendix C. Although the gradient for ground-water discharge to the River is flatter upstream of SG-1, the general condition of ground-water discharge to the stream prevails throughout the Elk Prairie area during both wet and dry periods.

Contours of equal ground-water elevations beneath Elk Prairie indicate that the hydraulic gradient is generally from the northeast to southwest and show ground water discharging to the River along the entire reach adjacent to Elk Prairie under both high and low flow conditions.

because the Franciscan Formation bedrock is highly fractured, and more interconnected in its fractures, in the proximity of the San Andreas Fault Zone.

Finally, although there are similarities in surface-water quality and ground-water quality, hydraulic gradients under all static and pumping conditions clearly show that ground water discharges to the North Fork Gualala River from beneath Elk Prairie. The source of surface water is, in part, ground-water discharge and not the other way around.

Further consideration of the above findings of this investigation suggests that, particularly during the dry season when there is no surface runoff, the maintenance of a live stream above Elk Prairie, and continuing downstream, results from discharge of ground water either directly from the fractured Franciscan bedrock material or from alluvial materials adjacent to the stream that are, in turn, receiving inflow from subjacent fractured bedrock.

In conclusion, there is a perennial ground-water gradient for flow in a perpendicular direction toward the North Fork Gualala River and no "channelized" ground-water flow parallel to the River at Elk Prairie. These conditions and the response of the aquifer to precipitation, to pumping, and to dry-season lack of rainfall recharge all show that ground water is not recharged by influent stream seepage and is not flowing in a defined channel. Ground water beneath Elk Prairie is maintained by some combination of deep percolation of precipitation and subsurface flow from the basement complex. Similarities in surface-water quality and ground-water quality are not the result of recharge from the North Fork Gualala River since ground water is discharging to the River, and not being recharged by it, under both static and pumping conditions. Consequently, ground water beneath Elk Prairie does not occur in a subterranean stream. For at least one of the same reasons, ground water beneath Elk Prairie is also not underflow of the North Fork Gualala River. Although neither the Slade report nor the SWRCB staff considered ground water to be underflow of the River, the perennial ground-water flow direction perpendicular to the River is contrary to the requirement that underflow be moving in the same direction as the surface stream.

**Permitting Team
Exhibit 5g**

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

DECISION 1639

In the Matter of Application 29664 of
Garrapata Water Company:
Extraction of Water by Garrapata Water Company
From the Alluvium of the Valley of Garrapata Creek
in Monterey County, California

GARRAPATA WATER COMPANY,
Applicant,

DEPARTMENT OF FISH AND GAME,
Protestant,

STATE WATER RESOURCES CONTROL BOARD PERMITTING TEAM,
Interested Party

SOURCE: Garrapata Creek Subterranean Stream

COUNTY: Monterey

DECISION DETERMINING THAT WATER IN THE ALLUVIUM OF THE VALLEY OF GARRAPATA CREEK IS A SUBTERRANEAN STREAM AND THAT APPLICATION 29664 IS NOT EXEMPT FROM THE CALIFORNIA ENVIRONMENTAL QUALITY ACT

BY THE BOARD:

1.0 BACKGROUND

On October 13, 1998, the Monterey County Superior Court entered a judgment granting a peremptory writ of mandate in Garrapata Water Company, Inc. v. State Water Resources Control Board, case number M 39441 (judgment). The judgment required the State Water Resources

**Permitting Team
Exhibit 6**

Control Board (SWRCB) to hold a hearing regarding the SWRCB's authority to issue a permit for the appropriation of water from the alluvium of the valley of Garrapata Creek by the Garrapata Water Company (Company). The judgment allows the inclusion of other issues in the hearing. On February 1 and 2, 1999, the SWRCB held a hearing to comply with the judgment.

2.0 HEARING ISSUES

On October 28, 1998, the SWRCB issued a Notice of Hearing. The Notice of Hearing contained the following issues:

> "1. At the point of diversion by the Company, is the water in the alluvium of the valley of Garrapata Creek part of a subterranean stream flowing through a known and definite channel?
>
> "2. Is the Company's project exempt from the California Environmental Quality Act (CEQA)?
>
> A. Is this an ongoing project?
>
> i. What prior approvals have been issued for the project?
>
> ii. To what extent did the approvals review and exercise oversight and control over the project as a whole?
>
> B. Does the project qualify for a categorical exemption? If so, which one(s) and why?
>
> i. Is this project exempt as an existing facility?
>
> a. How much water was the Company extracting from the alluvium of the valley of Garrapata Creek prior to the enactment of CEQA?
>
> b. How much water is the Company extracting from the alluvium of the valley of Garrapata Creek at the present time?
>
> c. How much water does the Company intend to extract from the alluvium of the valley of Garrapata Creek in the future?
>
> ii. Does this project have the potential to adversely affect threatened or endangered species?"

3.0 LEGAL CLASSIFICATION OF GROUNDWATER EXTRACTED BY THE COMPANY

3.1 Applicable Law

The California Water Code defines the water that is subject to appropriation and is thus subject to the SWRCB's permitting authority. Water Code section 1200 states:

> "Whenever the terms stream, lake or other body of water occurs in relation to applications to appropriate water or permits or licenses issued pursuant to such applications, such term refers only to surface water, and to subterranean streams flowing through known and definite channels." (Emphasis added.)

Groundwater which is not part of a subterranean stream is classified as "percolating groundwater." The distinction between subterranean streams and percolating groundwater was set forth by the California Supreme Court in 1899 in *Los Angeles* v. *Pomeroy* (1899) 124 Cal. 597 [57 P. 585]. In *Los Angeles* v. *Pomeroy*, the court stated that it is undisputed that subterranean streams are governed by the same rules that apply to surface streams. (*Id.* at 632 [57 P. at 598].) Percolating groundwater is not subject to the Water Code sections that apply to surface streams. Thus, the SWRCB has permitting authority over subterranean streams but does not have permitting authority over percolating groundwater.

Absent evidence to the contrary, groundwater is presumed to be percolating groundwater, not a subterranean stream. (*Id.* at 628 [57 P. at 596].) The burden of proof is on the person asserting that groundwater is a subterranean stream flowing through a known and definite channel. (*Ibid.*) Proof of the existence of a subterranean stream is shown by evidence that the water flows through a known and defined channel. (*Id.* at 633-634 [57 P. at 598].) In *Los Angeles* v. *Pomeroy*, the court stated:

> " 'Defined' means a contracted and bounded channel, though the course of the stream may be undefined by human knowledge; and the word 'known' refers to knowledge of the course of the stream by reasonable inference." (*Id.* at 633 [57 P. at 598].)

A channel or watercourse, whether surface or underground, must have a bed and banks which confines the flow of water. (*Id.* at 626 [57 P. at 595].) Although in *Los Angeles* v. *Pomeroy* the court stated that the bed and banks of a subterranean stream must be impermeable[1] (*Id.* at 631 [57 P. at 597]), all geologic materials are permeable to some degree. Therefore, if the rock forming the bed and banks is relatively impermeable compared to the aquifer material filling the channel, a subterranean stream exists.

In summary, for groundwater to be classified as a subterranean stream flowing through a known and definite channel, the following physical conditions must exist:

1. A subsurface channel must be present;
2. The channel must have relatively impermeable bed and banks;
3. The course of the channel must be known or capable of being determined by reasonable inference; and
4. Groundwater must be flowing in the channel.

3.2 Physical Setting

The Garrapata Creek watershed is located in Monterey County about 10 miles south of the city of Carmel. The watershed is approximately 10 square miles in area and includes two main tributaries to Garrapata Creek, Joshua Creek and Wildcat Canyon. Garrapata Creek is a perennial stream. The average annual outflow of surface water to the Pacific Ocean from the Garrapata Creek watershed was estimated by Division of Water Rights staff to be 4,668 acre-feet. (Permitting Team Exhibit S, p. 8.) The Company's expert witness, Dr. Nick Johnson, estimated the average annual discharge to be 5,000 acre-feet. (Company Exhibit 17, p. 3.)

The Company has a water supply well located near the mouth of the creek, about 1500 feet upstream from the Pacific Ocean. (Company Exhibit 17, p. 1.) The well site is the only point of diversion for the Company's water supply system. Another well is connected to the Company's conveyance system, but has not been used since 1990 or 1991 and has no power supply. The Company's attorney and agent, Mr. Donald Layne, testified that the well is not being used but it has not been capped. (TI, 24:14-25:17.)

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[1] The term used in *Los Angeles* v. *Pomeroy* is "impervious," a synonym for "impermeable." The latter term is used more commonly in scientific literature and the SWRCB will follow this convention.

From the Company's point of diversion eastward, the watershed is underlain entirely by crystalline bedrock of granitic composition. Having a granitic composition means that the mineral crystals composing the rock are principally quartz, feldspar, amphibole and mica. The Permitting Team's expert witness, Mr. Thomas Peltier, observed and described the granitic bedrock in Garrapata Creek canyon. According to Mr. Peltier, on the north side of the canyon, the granitic bedrock is hard and dense with moderate weathering. On the south side of the canyon, where exposed, the bedrock is more weathered, with many of the feldspar minerals altering to clay. The bedrock slopes are mantled with a relatively thin layer of loose rock and debris (called "colluvium") and soil. (Permitting Team Exhibit B1, p. 2.) Mr. Peltier estimated the thickness of the zone of weathered bedrock, colluvium and soil to be about 20 feet or more on the south side of the canyon, and a little less than 20 feet on the north side of the canyon. (TII, 285:25-286:7.)

West of the point of diversion, the bedrock changes to a sedimentary rock that Mr. Peltier described as marine sandstone. (Permitting Team Exhibit B1, p. 2; and J.) Because this unit is not relevant to the classification of groundwater at the Company's point of diversion, the marine sandstone will not be discussed further.

The canyons carved into the granitic bedrock by Garrapata Creek and its tributaries are steep and deeply incised. This feature is evident in several photographs submitted by the Department of Fish and Game (DFG) and the Permitting Team. (DFG Exhibit 2a, photographs 1 and 2; DFG 7, 4th photograph; Permitting Team Exhibits E and F.) In the canyon bottom is an unconsolidated deposit of cobbles, gravel, sand and clay eroded from the bedrock and lain down by Garrapata Creek. The technical term for this type of unconsolidated deposit is "alluvium." At the point of diversion, the alluvium is at least 40 to 50 feet thick (Permitting Team Exhibit B1, p. 3; Company Exhibit 17, p. 3.) The Company's well produces groundwater from the alluvium, and is reported to operate at a rate of 50 gallons per minute. (Company Exhibit 17, p. 3.)
Recharge is the technical term for the processes through which the alluvium becomes saturated with water. Recharge also refers to the amount of water added to the saturated zone in the alluvium. The alluvium in the Garrapata Creek watershed is recharged through several processes

including: (1) percolation of water through the soil and colluvium covering the bedrock slopes, (2) percolation through the shallow zone of weathered bedrock beneath the colluvium, (3) percolation through fractures in the bedrock beneath the shallow weathered zone, and (4) infiltration of surface water from Garrapata Creek.

3.3 Discussion

3.3.1 Relationship of the terms "Subterranean Stream Flowing Through a Known and Definite Channel" and "Underflow"

The Permitting Team and the Company disagreed on the definition of a subterranean stream. Mr. Peltier testified that two criteria are used to determine if groundwater is flowing in a subterranean stream: (1) is there flow, and (2) is the flow bounded by bed and banks. (Permitting Team Exhibit B1, p. 1.) This definition is consistent with the applicable law discussed in section 3.1.

Dr. Johnson used the following definitions in his analysis of groundwater classification.

> "Groundwater is all subsurface percolating water not flowing in a known and definite channel. A stream's underflow is a subterranean stream flowing through a known and definite channel having identifiable beds and banks."
> (Company Exhibit 17, p. 1.)

Dr. Johnson's definition confuses the technical term of "groundwater," which is water below the surface of the ground, with the legal concept of percolating groundwater, which is groundwater not flowing in a subterranean stream. Further, he equates the concept of underflow of a surface stream with a subterranean stream. Finally, Dr. Johnson demonstrated his misunderstanding of the characteristics of a subterranean stream when he testified that a subterranean stream consists of a surface stream and the water beneath it. (TI, 70:14-22.)

A subterranean stream need not be interconnected with a surface stream. A subterranean stream, like a surface stream, is merely the flow of water in a defined channel whether or not the subterranean stream is interconnected with a surface stream. The additional characteristic of a subterranean stream is that the subsurface channel through which it flows must have relatively impermeable bed and banks compared to the material filling the channel. Thus, Dr. Johnson's evidence concerning the interconnection of the groundwater in the alluvium with the surface flow of Garrapata Creek is immaterial to the legal classification of the groundwater.

Although not the subject of this hearing, Dr. Johnson introduced the term "underflow" in his written and oral testimony. The definition of underflow is included here to clarify the difference between the legal concepts of underflow and subterranean streams. Underflow was defined in *Los Angeles* v. *Pomeroy* as having the following physical characteristics:

1. Underflow must be in connection with a surface stream;
2. Underflow must be flowing in the same general direction as the surface stream; and
3. Underflow must be flowing in a watercourse and within a space reasonably well defined. (124 Cal. at 624 [57 P. at 594].)

The relationship between subterranean streams and underflow is that both must flow in a watercourse. A watercourse must consist of bed, banks or sides, and water flowing in a defined channel. (*Id.* at 626 [57 P. at 595].) Thus, underflow is a subset of a subterranean stream flowing in known and definite channels. While a subterranean stream includes underflow, it is not necessary that groundwater be underflow to establish the existence of a subterranean stream flowing through a known and definite channel.

3.3.2 Existence of a Subterranean Stream Flowing Through a Known and Definite Channel

Other than any confusion that may have been created by the parties' use of different definitions, their evidentiary presentations leave no room for argument as to whether three of the four elements of the test for a subterranean stream flowing through a known and definite channel have been established. A subsurface channel is present; the course of the channel is known or capable of being determined by reasonable inference; and groundwater is flowing in the channel. Based on the evidence presented, the SWRCB concludes that the fourth element, that the bed and banks be formed by relatively impermeable materials, has been established.

Mr. Peltier testified that the two sloping sides of the canyon meet at some depth beneath the alluvium, forming a channel. The location and limits of this channel can be inferred by projecting the slope of the walls of the canyon to their intersection beneath the alluvium. (Permitting Team Exhibit B1, p. 3.) The two canyon walls project into the subsurface, forming the banks of the channel. The intersection of the two sides form the bed of the channel. The Company did not dispute the Permitting Team's conclusion that a subsurface channel exists in the Garrapata Creek watershed.

Both the Permitting Team and the Company testified that groundwater flows through the alluvium. According to Mr. Peltier:

> "Groundwater within the alluvium flows under the force of gravity, within the channel formed by the sloping walls of the canyon, toward the ocean, in the same fashion as the surface flow in Garrapata Creek, though moving with much less velocity than the surface stream." (Permitting Team Exhibit B1, p. 3.)

Dr. Johnson also testified that groundwater flows within the alluvium. (TI, 43:12-13.) Accordingly, the SWRCB finds that a subsurface channel exists, that the channel has definite bed and banks, and that there is groundwater flowing within the alluvium deposited in the channel.

Thus, whether the groundwater in the alluvium of Garrapata Creek should be classified as a subterranean stream flowing through a known and definite channel at the Company's point of diversion hinges on whether the granitic bedrock is sufficiently impermeable to bound the flow of groundwater. Put another way, is the granitic bedrock sufficiently impermeable at the point of diversion to prevent the transmission of all but relatively minor quantities of water through the channel boundary. All naturally occurring earth materials have some intrinsic permeability. Thus, the test of a subterranean stream is not that the bed and banks be absolutely impermeable, but rather, relatively impermeable compared to the alluvium filling the channel. This is a subjective test, as no SWRCB decisions or appellate court decisions have quantified the difference in permeability between bedrock and alluvium needed to establish a subterranean stream. Additionally, the condition of impermeable bed and banks must be shown to exist only in a reach that includes the point of diversion, not necessarily throughout the entire length of the alluvial aquifer.

Mr. Peltier testified that the granitic bedrock is relatively impermeable to groundwater flow. He testified that the alluvium was recharged principally through the shallow percolation of rainfall through the zone of weathered bedrock, colluvium and soil, and through infiltration from surface flow in Garrapata Creek. (Permitting Team Exhibit B1, p. 3.) Mr. Peltier argued that the granitic bedrock is relatively impermeable and forms the bed and banks of a subterranean stream along its contact with the alluvium. (Permitting Team Exhibit B1, p. 4.) Based on published literature regarding typical aquifer characteristics of alluvium and granitic rock, on his observations made during a field investigation on August 12, 1997, and on information in water well driller's reports for wells in the Garrapata Creek watershed, he concluded that the granitic bedrock is relatively impermeable compared to the alluvium both at the point of diversion and throughout the watershed.

Mr. Peltier provided the following information about typical aquifer characteristics of granitic rocks. All granitic rocks consist of interlocking mineral crystals. Most crystalline rocks have no voids or pores between the mineral crystals. Thus, the only porosity these rocks contain is imparted through joints and fractures. Granitic rocks generally have poor permeability because the joints and fractures tend to be shallow, narrow, sometimes clay-filled, of limited extent, and not interconnected over large areas.

Mr. Peltier's testimony is supported by the Department of Water Resources Water Facts Number 1 entitled "Ground Water in Fractured Hard Rock." (Permitting Team Exhibit M.) According to this publication:

> "About 60 percent of California is composed of hard rocks. However, only a small quantity of ground water is stored in the fractures of these rocks. The majority of ground water is stored in what the average person would call "dirt" or "soil," more accurately described as alluvium, which has pore spaces between the grains. (Permitting Team Exhibit M, p. 1.) The volume of water stored in fractured hard rocks near the surface is estimated to total less than 2 percent of the rock volume. This percentage decreases with depth as fractures become narrower and farther apart." (Permitting Team Exhibit M, p. 3.)

Alluvium has a much higher permeability than granitic rocks because the porosity of alluvium is higher and the pore spaces are interconnected over large areas. This statement is supported by the U.S. Geological Survey's report entitled "Basic Ground-Water Hydrology." (Permitting Team Exhibit C.) This report lists the typical specific yields of granite versus unconsolidated sand and gravel. The specific yield of a material is the amount of water that will drain out of a unit volume under the influence of gravity. The typical specific yields of sand, gravel and granite are listed as 22 percent, 19 percent, and .09 percent respectively.

Based on his field investigation, Mr. Peltier testified that the general characteristics of granitic rocks and alluvium described above were true for the granitic bedrock and alluvium at the point of diversion and throughout the Garrapata Creek watershed. Mr. Peltier described the bedrock as hard and dense, a description that is consistent with the samples he collected and offered into evidence. (Permitting Team Exhibits G and H.) Mr. Peltier reported that the bedrock exhibited a network of intersecting joints spaced about 6 to 12 inches apart. Mr. Peltier also observed a small fault in the bedrock. A geologic fault is a fracture or fracture zone along which there has been displacement of the sides of the fracture relative to one another.

Mr. Peltier concluded that these joints and fractures were unlikely to impart significant permeability to the bedrock because they were narrow and filled or partially filled with clay. Clay fillings in joints and fractures can result either from the weathering and breakdown of feldspar minerals into clay minerals, or by the pulverization of rock along the moving surfaces of a fault. As discussed above, Mr. Peltier stated that these openings are likely to become smaller and farther apart with increasing depth. (Permitting Team Exhibit B1, p. 4.)

Mr. Peltier testified that the low yields and low specific capacities of wells in the granitic bedrock also support a conclusion that the bedrock is relatively impermeable compared to the alluvium. The specific capacity of a well is equal to the yield of the well (gallons per minute) divided by the drawdown of the water level in the well during pumping (feet). The units of specific capacity are gallons per minute per foot of drawdown. In general, the more permeable the aquifer material, the higher the specific capacity of the wells in the aquifer.

Based on information in State Water Well Drillers Reports, Mr. Peltier testified that the specific capacities of wells in the granitic bedrock were extremely low, ranging from 0.015 gallons per minute per foot of drawdown to a high of 0.28 gallons per minute per foot of drawdown. (Permitting Team Exhibit B1, p. 5.) Pumping and drawdown data were not available for the Company's well. However, based on his knowledge of typical values of specific capacity for alluvial wells, Mr. Peltier's opinion was that the specific capacity of the Company's well was likely to be several orders of magnitude higher than the specific capacities calculated for the granitic bedrock wells.

Based on these observations, Mr. Peltier formulated a conceptual model of the groundwater/surface water flow system that accounts for the dry season surface flow in Garrapata Creek. Because there is little rainfall in the Garrapata Creek watershed during the dry season, the flows of the creek are attributable to baseflow. The term "baseflow" refers to the portion of the flow in a surface stream that comes from the seepage (or discharge) of groundwater into the stream.

In Mr. Peltier's conceptualization, the dry season flow is sustained by the slow percolation of winter rainfall through the shallow zone of soil, colluvium and weathered bedrock into the alluvium, and eventually into Garrapata Creek. According to this model, infiltrated rainfall will percolate vertically through the permeable soil, colluvium and weathered bedrock until encountering the impermeable bedrock at depths of 10 to 20 feet. The infiltrated water then moves laterally along this low permeability boundary until entering the alluvium, or where the alluvium is absent, the creek, at the base of the slopes.

The Company presented testimony by Dr. Johnson in which he argued that the subterranean channel was not impermeable because the baseflow component of Garrapata Creek was so high that significant amounts of groundwater have to leak from the bedrock to recharge the alluvium and sustain the surface flow. (TI, 135:20-136:11.)

Dr. Johnson presented an alternate conceptual model of the groundwater/surface water flow system in the Garrapata Creek watershed, under which a different process is responsible for most of the recharge to the alluvium in the stream channel and subsequent baseflow to Garrapata Creek. Dr. Johnson testified that the principal process of recharge to the alluvium was deep percolation of rainfall into the weathered and fractured granitic bedrock. He testified that groundwater is transmitted through the weathered and fractured bedrock into the alluvium and then into Garrapata Creek. (Company Exhibit 17, Figure 8.) His conceptual flow model was based on the water balance and surface outflow of the watershed as a whole and did not address specific hydrologic conditions at the point of diversion. According to this conceptual model, infiltrating rainwater percolates vertically through the soil, colluvium and weathered zone into fractures in the bedrock until encountering the groundwater table. During the rainy season, the water table rises, reaching its highest elevation in April near the end of the winter rains. Groundwater flows laterally through interconnected fractures in the granitic bedrock and into the alluvium in the direction of the hydraulic gradient. The gradient goes from the bedrock into the alluvium because the water levels in the bedrock are higher than in the alluvium. From the alluvium, groundwater seeps into the channel of Garrapata Creek because the groundwater level in the alluvium is higher than the elevation of surface water in Garrapata Creek.

Dr. Johnson's conclusions were based on his estimates of the baseflow portion of the average annual surface flow of Garrapata Creek. Dr. Johnson testified that the weathering and fracturing in the granitic bedrock associated with the joints and faulting result in a secondary porosity capable of producing significant well yields. Dr. Johnson supported his conclusions by comparing water quality data for groundwater from the Company's well to data for Garrapata Creek. (Company Exhibit 17, pp. 4 and 5.)

To estimate the baseflow portion of Garrapata Creek surface flow, Dr. Johnson first estimated the average annual surface outflow of Garrapata Creek to the Pacific Ocean. Dr. Johnson used two different methods to calculate outflow (also called discharge). Both methods resulted in an estimate of about 5,000 acre-feet per annum (afa) for the average annual discharge of Garrapata Creek to the ocean. In the first method, Dr. Johnson used a soil water balance for the watershed to arrive at the 5,000 afa discharge estimate. This method takes into account average annual precipitation in the watershed, air temperature, heat index, evapotranspiration, and soil moisture storage to determine the amount of surplus water available for surface runoff and groundwater recharge.

In the second method, Dr. Johnson compared instantaneous streamflow measurements of Garrapata Creek, reported by various observers, with average daily streamflows of the Big Sur River. The Big Sur River was used because it has the nearest recording gage to the Garrapata Creek watershed. Dr. Johnson developed a relationship that expressed Garrapata Creek flow as a percent of Big Sur River flow. Then, Dr. Johnson estimated the average monthly flows of Garrapata Creek as a percent of the average monthly flows of the Big Sur River. Summing the average monthly flows for Garrapata Creek gave an annual average streamflow of about 5,200 afa,[2] nearly the same as the estimate using the water balance approach.

To calculate the baseflow portion of Garrapata Creek streamflow, Dr. Johnson created an average annual hydrograph from the average monthly streamflow estimates. (Company Exhibit 17, Figure 7.) He assumed that from May through October, when there is little or no precipitation, 100 percent of the Garrapata Creek streamflow is baseflow. However, for the rainy season of November through April, the baseflow portion of the streamflow had to be separated from the runoff portion. Dr. Johnson reasoned that the rate of baseflow would reach its peak when the groundwater gradient in the watershed reached its peak at the end of the rainy season. (Company Exhibit 17, p. 3.) Thus he selected April as the month of peak baseflow.

Dr. Johnson estimated the magnitude of the peak baseflow to be 6 cubic feet per second (cfs) because an instantaneous streamflow of this magnitude was measured in Garrapata Creek on June 28, 1992. Since there had been no rain in almost two months, Dr. Johnson reasoned that the June 28 streamflow was 100 percent baseflow. (Company Exhibit 17, p. 3.) The baseflow separation curve is shown in the Company's Exhibit 17, Figure 7. The area beneath the lower curve in

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[2] Dr. Johnson's actual calculation was 5,010 afa. The estimate of 5,200 afa reported above corrects errors in Dr. Johnson's estimates of average flow for the months of November, May, June, July, August, and September.

Figure 7 represents the average annual baseflow in Garrapata Creek and is equal to 1,900 afa. Dr. Johnson concluded that:

> "It is not possible to transmit the measured and estimated rates of Garrapata Creek baseflow into the stream except through the bedrock aquifer." (Company Exhibit 17, p. 4.)

Dr. Johnson's testimony indicates that the amount of water transmitted into the alluvium from the deep fracture system in the granitic bedrock actually is less than the 1,900 afa estimate of baseflow. During cross examination, he testified that some of the 1,900 acre-feet of baseflow could have been transmitted to the alluvium through the shallow zone of soil, colluvium, and weathered bedrock. Dr. Johnson testified that he did not attempt to quantify the amounts of water transmitted from the different zones into the alluvium because all the water, once it reached Garrapata Creek, would be within the definition of baseflow. (TI, 113:20-114:10.) This testimony contradicts the illustration of his conceptual model of groundwater flow shown in Figure 8 of his written testimony. (Company Exhibit 17.) This illustration depicts the alluvium being recharged only with water coming from the deep fracture system in the granitic bedrock.

On rebuttal, the Permitting Team showed that the shallow zone of soil, colluvium and weathered bedrock is capable of transmitting 1,900 afa of recharge to the alluvium. To show this, Mr. Peltier used a Darcy flow analysis presented in Exhibit U. Darcy's Law describes the rate of flow of water through porous media. The rate of flow (Q) is equal to the hydraulic conductivity of the medium (K) multiplied by the hydraulic gradient (I) and the cross-sectional area through which the water flows (A). The relationship is expressed as: $Q = K\ I\ A$

Mr. Peltier testified that the Darcy flow analysis showed that the shallow zone of weathered bedrock, colluvium and soil was easily capable of transmitting 1,900 afa of recharge to the alluvial aquifer and, ultimately, baseflow to Garrapata Creek. (TII, 280:6-21.) Mr. Peltier assumed that the hydraulic conductivity (K) of the shallow zone was equal to one foot per day. The hydraulic gradient (I) was assumed to be 0.25 foot per foot. The cross-sectional area of flow was assumed to be 1,056,000 square feet. These values are reasonable estimates as set forth below. Plugging these values into the equation and converting the units to acre feet per year resulted in an annual flow through the shallow zone of 2,212 acre feet. (Permitting Team Exhibit U.)

Mr. Peltier testified that he used conservative estimates in this calculation. (TII, 281:18-283:4.) A hydraulic conductivity of one foot per day is appropriate for a highly fractured or weathered crystalline rock but is very conservative for colluvium and soil. Thus, the value of one foot per day is a reasonable, yet conservative, assumption for the hydraulic conductivity in the Darcy flow analysis. This assumption is consistent with Dr. Johnson's testimony that the hydraulic conductivity of the alluvium could range from 1 to 200 feet per day. The soil and colluvium would have a higher hydraulic conductivity because this material is less consolidated than the alluvium. Dr. Johnson testified that the hydraulic conductivity of the weathered bedrock and fractured bedrock could range from .01 to 5 feet per day. (TI, 126:2-7.) Mr. Peltier's estimate is within the range of values estimated by Dr. Johnson.

The hydraulic gradient of 0.25 represents a four to one slope (lateral run to rise) and is conservative based on the steepness of the canyon walls in Garrapata Creek which, at the point of diversion, is even steeper having a two to one slope. (TII, 282:10-19.) The cross-sectional area of flow is based on the Garrapata Creek watershed having 10 miles of surface channels and the shallow zone of weathered bedrock, colluvium and soil being 10 feet thick. The value of length and thickness is conservative based on topographic maps of the area (Permitting Team Exhibit S, Figure 2) and with Mr. Peltier's observations of the watershed. Thus, Mr. Peltier's conclusion that the shallow zone is capable of transmitting 1,900 afa of recharge to the alluvium is reasonable.

Mr. Peltier's conceptualization of the source of the baseflow in Garrapata Creek is supported by the evidence in the record. Dr. Johnson's calculations of the baseflow of the creek do not provide a convincing argument that groundwater must be transmitted from the deep fracture system in the granitic bedrock into the alluvium.

The Company did not present any testimony bearing directly on the permeability of the granitic bedrock in the Garrapata Creek watershed. However, Dr. Johnson testified that:

> "[A]quifers within fractured granitic rock are common throughout the world. The weathering of feldspar minerals into clay, contrary to the Division staff memorandum, does not compromise their viability." (Company Exhibit 17, p. 4.)

Dr. Johnson did not provide evidence to support his statement that aquifers within granitic rock are common throughout the world. Although such aquifers no doubt exist, the evidence provided by the Permitting Team indicates that such aquifers are the exception. (Permitting Team Exhibit M.) Dr. Johnson's statement that the weathering of feldspar minerals to clay does not compromise the permeability of those aquifers is true, provided the fractures and joints do not become clay filled as a result of the weathering process. As previously stated, however, the Permitting Team testified that some of the fractures and joints in the bedrock were observed to be clay-filled.

Based on anecdotal evidence, Dr. Johnson testified that wells in the granitic bedrock were capable of producing significant yields. (Company Exhibit 17, p. 4.) For example, Dr. Johnson reported that Mr. Layne knew of a bedrock well on the watershed ridge that provided water for 12 homes. Dr. Johnson testified that he did not know the pumping rate of this well. (TI, 75:4-25.) On rebuttal, Mr. Peltier testified that a well with a yield as low as 4 gallons per minute was capable of meeting a demand of 500 gallons per day per home for 12 homes. Mr. Peltier concluded that 4 gallons per minute of sustained flow does not necessarily indicate high productivity from the bedrock aquifer. (TII, 313:14-314:14.)

Another problem with the Company's case is that, even if the bedrock aquifer contributes an average of 1,900 afa of recharge to the alluvium in the watershed, the Company could not show where in the watershed this recharge is occurring. Even if substantial quantities of water are transmitted into the alluvium from the granitic bedrock in some parts of the watershed, that would not necessarily support the conclusion that the bedrock is sufficiently permeable to transmit significant quantities of water in the stream reach where the Company has its point of diversion. The Company offered no evidence that the bedrock is exceptionally permeable at the point of diversion to rebut the Permitting Team's observational evidence that, at the point of diversion, the joints and fractures were narrow and clay-filled and unlikely to impart any significant permeability to the bedrock. On this subject, Dr. Johnson testified that the granitic bedrock would have areas of greater and lesser fracturing, but he did not investigate where these areas might be in the watershed. (TI, 128:11-18.) Dr. Johnson testified that conditions in the watershed vary quite a bit with some areas much more fractured and weathered than other areas. (TI, 61:25-62:2.)

The only evidence Dr. Johnson presented pertaining to conditions at the well site was water quality data for water from the Company's well. Dr. Johnson's written testimony states that:

> "The electrical conductivity of groundwater averages about 3.5 times greater than the streamflow. The pH and turbidity also are distinctly different. These differences are significant given that groundwater has been extracted continuously at this site for several decades, and indicate that the groundwater pumped from the Water Company well is derived from a source other than Garrapata Creek. (Company Exhibit 17, p. 4.) The water quality differences between the Water Company well and Garrapata Creek are consistent with the interpretation that groundwater flows from the bedrock aquifer across the watershed toward the creek. The groundwater is more mineralized because of its residence time in the bedrock aquifer." (Company Exhibit 17, p. 5.)

The electrical conductivity of water is proportional to the salinity of the water. Thus, electrical conductivity often is used as a field test to determine the relative salinity of groundwater and surface water samples. The electrical conductivity of groundwater increases as residence time in the aquifer increases because more minerals dissolve over time raising the level of salinity of the water. Electrical conductivity of groundwater also increases due to contamination from buried sources like septic tanks or leaching of fertilizer and other chemicals from irrigation.

The difference in electrical conductivity between the well water and the creek water shows that the groundwater is, as expected, more saline than the surface water. The difference, however, is not indicative of the geologic unit from which the well water originated. Mr. Peltier's testimony that the higher electrical conductivity of the groundwater could be due to residence time in the alluvium (TII, 315:1-7) is as valid as Dr. Johnson's explanation that the higher value is due to residence time in the granitic bedrock. The higher electrical conductivity of the groundwater also could be due to contamination from a septic system. Dr. Johnson testified that there is a residence near the Company's well that probably has a septic tank. (TI, 79:21-23.) Mr. Layne testified that there are some septic systems upstream of the Company's well, but he thought they were in a "separate alluvium." (TI, 120:4-12.) Mr. Layne's meaning of "separate alluvium" is not clear from his testimony. Even if the Company could show that the salinity of the groundwater was due to residence time in the granitic bedrock, this information does not establish that groundwater is infiltrating from the bedrock into the alluvium at the Company's point of diversion.

The reliability of the water quality data presented by the Company is questionable. When asked to explain unusual trends in the temperature and pH data, Dr. Johnson testified that the trends were most likely due to errors in instrument calibration and typographical errors. Dr. Johnson testified that the unusually high pH values suggested an error in calibrating the pH meter. (TI, 124:8-20.) The temperature data included an unusual value that Dr. Johnson testified was perhaps a typographical error or a reporting error. (TI, 123:8-25.) These errors cast doubt on the reliability of the water quality data as a whole and do not inspire confidence that the electrical conductivity data are free of calibration errors or typographical errors. Mr. Layne testified that he calibrated the meters, took all of the temperature and pH measurements, and took 12 of the 14 electrical conductivity measurements. Mr. Layne testified that he had no special training regarding calibrating and using the meters, but operated them according to written instructions. (TI, 117:10-23.)

In summary, the record as a whole clearly demonstrates that the groundwater diverted from the Company's well is from a subterranean stream flowing through a known and defined channel. The granitic bedrock is relatively impermeable compared to the alluvium and forms the bed and banks of the subterranean stream. The Permitting Team's case is persuasive, and the Company's is not, because the Permitting Team addressed the aquifer characteristics of the bedrock and alluvium both at the point of diversion and throughout the watershed as a whole. The Permitting Team's evidence established that, in general, granitic rocks are very low in permeability because the crystalline texture of the rock has no primary porosity. The fractures and joints in granitic rocks generally do not impart significant secondary porosity or permeability because fractures are usually narrow, shallow and of limited extent. The Permitting Team provided direct observational evidence that the granitic bedrock in the Garrapata Creek watershed is typical of granitic rocks, having a crystalline texture and narrow joints and fractures, some clay-filled. Additionally, the low specific capacities calculated for several wells in the granitic bedrock support a conclusion that the bedrock is relatively impermeable compared to the alluvium.

The Company relied on a watershed wide estimate of the volume of baseflow in Garrapata Creek to argue that the bedrock has sufficient permeability to preclude the existence of a subterranean stream. Dr. Johnson testified that the alluvium is not extensive enough to store and transmit this volume of baseflow into the surface stream, and that transmitting this volume through the colluvium is highly improbable. The Company's testimony was effectively rebutted, however, by evidence presented by the Permitting Team showing that the shallow zone of weathered bedrock, soil, and colluvium is capable of transmitting the Company's estimated volume of baseflow into the alluvium. Further, as noted above, the Company did not inspect the bedrock and describe its characteristics at the point of diversion. The Company claimed that water quality data for the well water and surface water supported the conclusion that the bedrock was permeable. The water quality data were not persuasive because the data could be explained by valid hypotheses other than the Company's, and the reliability of the data was compromised by errors in the data set.

The evidence in the record clearly establishes the presence of a subsurface channel with impermeable bed and banks relative to the alluvium filling the channel, the location of the course of the subsurface channel, and that groundwater is flowing in the channel. Therefore, the SWRCB finds and concludes that at the point of diversion, and throughout the watershed where the deposits of alluvium are bounded by the granitic bedrock, the groundwater flowing in the alluvium of the valley of Garrapata Creek constitutes a subterranean stream flowing through a known and definite channel.

4.0 APPLICABILITY OF CEQA

In general, CEQA applies to discretionary projects which are proposed to be carried out or approved by public agencies. (Pub. Resources Code, § 21080(a).)

CEQA defines a "project" to mean:

> "[A]n activity which may cause either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment, and which is any of the following:
>
> ". . . .
>
> "(c) An activity that involves the issuance to a person of a . . . permit . . . by one or more public agencies." (Pub. Resources Code, § 21065.)

The Company admits that its application is a project as that term is used in section 21065 of the Public Resources Code. (TII, 329:24-330:10.)

The CEQA Guidelines (Cal. Code Regs., tit. 14, § 15000 et seq.) define a "discretionary project" to be a project "which requires the exercise of judgment or deliberation when the public agency or body decides to approve or disapprove a particular activity." (*Id.*, § 15357.) As will be discussed in Section 4.1 below, the Company believes its project is ministerial, not discretionary. Ministerial projects are exempt from CEQA. (Pub. Resources Code, § 21080, subd. (b)(1).)

"Approval" is defined in section 15352 of the CEQA Guidelines as "the decision by a public agency which commits the agency to a definite course of action in regard to a project intended to be carried out by any person." (Cal. Code Regs., tit. 14, § 15352, subd. (a).) For private projects such as the Company's Application 29664, "approval occurs upon the earliest commitment to issue or the issuance by the public agency of a discretionary . . . permit." (Cal. Code Regs., tit. 14, § 15352, subd. (b).)

The hearing which forms the basis for this decision was not held for the purpose of approving Application 29664. The SWRCB has not adopted a decision which commits it to a definite course of action with regard to Application 29664 and the SWRCB has made no commitment to issue a permit for the Company's project. Any findings concerning the potential for significant effects as a result of the project must be made based on the record before the SWRCB at the time the SWRCB approves the project. Therefore, any finding which finally determines CEQA applicability to Application 29664 is premature at this time. As explained below, although the

SWRCB tentatively concludes that CEQA applies to the approval of the Company's pending application, information regarding the Company's project and/or its impacts may become available in the future as part of an ongoing CEQA review which may change this conclusion. Further, as explained in section 4.3.1 below, the Company's project could be modified to qualify for a categorical exemption from CEQA.

The Company claims both statutory and categorical exemptions from CEQA. It claims to be statutorily exempt as a "ministerial project" pursuant to section 21080(b)(1) of the Public Resources Code and section 15268 of the CEQA Guidelines, and as an "ongoing project," pursuant to section 15261 of the CEQA Guidelines and section 21169 of the Public Resources Code. The Company also claims to be categorically exempt as an "existing facility" pursuant to section 15301 of the CEQA Guidelines.

4.1 Ministerial Project Exemption

The Company contends that its project is exempt from CEQA as a "ministerial project" pursuant to Public Resources Code section 21080(b)(1) and section 15268 of the CEQA Guidelines. The Company also contends that the SWRCB's regulations exempt the issuance of water right permits and licenses from CEQA. (TII, 337:17-341:12.)

Public Resources Code section 21080 provides that CEQA applies to discretionary projects. Subdivision (b)(1) of section 21080 exempts ministerial projects from CEQA. According to the CEQA Guidelines, a ministerial project is one in which the agency's decision to approve it involves:

> "[L]ittle or no personal judgment by the public official as to the wisdom or manner of carrying out the project. The public official merely applies the law to the facts as presented but uses no special discretion or judgment in reaching a decision." (Cal. Code Regs., tit. 14, § 15369.)

The ministerial exemption applies only where the agency has no discretion over whether and under what circumstances to approve an application. The exemption does not apply to the SWRCB's decision on Application 29664, because the SWRCB has broad discretion to approve, condition, or deny an application to appropriate unappropriated water. (See Wat. Code, § 1200, et seq.)

Water Code sections 1255-1259 require the SWRCB to determine that the proposed appropriation is in the public interest and to consider such things as the relative benefit to be derived from all beneficial uses of water as well as the amounts of water needed to remain in the source for protection of beneficial uses. The SWRCB may subject appropriations to the terms and conditions "as in its judgment will best develop, conserve, and utilitze in the public interest the water sought to be appropriated." (Wat. Code, § 1257, emphasis added.)

The California Supreme Court held that the SWRCB exercises broad discretion in determining whether the approval of an application will best serve the public interest and that a decision of the SWRCB to approve an application is a quasi-judicial decision, not a ministerial act. (*Temescal Water Co.* v. *Dept. of Public Works* (1955) 44 Cal.2d 90, 100 [280 P.2d 1, 7].) The SWRCB must also consider the public trust when deciding whether to approve water right applications. (*National Audubon Society* v. *Superior Court* (1983) 33 Cal.3d 419 [189 Cal.Rptr. 346].) Because the SWRCB must exercise its discretion in deciding whether to approve applications to appropriate unappropriated water and whether to subject the appropriation to specific terms and conditions to protect the public interest and the public trust, the decision to approve, condition, or deny an application is not a ministerial act.

The Company contends that the SWRCB's regulations exempt the issuance of water right permits and licenses from CEQA because their issuance is a ministerial act. The regulations of the SWRCB provide, in pertinent part:

> "Ministerial projects are exempt from the requirements of CEQA and do not require the preparation of environmental documents. Generally, in the absence of special circumstances, the following activities have been determined to be ministerial projects:
>
> ". . . .

> "(c) Issuance of permits to appropriate water pursuant to a decision or order of the state board." (Cal. Code Regs., tit. 23, § 3730, subd. (c), (emphasis added).)

The plain language of the SWRCB's regulation applies to the actual issuance of permits to appropriate water and not to the adoption of decisions or orders of the SWRCB that approve the issuance of the permits. Issuance of the permit is ministerial because the descretionary decision to approve the permit and to determine what conditions should be included in the permit has already been made. (See also SWRCB Resolution 97-006, § 3.2.15 [in effect at the time of the hearing on this matter] and Resolution 99-031, § 3.2.17 [currently in effect] delegating authority to the Chief of Division of Water Rights to "[i]ssue permits . . . after Board decision or order." (emphasis added).) Given the SWRCB's broad discretion to approve, condition, or deny water right applications, the Company's contention that approval of its application is ministerial has no basis in law.

4.2 Ongoing Project Exemption

The Company contends that because it obtained approvals from the Public Utilities Commission (Certificate of Public Convenience and Necessity, Company Exhibit 3), Department of Highways of the State of California (Utilities Encroachment Permit, Company Exhibit 4), and the State Board of Public Health (Water Supply Permit, Company Exhibit 5) prior to 1973, it is exempt from CEQA as an ongoing project. (TII, 331:9-21.)

The statutory exemption for ongoing projects carried out by private parties but subject to governmental approvals is established by section 21169 of the Public Resources Code and applied and interpreted by subdivision (b) of section 15261 of the CEQA Guidelines. If the ongoing project exemption applies, no environmental documentation is required to meet the requirements of CEQA, although the SWRCB would still have authority under the Water Code and the public trust doctrine to require submission of information on environmental impacts relevant to its decision and to consider those environmental impacts in deciding whether and under what conditions to approve a permit. (See Wat. Code, § 1255-1276; Cal. Code Regs., tit. 14, § 15261, subd. (b)(1).)

The statutory exemption for ongoing projects should be distinguished from the categorical exemption for existing facilities. A project may be exempt from CEQA pursuant to the exemption for existing facilities, discussed in section 4.3, below, based on the determination that because the facility is already in place, approval of the facility will not cause an adverse impact on the environment. (See *Azusa Land and Reclamation Co.* v. *Main San Gabriel Basin Watermaster* (1997) 52 Cal.App.4th 1165, 1191-22 [61 Cal.Rptr.2d 447, 462] (hereafter *Azusa*).) The Legislature enacted the statutory exemption for ongoing projects, on the other hand, to allow completion of private projects approved after CEQA was enacted but before CEQA was interpreted to apply to private projects. (*Id.* at 1216-18 [61 Cal.Rptr.2d at 478-79].) The ongoing projects exemption was enacted as part of legislation that also placed a moratorium on the applicability of CEQA to governmental approvals of private projects. Together these sections exempt governmental approvals of private projects from CEQA if those approvals were issued before April 5, 1973. (See Pub. Resources Code, §§ 21169, 21171. But see *id.* § 21170.)

The courts are divided as to whether the ongoing project exemption has any applicability where a project was first approved before CEQA took effect, or before or during the moratorium on the applicability of CEQA to private projects, but another governmental approval is required later. In *Azusa* the court held that the ongoing project exemption does not apply to these later approvals. (52 Cal.App.4th 1165, 1216-18 [61 Cal.Rptr.2d 447, 478-79].) The court refused to follow section 15261 of the CEQA Guidelines, concluding that section 15261 is inconsistent with the statute, and is therefore invalid, because it exempts governmental approvals issued after the dates specified under CEQA. (*Id.* at 1218-19 [61 Cal.Rptr.2d at 479-80].) In *Nacimiento Regional Water Management Advisory Committee* v. *Monterey County Water Resources Agency* (1993) 15 Cal.App.4th 201 [19 Cal.Rptr.2d 1] (hereafter *Nacimiento*), on the other hand, the Court of Appeal applied section 15261 of the CEQA Guidelines to a 1991 agency decision. The court held that because the construction and operation of a reservoir initially approved and built before CEQA was an ongoing project, a later decision that adjusted project operations but did not enlarge project facilities was exempt from CEQA. (*Id.* at 202-205 [19 Cal.Rptr.2d at 2-4].)

We need not decide here which approach is correct.[3] The decision to issue a water right permit for the Company's well does not qualify as an ongoing project under either the *Azusa* interpretation or under the approach followed by *Nacimiento* and the CEQA Guidelines. Obviously, because any SWRCB approval would be issued after the April 5, 1973, expiration of the moratorium on the applicability of CEQA to private projects, the SWRCB's action would not come within the ongoing project exemption as interpreted by *Azusa.* Nor would issuing a water right permit constitute an ongoing project as the exemption is interpreted in *Nacimiento,* because the SWRCB action would be beyond the scope of the exemption as set forth in section 15261 of the CEQA guidelines.

Section 15261 of the CEQA Guidelines states in relevant part:

> "(b) A private project shall be exempt from CEQA if the project received approval of a lease, license, certificate, permit, or other entitlement for use from a public agency prior to April 5, 1973, subject to the following provisions:
>
> ". . . .
>
> "(3) Where a private project has been granted a discretionary governmental approval for part of the project before April 5, 1973, and another or additional discretionary governmental approvals after April 5, 1973, the project shall be subject to CEQA only if the approval or approvals after April 5, 1973, involve a greater degree of responsibility or control over the project as a whole than did the approval or approvals prior to that date."

Approval of a water right application by the SWRCB involves a greater degree of responsibility or control than earlier approvals by the Public Utilities Commission, the State Department of Highways, and the State Board of Public Health. These prior approvals did not entail an overall evaluation of the project and its impacts. Rather, these other agency approvals focused on specific aspects of the project. A review of the approvals issued by the other agencies also reveals

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[3] *Azusa,* which was decided later, does not distinguish or otherwise discuss *Nacimiento.* Although *Azusa,* like this proceeding, involved a private project, while *Nacimiento* involved a project carried out by a public agency, that does not provide a logical basis for distinguishing the two cases. Both cases involved the issue whether a discretionary approval that would otherwise be subject to CEQA should nevertheless be exempt based on its relationship to earlier approvals of the same project that were not subject to CEQA, either because those earlier

that these were routine approvals, not involving extensive review or control over the project. The Public Utilities Commission approval, issued without a hearing based on the information provided in the Company's application, involved a determination whether the Company's service area was already served by another public utility, whether the Company had adequate finances to provide water service, whether the rates to be charged for water service were reasonable, and whether the Company's water supply and distribution facilities met minimum requirements. (Company Exhibit 3, p. 3.) The Department of Highways and Board of Public Health approvals are form approvals, subject to a few conditions requiring compliance with requirements for avoiding interference with state highways, and compliance with state health requirements for drinking water, respectively. (Company Exhibits 4 and 5.) None of these prior approvals involve consideration of the effects of diversions from Garrapata Creek on the environment or on other users of the creek.

In contrast, when the SWRCB reviews a water right application, the SWRCB considers the availability of unappropriated water to supply the applicant, the effects of the diversion on prior rights and public trust resources, as well as impacts on the river and the aquifer, and whether the appropriation is in the public interest. If there is unappropriated water available to supply the applicant, the SWRCB then determines under what terms and conditions the applicant may divert and use the water. These conditions will almost certainly be more extensive than those established in the prior agency approvals.

The SWRCB's review process provides opportunities for third party intervention. In contrast to the other approvals, which were uncontested, three parties filed protests to the Company's water right application. The SWRCB's process provides opportunity for the presentation of evidence and resolution of the protests before final action is taken on the application.

Because the SWRCB's review of a water right application involves a greater degree of oversight and control than was involved in the prior approvals, the SWRCB approval is not within the scope of section 15261 of the CEQA Guidelines, and the ongoing project exemption does not

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approvals were issued before CEQA was enacted or because the sections enacted in response to *Friends of Mammoth* made CEQA inapplicable to those earlier approvals.

apply. (See *People* v. *County of Kern* (1974) 39 Cal.App.3d 830, 835 n. 5, 839-40 [115 Cal.Rptr. 65, 70-71 n.5, 73-74] [holding that the ongoing project exemption did not apply to an approval issued after April 5, 1973, that the governmental agency issuing the approval had determined to involve a greater degree of responsibility and control than previous approvals].)

Even if the ongoing project exemption were otherwise available, it does not apply to projects being operated unlawfully, without obtaining all necessary approvals. Public Resources Code section 21169 states in relevant part:

> "Any project defined in subdivision (c) of Section 21065 undertaken, carried out, or approved on or before the effective date of this section [December 5, 1972] and the issuance by any public agency of any lease, permit, license, certificate or other entitlement for use executed or issued on or before the effective date of this section notwithstanding a failure to comply with this division, if otherwise legal and valid, is hereby confirmed, validated and declared legally effective." (Emphasis added.)

The Company needs a permit to appropriate the water it is now diverting from the Garrapata Creek subterranean stream to be "otherwise legal and valid" in accordance with section 21169. (Wat. Code § 1052.) Therefore, the Company's project cannot be validated pursuant to section 21169 and is not exempt from CEQA.[4]

Finally, the ongoing project exemption applies only to the original project, not to subsequent expansions. (See SWRCB Order WQ 88-5 at 5-7 [observing that, in addition to the requirement that the later approval must not involve a greater degree of responsibiity and control, the later approval must not involve an expansion beyond what was estimated in the original approval].) As

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[4] The purpose of section 21169 was to ameliorate the hardship that could have been created by the Supreme Court's decision in *Friends of Mammoth* v. *Board of Supervisors* (1972) 8 Cal.3d 247 [104 Cal.Rptr.761] (hereafter *Friends of Mammoth*), which held that CEQA applies to private as well as public projects and applied its ruling retroactively. (*Azusa, supra,* 52 Cal.App.4th 1165, 1616-17 [61 Cal.Rptr.2d 447, 478].) Development projects being constructed in reliance on governmental approvals previously thought to be exempt from CEQA could be disrupted if those approvals were invalidated for failure to comply with CEQA. The effect of section 21169 was to protect these approvals from challenge by limiting the retroactive applicability of *Friends of Mammoth*. (*Id.*; *Cooper* v. *County of Los Angeles* (1977) 69 Cal.App.3d 529, 533 [138 Cal.Rptr. 229, 231].) Where the project is completed without obtaining all necessary approvals, however, the case for exempting the project from CEQA based on the project proponent's actions is less than compelling.

part of its application for approval by the Public Utilities Commission, the Company estimated that "there will ultimately be about 30 residential customers and one commercial user." (Company Exhibit 2, p. 2.) As discussed in section 4.3.1, the Company now serves 38 residential customers and one commercial user, and the Company's application proposes to more than double the amount of water diverted. Even assuming the ongoing project exception was otherwise applicable to the issuance of a water right permit to the Company, it is questionable whether the exemption would apply unless the Company modified its application or the SWRCB conditioned its approval to avoid this expansion.

4.3 Existing Facility Exemption

The Company contends that its project is exempt from CEQA as an "existing facility" pursuant to section 15301 of the CEQA Guidelines.

4.3.1 Applicability of the Existing Facilities Exemption

Section 15301 describes existing facilities which are exempt as:

> "[T]he operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographic features, involving negligible or no expansion of use beyond that existing at the time of the lead agency's determination." (Cal. Code. Regs., tit. 14., § 15301, emphasis added.)

The baseline for determining whether the existing facilities exemption applies is the time the SWRCB determines CEQA applicability to Application 29664, not the effective date of CEQA. (*Bloom* v. *McGurk* (1994) 26 Cal.App.4th 1370 [31 Cal.Rptr.2d 914, 918]; Cal. Code Regs., tit. 14, § 15301.)

The Company currently serves 38 homes and the Rocky Point Restaurant. (Company Exhibit 18, p. 3.) There are six lots which have not yet been developed, one of which may not be developed. (*Id.*; TI, 30:22-31:20.)

Several years ago, the Company installed a meter at its well site. (Company Exhibit 18, p. 8; TI, 20:19-21:24.) The meter has been in operation continuously since its installation. (TI, 21:25-22:2.) The meter is not read on any regular basis and there are only three meter readings in the record. (Company Exhibit 18, p. 8; TI, 22:3-15.) Individual connections do not have meters. (TI, 25:24-26:1.) No limit on water use for each connection exists, each user may use as much as the user wants. (TI, 26:25-27:4.)

The Company has provided three estimates of its current water use. Mr. Layne estimated the Company's current water use to be 0.1 cfs which is equal to 64,632 gallons per day (gpd) or 72 afa. (Company Exhibit 18, p. 7.) Mr. Layne provided no basis or support for this estimate of water use. Mr. Layne did not define "water use." Whether his estimate is the amount of groundwater pumped or the amount of water put to beneficial use or whether there is a significant difference between the two amounts is not clear. Mr. Layne also estimated the

Company's current water use to be 23,310 gpd or 25.55 afa based on meter readings.[5] (Company Exhibit 18, p. 8.) Dr. Johnson estimated the current water use of the Company to be approximately 35 afa. (TI, 45:12-14.) Although Dr. Johnson testified that 35 afa is a high estimate (TI, 68:2-13), it is a reasonable estimate of current annual water use by the Company.

In Application 29664, the Company has applied to divert 72,000 gpd year round from Garrapata Creek Subterranean Stream with a limitation of 81 afa. According to the Company, this amount represents actual use "plus a little extra in case some of our weekend houses turn into permanent residences, plus a little extra in case of leaks, and a little extra for 6 more homes and lastly, a goodly allowance as an error factor." (Company Exhibit 18, p. 8.) In fact the amount applied for is considerably more than any of the estimates of current use. Accordingly, the Company's project is not exempt as an existing facility because, by its own admission, the Company's water use and service connections will increase in the future as full build-out occurs, and because the amount applied for by the Company in Application 29664 far exceeds existing use. This expansion of use negates the use of the categorical exemption for existing facilities. (Cal. Code Regs., tit. 14, § 15301, *Bloom* v. *McGurk, supra.*)

As noted above, any findings concerning the applicabilty of CEQA must be based upon the facts in the record at the time the SWRCB makes its decision. Thus, the SWRCB's determination as to the applicability of the existing facility exemption could change from the tentative conclusions of this order, based on new information on actual water use or a willingness of the Company to reduce the amount it applied for in its application to the amount of existing use. The Company may find it beneficial to commence reading its meter on a regular basis to have a more complete record of its diversions from Garrapata Creek. If the Company reduces the amount applied for in Application 29664 to the amount of its current annual diversion, the existing facilities exemption

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[5] According to the Company, the meter showed 40,673,500 on July 12, 1997; 43,073,300 on September 13, 1997; and 53,773,000 on December 17, 1998. Company Exhibit 18, p. 8; Permitting Team Exhibit A, September 15, 1997, letter to Robert Been from Donald M. Layne. Accordingly, between July 12, 1997 and December 17, 1998 (524 days), 13,099,500 gallons were used. This computes to 25,000 gpd or 28 afa, not 23,310 gpd or 25.55 afa as calculated by Mr Layne.

probably would apply. (Cf. *Committee for a Progressive Gilroy* v. *SWRCB* (192 Cal.App.3d 847, 864 [237 Cal.Rptr. 723, 733-34] [order permitting sewage treatment plant, without authorizing any expansion of capacity, was exempt from CEQA under the categorical exemption for existing facilities].)

Ordinarily, the SWRCB would be reluctant to apply the existing facilities exemption in a case where facilities have been constructed and diversion of water has been initiated without first obtaining a water right permit. Applying the existing facilities exemption to existing, unauthorized diversions would encourage applicants to initiate diversions without first obtaining water right permits, undermining the policies of both CEQA and the Water Code. (See generally *People* v. *Shirokow* (1980) 26 Cal.3d 301, 308-10 [162 Cal.Rptr. 30, 35-56] [the Legislature intended to vest the SWRCB with "expansive powers to safeguard the scarce water resources of the state," but the SWRCB's ability to carry out its statutory mandates is impaired to the extent that there are unsanctioned uses]; *Friends of Mammoth, supra,* 8 Cal.3d 247, 259 [104 Cal.Rptr. 761, 768] ["the Legislature intended [CEQA] to be interpreted in such a manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language"].) We do not believe that applying the existing facilities exemption would undermine those policies under the circumstances presented in this case, where project construction was completed before CEQA and the applicant apparently did not know that a water right permit was required. Nor has there been any change or expansion in place of use or purpose of use since CEQA was enacted. Applying the categorical exemption under these limited circumstances would not provide any incentive for appropriators to initiate new diversions or increase existing diversions in the hopes of circumventing environmental review or undermining the SWRCB's ability to require modifications to the project to avoid adverse affects on water resources.

4.3.2 Exceptions to the Categorical Exemption

The CEQA Guidelines contain exceptions to the categorical exemptions to CEQA. (Cal. Code Regs., tit. 14, § 15300.2.) The DFG and the Permitting Team contend that even if the Company's project would otherwise be categorically exempt as an existing facility, the exemption cannot be used because the exception provided in subdivision (c) of section 15300.2 of the CEQA

Guidelines applies to this case. The exception to the exemption applies where "there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances." (Cal. Code Regs., tit. 14, § 15300.2, subd. (c).)

The DFG and the Permitting Team contend that the possible significant effect on the environment due to unusual circumstances is the possible impact to steelhead trout from the diversion of water from Garrapata Creek by the Company. Steelhead trout are listed as threatened pursuant to the federal Endangered Species Act and are a State Species of Special Concern. (DFG Exhibit 6, p. 2.) The evidence in the record indicates that steelhead trout reside in Garrapata Creek. (DFG Exhibit 6, p. 2; DFG Exhibit 7, p. 1; DFG Exhibit 8; DFG Exhibit 9, p. 4; TI, 164:17-21; TII, 343:1-8.)

Relatively minor changes in the environment that would be considered insignificant elsewhere, may constitute significant impacts where they would adversely affect an endangered species. Thus, the increase in diversion that would be authorized if the SWRCB approved the Company's application as proposed might well preclude reliance on a categorical exemption that might otherwise apply. As noted in section 4.3.1, however, the categorical exemption cannot be relied upon for approval of the Company's diversion unless the proposed diversion is reduced to avoid any expansion of water use. If any increase or expansion of diversion or use is precluded, the possibility of a significant effect will be avoided.

According to CEQA, a "significant effect on the environment" is defined as "a substantial, or potentially substantial, adverse change in the environment." (Pub. Resources Code, § 21068 (emphasis added). See also Cal. Code Regs., tit. 14, § 15382.) "Environment" is defined in CEQA and the Guidelines as "the physical conditions which exist within the area which will be affected by a proposed project including . . . fauna . . . ." (Pub. Resources Code, § 21060.5; Cal. Code Regs., tit. 14, § 15360.) According to *Bloom, supra,* the baseline for analyzing change in the environment is the time of the SWRCB's determination. Therefore, if amount of diversion and use is restricted so the categorical exemption for existing facilities applies, and there is no evidence in the record that operations will be altered in a manner that could adversely affect the environment, by definition there cannot be a significant effect on the environment because there is no change in the environment.

The mere existence of "unusual circumstance" does not necessarily preclude the applicability of a categorical exemption. Rather, there must be a reasonable possibility of a significant effect as a result of the unusual circumstance. Thus, the presence of a threatened species does not preclude use of a categorical exemption if there will be no effect on the species or its habitat, or any potential effect would be beneficial. If the diversions were limited so that the categorical exemption for existing facilities were applicable, there would be no evidence of any change in the environment caused by unusual circumstances because both the threatened species and the Company's diversion are part of the existing environment. Therefore, the exception to the exemption would not apply, and the SWRCB's action on the Company's application would be categorically exempt from CEQA.

The applicability of a categorical exemption does not mean that the needs of rare, threatened or endangered species will be ignored. To carry out its duty of continuing supervision to apply the public trust doctrine, the SWRCB will give careful scrutiny to possible impacts to threatened species in reviewing the Company's application. Even where the Company is not proposing any change in operations or the amount of water diverted or used, the SWRCB retains authority in reviewing the Company's application under the Water Code and the public trust doctrine, to establish terms and conditions to avoid or migitate any harm that the Company's diversions are causing or threaten to cause to the steelhead trout in Garrapata Creek, even though that harm is part of the existing conditions.

5.0 CONCLUSION

The SWRCB finds and concludes the following:

1. The water in the alluvium of the valley of Garrapata Creek is part of a subterranean stream flowing through a known and definite channel.

2. The diversion of water from the Garrapata Creek Subterranean Stream is within the permitting authority of the SWRCB.

3. The project described in the Company's Application 29664 is not exempt from CEQA.

4. If the Company were to modify its project to limit the amount of water in its application to existing use, the project may be exempted from CEQA under the categorical exemption for existing facilities.

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ORDER

IT IS HEREBY ORDERED THAT the Chief of the Division of Water Rights expedite processing of Application 29664.

CERTIFICATION

The undersigned, Administrative Assistant to the Board, does hereby certify that the foregoing is a full, true, and correct copy of a decision duly and regularly adopted at a meeting of the State Water Resources Control Board held on June 17, 1999.

AYE: James M. Stubchaer
Mary Jane Forster
John W. Brown
Arthur G. Baggett, Jr.

NO: None

ABSENT: None

ABSTAIN: None

Maureen Marché

Maureen Marché
Administrative Assistant to the Board

SURNAME/FILES

al/EPA

Pete Wilson
Governor

State Water Resources Control Board

Division of Water Rights

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MAY 4 - 1998

Mr. Allan Lilly
Attorney at Law
Bartkiewicz, Kronick & Shanahan
1011 22nd Street, Suite 100
Sacramento, CA 95816-4907

Dear Mr. Lilly:

PETITION TO CHANGE PERMIT 14853 (APPLICATION 21833) OF NORTH GUALALA WATER COMPANY, NORTH FORK GUALALA RIVER IN MENDOCINO COUNTY

Your letter of January 29, 1998 requests that the State Water Resources Control Board (State Board) not take any further actions on North Gualala Water Company's petition to change the authorized point of diversion in Permit 14853. The request, which asserts that the State Board does not have water-right permitting authority over this groundwater, is based on the report entitled "Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie" prepared by Luhdorff and Scalmanini Consulting Engineers. The report concludes on page 39 that "ground water beneath Elk Prairie does not occur in a subterranean stream."

Division staff have reviewed the report and other information regarding basement material underlying the Elk Prairie area where North Gualala Water Company's Well No. 4 is located. From the available information, it appears that the bedrock is sufficiently impervious relative to the alluvial aquifer material to form the bed and banks of a subterranean stream, thereby rendering the water to be diverted within the jurisdiction of the State Board.

The Luhdorff-Scalminini report states that, "Both the alluvium and the underlying Franciscan Complex in the Elk Prairie area are water bearing...." This conclusion is contrary to the findings of an earlier report prepared by Richard C. Slade & Associates and other available information on the Franciscan Complex.

According to the Department of Water Resources (DWR) report, "Water Quality Investigation Report No. 10, the Franciscan Complex and other Cretaceous rocks in the area "...do not absorb, transmit, or yield water readily. In areas where the rocks are highly jointed or fractured, ground water sufficient for domestic [individual household] supply may be obtained." Another study by DWR Northern District, "Mendocino County Coastal Groundwater Study," cites the performance of wells in Franciscan bedrock in the Point Arena subunit, which includes a portion of Elk Prairie. This report states a mean specific capacity of only 0.265 gpm per foot of drawdown for wells constructed in

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Permitting Team
Exhibit 7

Franciscan bedrock, indicating the bedrock is not a significant water bearing unit relative to the alluvial aquifer beneath Elk Prairie.

The conclusion that the rocks of the Franciscan Complex are non-water bearing is further supported by the findings of the "Seismic Survey of Elk Prairie Gualala, California" prepared by Bailey Scientific (1996), which was included as an appendix to the Luhdorff-Scalmanini report. The results of the seismic survey indicate a clear and definite boundary between the alluvium and the underlying bedrock. Significantly higher seismic velocities indicate a much higher density for the bedrock unit. The Bailey Scientific report gives velocity values for the fresh bedrock ranging from 8,000 to 11,500 ft/sec, while velocities for the alluvium ranged from 1,000 to 6,000 ft/sec, with the higher velocities in the alluvium attributed to areas of groundwater.

According to the Luhdorff-Scalmanini report, high water storage in the bedrock is evidenced by perennial seeps and springs, shallow depths to saturated soils and weathered bedrock, and the propensity of shallow and deep-seated landsliding occurring on slopes underlain by the Franciscan Complex. However, these observations are not conclusive, and may more likely indicate the area in question is underlain by relatively impermeable bedrock.

We believe the evidence before us supports the conclusion that the water underlying the proposed point of diversion is flowing in a known and definite channel and is, therefore, within the State Board's jurisdiction. If North Gualala Water Company withdraws their petition to change the point of diversion under Permit 14853, the Division will recommend to the State Board that a hearing be scheduled to receive evidence to determine whether the water in question is within the State Board's permitting authority.

Please advise us within 30 days of North Gualala Water Company's intentions. If you have any questions, please telephone me at the above number or Luann Erickson, the staff person handling this matter, at (916) 657-1972.

Sincerely,

ORIGINAL SIGNED BY:

Edward C. Anton, Chief
Division of Water Rights

cc: continued next page

LUHDORFF & SCALMANINI

June 1, 1998
File No. 96-1-011

Mr. John H. Bower
North Gualala Water Company
38958 Cypress Way
Gualala, CA 95445

SUBJECT: RESPONSE TO COMMENTS ON ELK PRAIRIE GROUND-WATER INVESTIGATION

Dear Mr. Bower:

At the request of North Gualala Water Company (NGWC), Luhdorff and Scalmanini Consulting Engineers (LSCE) have reviewed two letters commenting on our report entitled *Investigation of Ground-Water Occurrence and Pumping Impacts at Elk Prairie* (LSCE, 1998). One of the letters was written by Edward Anton of the State Water Resources Control Board (SWRCB) Division of Water Rights on May 4, 1998; and the other was written by Joseph Hayes of Weber, Hayes & Associates at the request of California Trout on May 1, 1998. Our initial responses to their comments are as follows.

The letter from Mr. Anton focuses only on SWRCB staff's review of the geology and water-bearing properties of the Franciscan Complex and the overlying alluvium at Elk Prairie; it ignores hydrologic factors such as ground-water elevation and the direction of ground-water flow. Mr. Anton concludes that the Fransican Complex is non-water bearing and, therefore, that ground water beneath Elk Prairie is flowing in a known and definite channel and is subject to SWRCB jurisdiction.

With regard to the water bearing characteristics of the Coastal Franciscan Complex, the difference between the approaches of the SWRCB Division of Water Rights personnel and LSCE appears to be one of semantics and perspective. To the SWRCB staff, interpretation of the low-yielding characteristics of the formation as described in previous reports (e.g.: DWR, 1956, *Water Quality Investigation Report No. 10*) results in its classification as impervious and impermeable in relation to the highly permeable alluvium; that interpretation leads to the conclusion that the formation is non-water bearing. While we might agree with the statement in the anonymously authored, 40-year old DWR report that the Coastal Franciscan rocks.... "do not absorb, transmit, or yield water readily..." we nevertheless would term the formation as water-bearing and low-water yielding because low-yielding wells can be constructed and exist in the Coastal Franciscan. As discussed below and in our report, the Franciscan appears to perennially yield ground water to sustain stream flow and, in the case of Elk Prairie, to provide subsurface inflow to the adjacent alluvial aquifer materials.

As noted in Mr. Anton's letter, DWR (1982) reports a mean specific capacity or 0.265 gpm per foot of drawdown in Coastal Franciscan wells. With just 10 to 50 feet of drawdown, well yields of 3 to

**Permitting Team
Exhibit 8**

13 gpm would be possible, which is significant for domestic use. This conclusion is supported by a more current and more detailed evaluation of the water bearing characteristics of the Coastal Franciscan by Farrar (1986; Ground-Water Resources in Mendocino County, California; USGS WRI 85-4258). A more general discussion of water-bearing formations is contained in Driscoll (1986; p. 62): .... "In reality, almost all formations will yield some water, and therefore are classified as aquifers or aquitards. In water-poor areas, a formation producing such quantities of water may be called an aquifer, whereas the same formation in a water-rich area would be called an aquitard." From this perspective, if the alluvial deposits did not exist along the North Fork Gualala River, the Coastal Franciscan would be the significant aquifer in the area.

The higher seismic velocities for the Coastal Franciscan reported by Bailey Scientific are interpreted by SWRCB staff to mean higher density rocks which the staff concludes to be "non-watering bearing." The reported seismic velocities fall within the range of sandstone and shale (Driscoll, 1986; p.172), but this does not establish that these types of formations are necessarily "non-water bearing." These units could be water bearing in secondary porosity such as fractures or joints, although they are generally recognized to be lower water yielding than unconsolidated coarse-grained alluvium. The proximity of Elk Prairie to the San Andreas fault zone suggests that a relatively high density of fractures in the underlying Franciscan is likely.

SWRCB staff dismiss evidence of high water storage in the Coastal Franciscan by stating that "these observations are not conclusive, and may more likely indicate the area in question is underlain by relatively impermeable bedrock." There is no necessary nexus between ground-water storage and permeability. For example, even in higher yielding alluvial materials, clays have the highest storage capacity but lowest hydraulic conductivity. The relatively lower permeability of the Coastal Franciscan when compared to the alluvium is not disputed, but this difference does not address the water storage possibility within the Coastal Franciscan. High water storage in the unit is believed to be evidenced by the slow, natural release of subsurface water through the dry season which maintains, via ground-water gradients toward the stream, perennial stream flows. As with wells, the localized yield may be low, but the many square miles of the drainage basin from the upper few hundred feet of the Coastal Franciscan maintain stream flows during periods of no precipitation or runoff. Such conditions are contradictory to the SWRCB conclusion that the area is "more likely....underlain by relatively impermeable bedrock."

Ground-water discharge from the Coastal Franciscan to the alluvium could also occur in the subsurface as direct ground-water inflow. LSCE believes that evidence of such inflow is shown on ground-water elevation contour maps developed for Elk Prairie. However the SWRCB staff's simplistic picture of a channel as just defined by "relative impermeable" bed and banks ignores the reality of hydrogeologic flow systems. For example, we suspect that, if the topic of discussion was the siting of a hazardous waste disposal facility on the Coastal Franciscan, the State Board would not be using terms such as "impermeable," "impervious," and "non-water bearing"!

The letter from Mr. Hayes comments on several aspects of the analysis presented in our report and reaches three conclusions: 1) the ground-water gradient has the same direction and almost the same magnitude as the surface-water gradient, 2) the alluvial aquifer is a known and defined channel, and 3) ground-water pumping induces recharge from the River. The second conclusion has been addressed above. The other two conclusions and our general responses are briefly discussed below. If a more detailed response to each of the specific technical points in the letter is required, we can do so at a later date.

We developed ground-water elevation contour maps for January and October, 1997, which indicate that ground-water flow beneath Elk Prairie is generally perpendicular to the River. We also examined hydrographs of monthly ground-water levels to conclude that the plotted contour maps were illustrative of hydrologic conditions throughout the year. Mr. Hayes disputes the conclusion that ground-water flow is toward the River, and suggests instead that ground-water flow is parallel to the River based solely on ground-water elevations measured in two of the monitoring wells, MW-1 and MW-5. (Ironically, it takes a "limited presentation of monitoring well data", a term used by Mr. Hayes to challenge our conclusions, to develop his conclusions about ground-water flow directions and rate.) Because hydraulic head is higher in MW-5 than MW-1, Mr. Hayes concludes that ground water flows between these two wells, parallel to the stream. This interpretation is flawed because the true gradient for ground-water flow cannot be determined based only on the two points used by Mr. Hayes. Ground-water flow is perpendicular to contours of equal ground-water elevation, which require a minimum of three points to even approximate. Further, accurate ground-water contour maps can only be developed by using all available water-level data. Trying to determine the direction and magnitude of the hydraulic gradient based only on data from two wells, while ignoring data from all other wells, is erroneous. As shown on Figure 4-4 of our report, the general direction of ground-water flow at Elk Prairie is from the vicinity of MW-4 toward MW-3, not parallel to the River. The ground-water gradient is 5.0×10^{-3}, which is steeper than the stream gradient, and not 2.8×10^{-3} as erroneously computed by Mr. Hayes based on selective ground-water levels.

In his discussion of stream/aquifer interactions during pumping, Mr. Hayes disagrees with our conclusion that pumping does not induce flow from the River to the well. He states that the stream acts as a source of recharge during pumping but does not explain how this could occur. As discussed in our report, there can be no recharge from the stream to the aquifer as long as the gradient for ground-water flow is toward the stream. A reversal of gradient cannot occur unless, at a minimum, the pumping water level in the well is lower than the stage in the stream, but this did not occur at any time during the pumped well testing. This observation should not be taken to imply that there are no pumping impacts on streamflow. Our report clearly states that there is a small reduction in streamflow due to pumping because the well intercepts some ground water that would otherwise flow to the stream.

Mr. Hayes also suggests that changes in slope on the aquifer test drawdown plots may be due to recharge from the stream. When analyzing the aquifer test data, we evaluated the possibility that a recharge boundary might have caused the flatter slope observed after 20 minutes on the drawdown-response plots. We rejected this possibility for several reasons:

- As long as ground-water levels are higher than stream stage, there is no gradient for water to flow from the stream to the well, as discussed above.
- Distance-drawdown calculations indicate that the cone of depression produced by pumping reaches the River, which is 180 feet from Well 4, less than a minute after the pump is turned on. By the time the change in slope occurs (after 20 minutes of pumping), the areal extent of the cone of depression has reached a radius of over 1,000 feet from the well. However, the magnitude of drawdown within the cone of depression is insufficient to lower the ground-water surface enough to reverse the gradient and induce infiltration from the stream to the well.
- An S-shape drawdown curve is a classic indicator of unconfined conditions, and it is no coincidence that curve matches achieved using the Neuman method were so good. The generally unconfined behavior of the aquifer is not altered by possible semi-confinement in deeper portions of the alluvium which, as noted in our report, is one explanation for the higher head observed at Well 4.

After consideration of the SWRCB comments and those presented by Joseph Hayes for California Trout, we continue to conclude as we did in our original report on the investigation of ground water beneath Elk Prairie that the pumping of NGWC's Well 4 does not induce any infiltration of water from the North Fork Gualala River. Rather, pumping intercepts ground water that is flowing toward, and partially discharging into the River. There is no channelized ground-water flow parallel to the River at Elk Prairie. Finally, there are several alternative scenarios which NGWC might pursue to use the existing wells at Elk Prairie to meet existing and near-term future water demand without causing any induced infiltration from the River, i.e., without reversing the prevailing hydraulic gradient from the aquifer toward the River.

Please contact us if you have any questions regarding these responses to comments or would like us to respond in more detail.

Sincerely,

LUHDORFF AND SCALMANINI
CONSULTING ENGINEERS

Joseph C. Scalmanini

JCS/sr

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Groundwater
and
Wells

Second Edition

Fletcher G. Driscoll, Ph.D.
Principal Author and Editor

Published by Johnson Filtration Systems Inc., St.Paul, Minnesota 55112

Permitting Team
Exhibit 9

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Table 5.1 Porosities for Common Consolidated and Unconsolidated Materials

Unconsolidated Sediments	η (%)	Consolidated Rocks	η (%)
Clay	45–55	Sandstone	5–30
Silt	35–50	Limestone/dolomite (original & secondary porosity	1–20
Sand	25–40	Shale	0–10
Gravel	25–40	Fractured crystalline rock	0–10
Sand & gravel mixes	10–35	Vesicular basalt	10–50
Glacial till	10–25	Dense, solid rock	< 1

volume of water an aquifer can hold, it does not indicate how much water the aquifer will yield.

When water is drained from a saturated material under the force of gravity, the material releases only part of the total volume stored in its pores. The quantity of water that a unit volume of unconfined aquifer gives up by gravity is called its specific yield (Figure 5.5). Specific yields for certain rocks and sediment types are presented in Table 5.2. Some water is retained in the pores by molecular attraction and capillarity. The amount of water that a unit volume of aquifer retains after gravity drainage is called its specific retention. The smaller the average grain size, the greater is the percent of retention; the coarser the sediment, the greater will be the specific yield when compared to the porosity. The surface area for different-size sand grains is shown in Table 5.3. Note the large increase in surface area for the finest sediment. As the surface area increases, a larger percentage of the water in the pores is held by surface tension or other adhesive forces. Therefore, finer sediments have lower specific yields compared to coarser sediments, even if they both have the same porosity.

Specific yield plus specific retention equals the porosity of an aquifer. Both specific yield and specific retention are expressed as decimal fractions or percentages. Specific yields of unconfined aquifers (equivalent to their storage coefficients*) range from 0.01 to 0.30. Specific yields cannot be determined for confined aquifers because the aquifer materials are not dewatered during pumping.

Storage coefficients are much lower in confined aquifers because they are not drained during pumping, and any water released from storage is obtained primarily by compression of the aquifer and expansion of the water when pumped. During

Table 5.2. Representative Specific Yield Ranges for Selected Earth Materials

Sediment	Specific Yield, %
Clay	1–10
Sand	10–30
Gravel	15–30
Sand and Gravel	15–25
Sandstone	5–15
Shale	0.5– 5
Limestone	0.5– 5

(Walton, 1970)

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*The coefficient of storage is fully defined in Chapter 9. Briefly, it is the volume of water taken into or released from storage per unit change in head per unit area.

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before pumping began. During water-level recovery, the distance between the water level and the initial static water level is called residual drawdown.

Well Yield — Yield is the volume of water per unit of time discharged from a well, either by pumping or free flow. It is measured commonly as a pumping rate in gallons per minute or cubic meters per day.

Specific Capacity — Specific capacity of a well is its yield per unit of drawdown, usually expressed as gallons of water per minute per foot (gpm/ft) of drawdown or cubic meters per day per meter (m^3/day/m) of drawdown, after a given time has elapsed, usually 24 hours. Dividing the yield of a well by the drawdown, when each is measured at the same time, gives the specific capacity. For instance, if the pumping rate is 1,000 gpm (5,450 m^3/day) and the drawdown is 30 ft (9.1 m), the specific capacity of the well is about 33.3 gpm per ft of drawdown (599 m^3/day/m of drawdown) at the time the measurements were taken. Specific capacity generally varies with duration of pumping — as pumping time increases, specific capacity decreases. Also, specific capacity decreases as discharge increases in the same well. The reasons for decreasing specific capacity are discussed later in this chapter.

Static water level, pumping water level, drawdown, and residual drawdown apply similarly to a pumped well or other nearby wells and observation wells. For example, if the water level in an observation well located 80 ft (24.4 m) from a pumping well dropped 3 ft (0.9 m) as a result of the pumping, this lowering in the observation well is called its drawdown.

NATURE OF CONVERGING FLOW

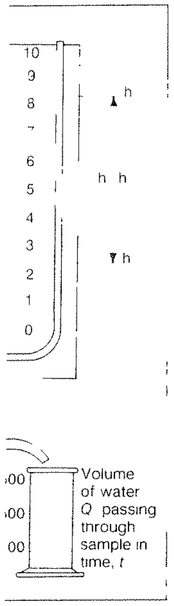
The water level in the vicinity of a pumped well under unconfined conditions is lowered when pumping begins, with the greatest drawdown occurring in the well. As the pump removes water, an area of low pressure develops near the well bore. Because the water level is lower in a pumped well than at any place in the water-bearing formation surrounding it, water moves from the formation into the well to replace water being withdrawn by the pump. The pressure (force) that drives the water toward the well is called the head, which is the difference between the water level inside the well and the water level at any place outside the well. At some distance from the well a point is reached where the water level is essentially unaffected. This distance varies for different wells. It also varies for the same well, depending on both the pumping rate and the length of time the well is pumped.

In confined formations, the saturated thickness of the aquifer is generally not reduced during pumping. Hydrostatic pressure, however, is reduced in the aquifer, and the pressure drop is greatest at the well bore. The pressure drop is directly analogous to the dewatering effect in unconfined aquifers.

During pumping, water flows toward the well from every direction. As the water moves closer to the well, it moves through imaginary cylindrical sections that are successively smaller in area. Thus, as the water approaches the well, its velocity increases. In Figure 9.2, A_1 represents the area of a cylindrical surface 100 ft (30.5 m) from the center of the well, and A_2 represents the area of a similar surface 50 ft (15.2 m) from the well. Because A_1 is twice A_2 and the same quantity of water flows toward the pumped well through both cylinders, the velocity V_2 must be twice V_1*.

---

*The equation for the surface area of a cylinder is $A = 2\pi rh$, where $\pi = 3.14$, r is the radius of the cylinder, and h is its height.



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hydraulic gradient. If the hydraulic gradient (head loss per unit length of travel) is doubled, the rate of flow in a given sand is also doubled. Conversely, doubling of the flow rate requires doubling of the hydraulic gradient. These ratios apply only to laminar flow, however. If turbulent flow is present, the flow rate does not change in direct proportion with the hydraulic gradient; doubling of the hydraulic gradient may increase the flow rate by only 1.5 times. The information in this paragraph is vital to understanding water-well hydraulics, which is presented in Chapter 9.

The slope of the water table or potentiometric surface is the hydraulic gradient under which groundwater movement takes place. The total flow through any vertical section of an aquifer can be calculated if we know the thickness of the aquifer, its width, its average hydraulic conductivity, and the hydraulic gradient. The flow, q, through each foot of aquifer width is:

$$q = KbI \qquad (5.12)$$

where K is the hydraulic conductivity averaged over the height of the aquifer, b is the aquifer thickness in feet, and I is the hydraulic gradient.

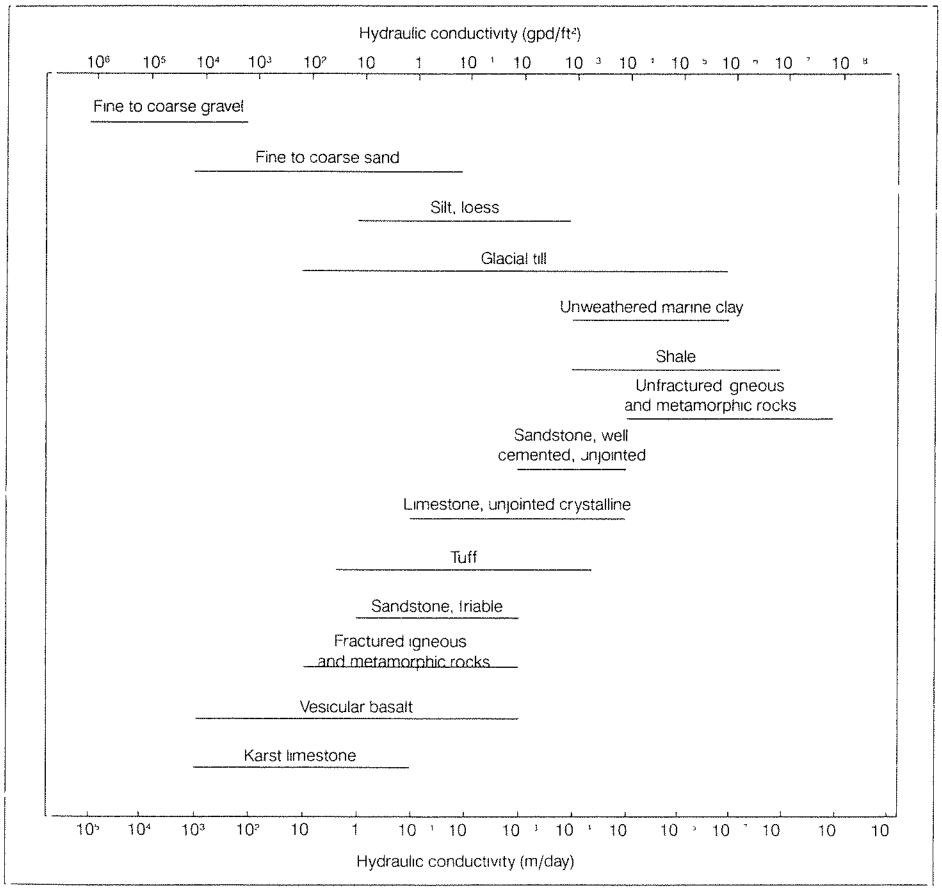


Figure 5.14. Typical *K* values for consolidated and unconsolidated aquifers. *(After Davis, 1969; Dunn and Leopold, 1978; Freeze and Cherry, 1979).*

MENDOCINO COUNTY COASTAL

GROUND WATER STUDY

JUNE 1982

Permitting Team
Exhibit 10

This report was prepared under the direction of

Ralph Scott	Senior Engineering Geologist

by

Dennis G. Parfitt	Assistant Engineering Geologist

and

Laura F. Germain[1]	Assistant Engineering Geologist

Special services were provided by

Well Monitoring

William G. Rummel, R.S.	Environmental Consultant

Cover

Michael Serna	Drafting Aid II

Report Preparation

Diane McGill	Secretary
Helen Chew	Office Assistant II
Mitch Clogg	Research Writer
Sheryl Lewis	Student Assistant

---

[1] Laura Germain was the project geologist from July 1, 1980 to June 30, 1981, and author of the "Mendocino County Coastal Ground Water Study" Memorandum Report, 1980.

TABLE 6

SUMMARY OF WELL DATA [1]

Formation	Yield		Drawdown		Mean Specific Capacity L/min/m (gpm/ft)	Percent of Wells Yielding 38 L/min (10 gpm) or More
	Average	Range	Average	Range		
Gualala	49 L/min (13 gpm)	1.3 to 190 L/min (0.33 to 50 gpm)	17.4 m (57.2 ft)	0.3 to 46 m (1 to 150 ft)	2.8 (0.23)	34
German Rancho	16 L/min (4.2 gpm)	0.4 to 150 L/min (0.1 to 40 gpm)	23.4 m (77 ft)	1.5 to 52 m (5 to 170 ft)	0.7 (0.06)	6
Schooner Gulch and Gallaway	36 L/min (9.5 gpm)	5.7 to 95 L/min (1.5 to 25 gpm)	17.4 m (57 ft)	1.5 to 33 m (5 to 108 ft)	2.1 (0.17)	33
Monterey [2]	63 L/min (16.6 gpm)	2.5 to 114 L/min (0.66 to 30 gpm)	11.7 m (38.5 ft)	6 to 26 m (20 to 85 ft)	4.2 (0.34)	75
Coastal Belt Franciscan	68 L/min (18 gpm)	11 to 136 L/min (3 to 36 gpm)	21 m (68.3 ft)	12 to 27 m (40 go 90 ft)	3.3 (0.265)	50 [3]
Iversen Basalt			NO DATA			
Marine Terrace	100 L/min (26.5 gpm)	7.6 to 284 L/min (2 to 75 gpm)	5.8 m (19 ft)	0.3 to 10.7 m (1 to 35 ft)	18.1 (1.46)	61

---

[1] From information in "Water Well Drillers' Reports"

[2] Based on data from 2 bedrock wells and 7 composite wells

[3] Based on limited data from 4 wells

TRIPLICATE
Owner's Copy

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 105380

State Well No.
Other Well No.

e of Intent No.
Permit No. or Date

(1) OWNER:
Name North Gualala Water Co
Address P.O. Box 1000
City Gualala, Ca Zip 95445

(2) LOCATION OF WELL (See instructions) 241-270-05
County Mendocino Owner's Well Number
Well address if different from above Confluence Little N Fork & N Fork Gualala River
Township Range Section
Distance from cities, roads, railroads, fences, etc.

WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☒
Other ☐

(5) EQUIPMENT:
Rotary ☐ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☒

(6) GRAVEL PACK: Fine pea
Yes ☒ No ☐ Size
Diameter of bore 30"
Packed from 25 to 59 ft.

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	59	12	7

(8) PERFORATIONS: Machine
Type of perforation or size of screen

From ft.	To ft.	Slot size
39	59	1/8 x 3

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 25 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing concrete on pack

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion 20 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Weeks
Type of test Pump ☐ Bailer ☒ Air lift ☐
Depth to water at start of test 20 ft. At end of test 35 ft
Discharge 60+ gal/min after 1 hours Water temperature cool
ical analysis made? Yes ☐ No ☒ If yes, by whom?
electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:
Total depth 59 ft. Depth of completed well 59 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
		WELL #1
0	1	Brown topsoil
1	15	Brown sandy clay
15	16	Gravel and sand making water
16	18	Brown and gray clay
18	19	Sand and gravel making water
19	30	Gray clay
30	37	Brown gravel making water
37	50	Blue clay embed gravels
50	55	Boulders and gravel making wate
55	59	Blue clay and trace wood.

Work started 7/11/78 19 Completed 7/11/78 19

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED Gerald G. Thompson. by Mary E. Thompson
(Well Driller)

NAME Weeks Drilling and Pump Company
(Person, firm, or corporation) (Typed or printed)

Mary E. Thompson

Address 6100 Sebastopol Rd
City Sebastopol, Calif Zip 95472
License No. 177681 Date of this report 7/11/78

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED. USE NEXT CONSECUTIVELY NUMBERED FORM

Permitting Team
Exhibit 11

TRIPLICATE
Owner's Copy

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 105412

State Well No.
Other Well No. Well No. 2

Notice of Intent No.
Local Permit No. or Date

(1) OWNER:

Name North Gualala Water Co
Address P.O. Box 1000
City Gualala, Ca Zip 95445

(2) LOCATION OF WELL (See instructions):

County Mendocino Owner's Well Number
Well address if different from above Confluence of Little No. ~~XXXX~~ No. Fork Fork Gualala River
Township Range Section
Distance from cities, roads, railroads, fences, etc.

WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☒
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☒
Other ☐

(5) EQUIPMENT:

Rotary ☐ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☒

(6) GRAVED PACK:

Yes ☒ No ☐ Size 3/8"
Diameter of bore 24"
Packed from 20 to 100 ft.

(7) CASING INSTALLED:

Steel ☒ Plastic ☐ Concrete ☐

From ft.		Dia. in.	Gage or Wall
0	[illegible]	12 3/4	.250

(8) PERFORATIONS: machine

Type of perforation or size of screen

From ft.	To ft.	Slot size
48	100	~~xxxxxx~~ 3/16 x 3

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing concrete on pack

(10) WATER LEVELS:

Depth of first water, if known ft.
Standing level after well completion 15 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Weeks
Type of test Pump ☐ Bailer ☒ Air lift ☐
Depth to water at start of test 15 ft. At end of test 20 ft
Discharge gal/min after 1 hours Water temperature cool
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:

Total depth 100 ft. Depth of completed well 100 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	1	Brown topsoil
1	3	Brown sand and clay
3	25	Brown clay
25	30	Brown gravel making water
30	60	Brown clay w/ gray
60	62	Blue clay
62	64	Blue gravel making water
64	73	Blue clay and imbed gravel
73	75	Clean gravel making water
75	80	Blue clay pieces of wood
80	90	Brown clay embed gravel
90	93	Brown gravel possibly making water
93	100	Brown and blue clay fractured sandstone

PUBLIC SEC 13752
WATER CODE

Work started 8/2/78 19 Completed 8/1/78 19

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED Gerald G. Thompson/ by Mary E. Thompson
(Well Driller)

NAME Weeks Drilling and Pump Company
(Person, firm, or corporation) (Typed or printed)

Mary E. Thompson

Address 6100 Sebastopol Rd
City Sebastopol, Ca Zip 54972
License No. 177681 Date of this report 8/1/78

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

TRIPLICATE
Owner's Copy

of Intent No.
Permit No. or Date 7218

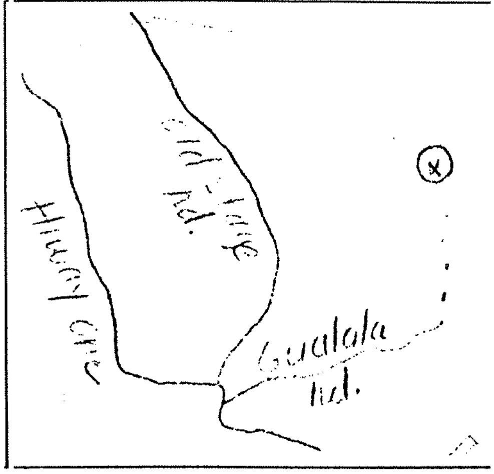
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in
No. 211073
State Well No.
Other Well No.

(1) OWNER:
Name NORTH GUALALA WATER COMPANY
Address P.O. Box 1000
City Gualala, California Zip 95445

(2) LOCATION OF WELL (See instructions):
County MENDOCINO Owner's Well Number
Well address if different from above
Township 11N Range 15W Section 23
Distance from cities, roads, railroads, fences, etc.
44320 Gualala Road
Gualala
A.P. # 141-270-05



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☒
Other ☐

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size pea
Diameter of bore 13½"
Packed from 35 to 162 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen micro

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	161	8"	CL200	135	155	.030

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 35 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing concrete on gravel pack

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion 15 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Weeks
Type of test Pump ☐ Bailer ☒ Air lift ☐
Depth to water at start of test 15 ft. At end of test 17 ft
Discharge 60+ gal/min after 2 hours Water temperature cool
cal analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:
Total depth 162 ft. Depth of completed well 161 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
		WELL # 3
0	18	Brown sand
18	27	Blue coarse sand and gravels
27	28	Sandy clay
28	31	Sand and gravel
31	36	Silt and wood
36	50	Sand and gravel
50	65	Silt and wood
65	74	Sand and gravel
74	86	Silt
86	95	Sand and gravel
95	105	Silt
105	117	Cemented sands
117	139	Conglomerate
139	158	Brown and gray fractured rock
158	162	Rock

Work started 7-28 1989 Completed 8-1 1989

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED Ward Thompson By: Don Sinclair
(Well Driller)
NAME WEEKS DRILLING AND PUMP COMPANY
(Person, firm, or corporation) (Typed or printed)
Address P.O. Box 176-6100 Sebastopol Road
City Sebastopol, California Zip 95472
License No. C57-177681 Date of this report August 14, 1989

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Order on
Four Complaints Filed Against
The California-American
Water Company

Carmel River
Monterey County

Order No. WR 95-10

JULY 6, 1995

STATE WATER RESOURCES CONTROL BOARD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Permitting Team
Exhibit 12

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF FIGURES & TABLE

CITING THE RECORD

When citing evidence in the hearing record, the following conventions have been adopted:

Information derived from the hearing transcript:

```
T,II,12:1 - 15:17
| |  |          └──ending page and line number (may be omitted if
| |  |             single line reference is cited)
| |  └──────────beginning page and line number
| └──────────hearing transcript volume number
└──identifying abbreviation of the information source
```

Information derived from an exhibit:

```
SWRCB:5,4
|      | └──page number, volume, table, graph, or figure number;
|      |    or application number if a file is cited
|      └exhibit number
└──identifying abbreviation of information source
```

Abbreviations of information sources:

AC	Archeological Consulting
ACOE	U.S. Army Corps of Engineers
CAL-AM	California American Water Company
CRSA	Carmel River Steelhead Association
CSPA	California Sportfishing Protection Alliance
DISTRICT or MPWMD	Monterey Peninsula Water Management District
DFG	California Department of Fish and Game
ESSELEN TRIBE	Esselen Tribe of Monterey County
ESSELEN NATION	Esselen Nation of United Families of the Central Coast of CA
EVANS	Willis Evans
PARK	Monterey Peninsula Regional Park District
PHBr	Post-Hearing Brief
SWRCB	State Water Resources Control Board
SIERRA CLUB	Ventana Chapter of the Sierra Club
T	Hearing Transcript

Other commonly used abbreviations:

af	Acre-feet
afa	Acre-feet annually
cfs	Cubic feet per second
CEQA	California Environmental Quality Act
gpm	Gallons per minute
RM	River mile, measured from river mouth
USGS	United States Geologic Survey

ORDER FINDING AGAINST RESPONDENT, IN PART, AND DIRECTING CORRECTIVE ACTIONS

SYNOPSIS

The California-American Water Company (Cal-Am) currently diverts water from the Carmel River and supplies the water, primarily, for use outside of the watershed to users on the Monterey Peninsula. Four complaints were filed with the State Water Resources Control Board (SWRCB) against Cal-Am for its diversion of water from the Carmel River. The complaints generally allege that Cal-Am: (a) does not have the legal right to divert water from the river and (b) diversions are adversely affecting public trust resources within the river. The SWRCB concludes that Cal-Am: (a) does not have legal right for about 10,730 acre-feet annually which is currently diverted from the river (about 69 percent of the water currently supplied to Cal-Am users) and (b) diversions are having an adverse affect on the public trust resources of the river. This order directs Cal-Am to: (a) diligently proceed in accord with a time schedule to obtain rights to cover its existing diversion and use of water and (b) implement measures to minimize harm to public trust resources. Measures to minimize harm to public trust resources require Cal-Am to reduce the quantity of water which is currently being pumped from the river. Because water is not available for appropriation by direct diversion in the river during summer months, Cal-Am must either obtain the right to additional water supplies from: (a) sources other than the river, (b) a storage project similar to the New Los Padres (NLP) project proposed by the Monterey Peninsula Water Management District (District), or (c) contract with the District for supply from the proposed NLP project.

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

In the Matter of Complaints Against
Diversion and Use of Water by the

CALIFORNIA-AMERICAN WATER COMPANY,

Respondent,

CARMEL RIVER STEELHEAD
ASSOCIATION, RESIDENTS WATER
COMMITTEE, SIERRA CLUB,
CALIFORNIA DEPARTMENT OF PARKS
AND RECREATION,

Complainants.

ORDER: WR 95-10

SOURCE: Carmel River
Tributary
to Pacific Ocean

COUNTY: Monterey

ORDER FINDING AGAINST RESPONDENT, IN PART, AND DIRECTING CORRECTIVE ACTIONS

BY THE BOARD:

Complaints having been filed against Cal-Am for its diversion and use of water from the Carmel River by Carmel River Steelhead Association, Residents Water Committee, Sierra Club, and Department of Parks and Recreation; a hearing having been held on August 24, 25, 26, 31, September 1, 8, and 9, October 19 and 21, and November 7, 8, and 22, 1994; the complainants, Cal-Am, and other interested persons having been provided opportunity to present evidence; closing briefs having been filed; the evidence and briefs having been duly considered; the Board finds as follows:

1.0 CAL-AM, CAL-AM FACILITIES AND CAL-AM OPERATIONS

Cal-Am is an investor-owned public utility subject to the jurisdiction of the California Public Utilities Commission. (T,Sept. 9, 1992, 95:1-95:7; T,I,49:14-49:22.) Cal-Am currently diverts about 14,106 afa of water from the Carmel River and

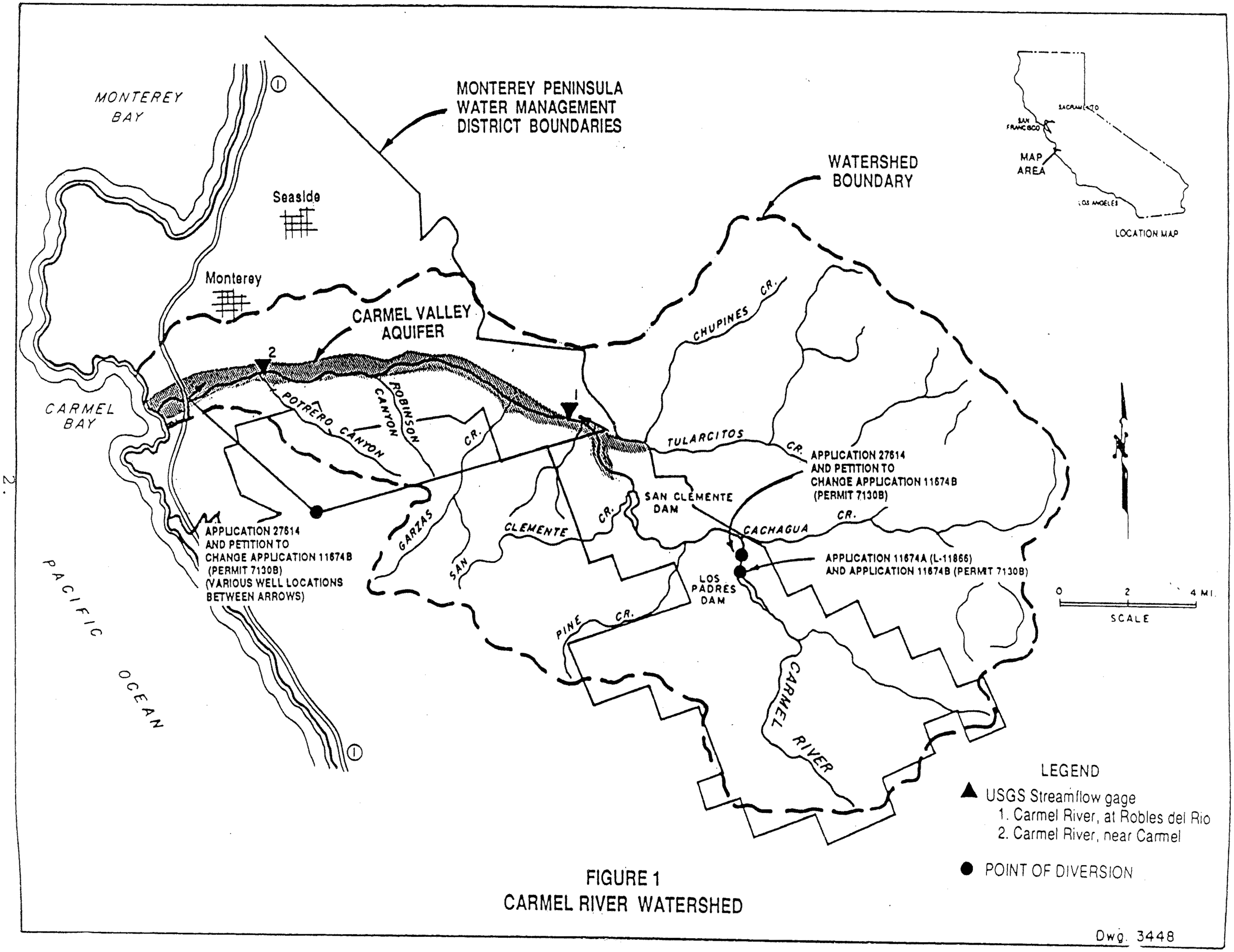


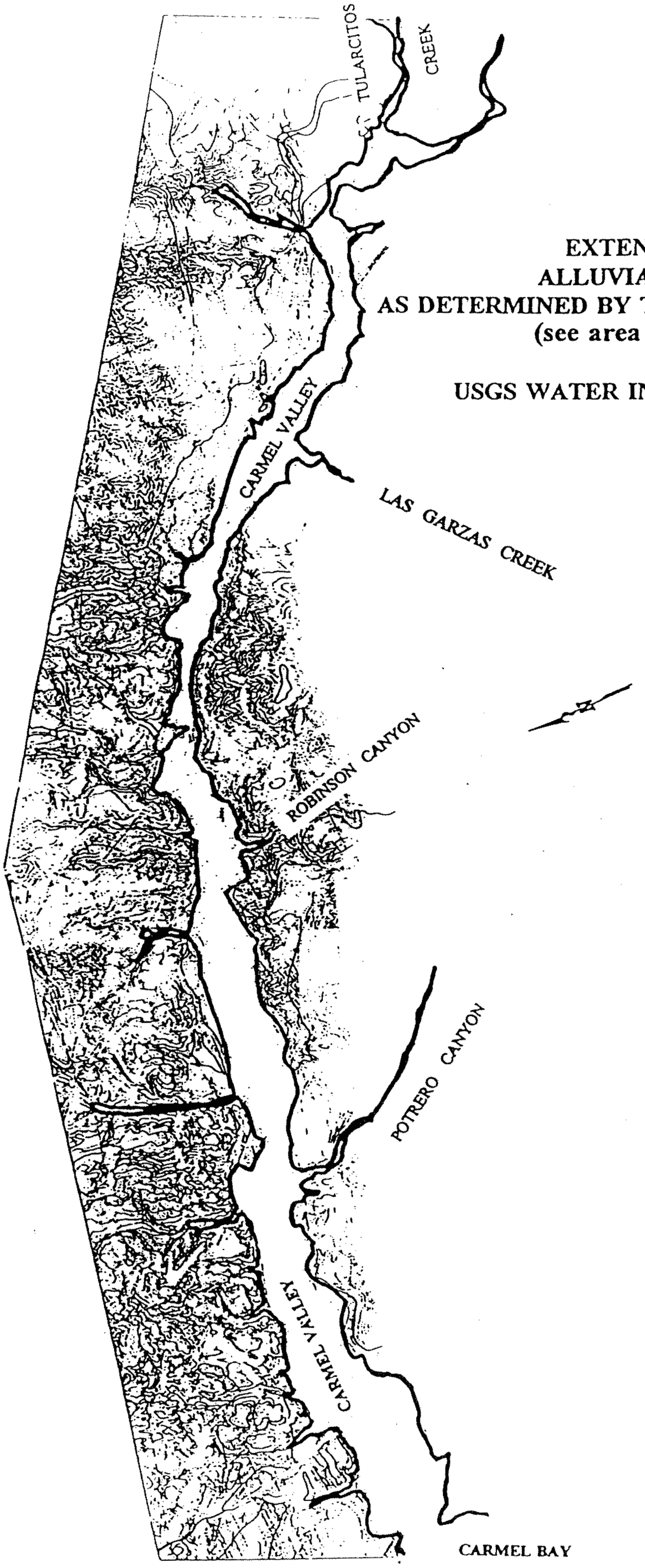
FIGURE 1
CARMEL RIVER WATERSHED

FIGURE 2

EXTENT OF CARMEL VALLEY ALLUVIAL GROUNDWATER BASIN AS DETERMINED BY THE U.S. GEOLOGICAL SURVEY (USGS)

(see area defined by the bold lines)

USGS WATER INVESTIGATIONS REPORT 83-4280
JUNE 1984

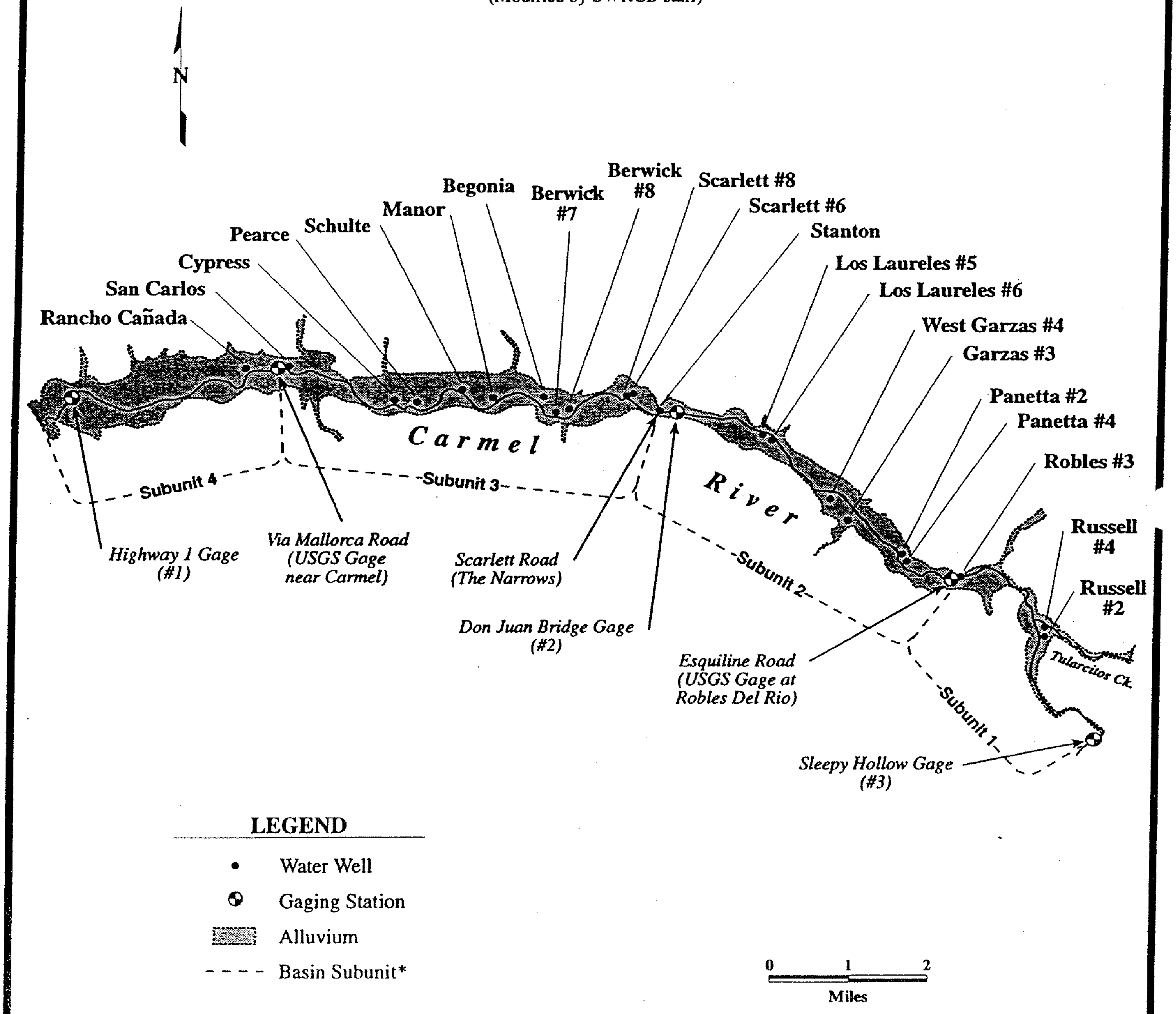


THE CARMEL RIVER (NOT SHOWN)
FLOWS THROUGH CARMEL VALLEY

FIGURE 3

ALLUVIAL GROUNDWATER BASIN SHOWING THE LOCATION OF THE CALIFORNIA-AMERICAN WATER COMPANY WELLS

Information obtained from MPWMD Exhibit 287 - Figure 7-2
(Modified by SWRCB staff)

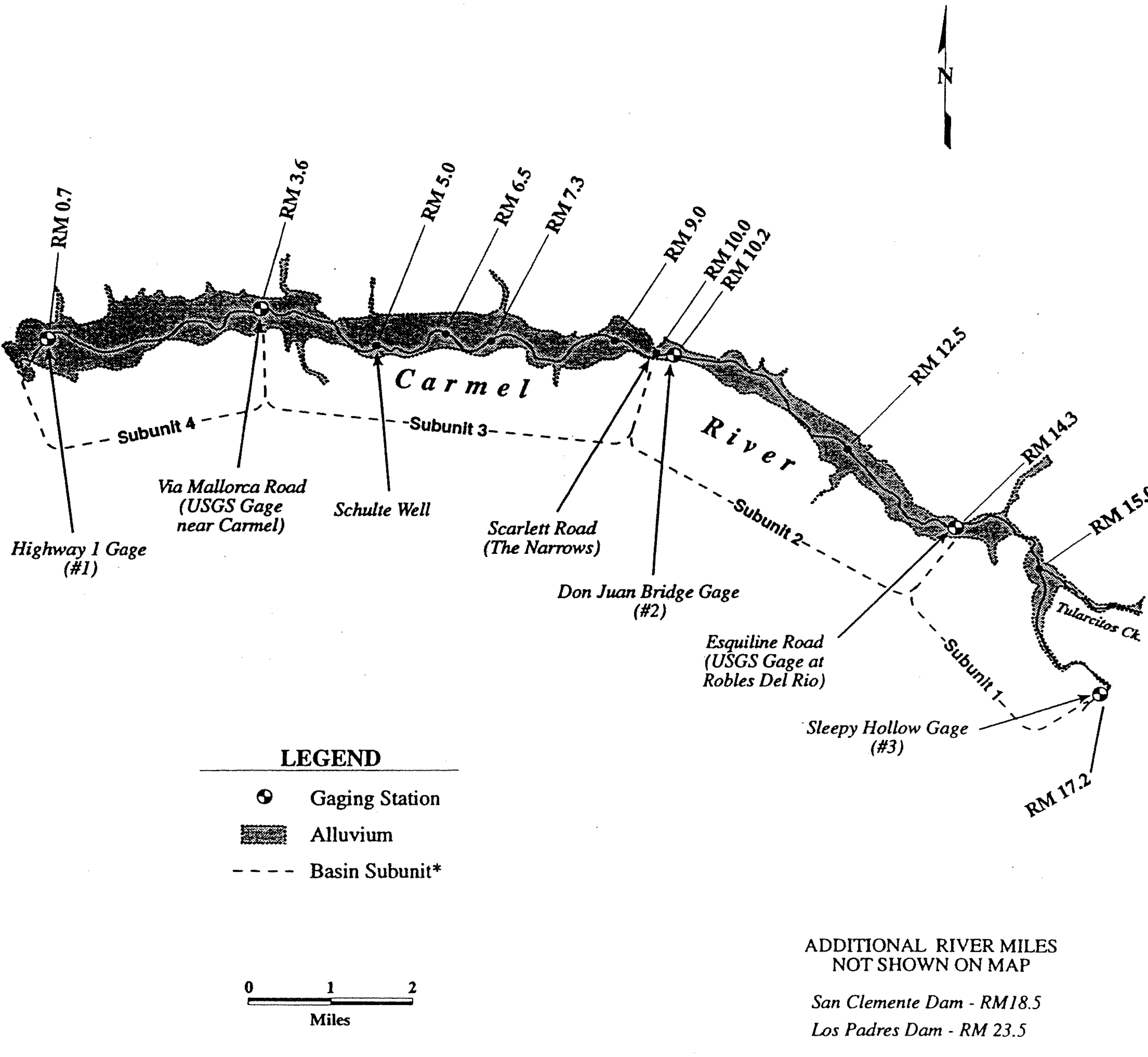


* Subunits 1-4 form the Carmel Valley Groundwater Basin. The subunit boundaries are: 1. Via Mallorca Road (USGS Gage Near Carmel), 2. Scarlett Road (The Narrows), 3. Esquiline Road (USGS Gage at Robles Del Rio), 4. Sleepy Hollow Gage.

Streamgaging will occur at the Highway 1 Gage (#1), Don Juan Bridge Gage (#2), and Sleepy Hollow Gage (#3).

FIGURE 4

ALLUVIAL GROUNDWATER BASIN IDENTIFYING RIVER MILES (RM)



ADDITIONAL RIVER MILES
NOT SHOWN ON MAP

San Clemente Dam - RM18.5

Los Padres Dam - RM 23.5

* Subunits 1-4 form the Carmel Valley Groundwater Basin. The subunit boundaries are: 1. Via Mallorca Road (USGS Gage Near Carmel), 2. Scarlett Road (The Narrows), 3. Esquiline Road (USGS Gage at Robles Del Rio), 4. Sleepy Hollow Gage.

Streamgaging will occur at the Highway 1 Gage (#1), Don Juan Bridge Gage (#2), and Sleepy Hollow Gage (#3).

supplies the water, primarily, for use outside of the watershed to users on the Monterey Peninsula.[1] About 105,000 persons are provided service by Cal-Am, most are supplied water from the Carmel River. (T,I,48:1-48:18.)

The primary source of water supply for Cal-Am customers is 21 wells situated on the lower Carmel River. (CAL-AM:91.) These wells supply about 69 percent of the water needs of Cal-Am customers. The balance of the water delivered to Cal-Am customers is supplied from: (1) San Clemente and Los Padres reservoirs in the upper reaches of the Carmel River and (2) pumped ground water in the City of Seaside.[2] (T,I,131:1-19.)

San Clemente Dam has a storage capacity of approximately 2,140 af. Water is stored in this facility under claim of pre-1914 appropriative right.[3] (Statement of Water Diversion and Use No. 8538.) Los Padres Dam is operated pursuant to License 11866 (Application 11674) and authorizes maximum annual withdrawal of 2,950 af. Stored water is released from Los Padres to the river and it is rediverted for use at San Clemente Dam. (T,I,130:16-24.) Sedimentation has reduced the combined usable storage at the

---

[1] *Cal-Am supplies about 17,000 af during a normal year . This estimate is obtained by adding the 2,700 af which is supplied from the wells in Seaside (T,I,131:1-19) to the 14,106 af which is obtained from the Carmel River. (CAL-AM:90.) The 14,106 af represents the recent average, non-drought use (average use from 1979 through 1988, based upon Cal-Am Exhibit 90). (14,106 + 2,700 = 16,806 af, or approximately 17,000 afa.)*

[2] *In addition to supplies from the Carmel River and pumped ground water in the area of Seaside, reclaimed wastewater is available to some Cal-Am users from the Carmel Area Wastewater District/Pebble Beach Community Services District Wastewater Reclamation Project. The Project will provide 800 acre-feet of reclaimed water for the irrigation of golf courses and open space in the Del Monte Forest. In return for financial guarantees, the Pebble Beach Company and other sponsors, received a 380 af potable water entitlement from the District, based upon issuance of an appropriative right permit to the District, for development within Del Monte Forest. As of the end of fiscal 1993-1994, the District had not allocated the remaining 420 af of project yield. (MPWMD,337,25.)*

[3] *Diversion at San Clemente Dam was the sole supply for the Monterey Peninsula until the 1940s when wells at the upper end of the Carmel Valley began producing water to meet summer demand (SWRCB:1, A-27614, Folder 6A).*

reservoirs to about 2,600 af, about one-half of their combined original capacity. The reservoirs supply about 15 percent of Cal-Am's estimated normal year customer demand. (MPWMD:106,7.) Finally about 2,700 afa is produced from wells in Seaside, California.

2.0 COMPLAINTS

Between 1987 and 1991, the SWRCB received four complaints regarding Cal-Am's operations in the Carmel River watershed. The complaints are summarized below:

2.1 Carmel River Steelhead Association (CRSA)

On July 27, 1987 CRSA filed a complaint alleging that Cal-Am diversions from the underflow of the Carmel River are unauthorized and are destroying the public trust resources of the river, including steelhead. As a possible solution, the CRSA recommended rescue and rearing in ponds of fish stranded by the unauthorized diversions, irrigation of riparian vegetation affected by the unauthorized diversions, and release of more water from San Clemente Dam for rediversion through wells downstream. (SWRCB,1,a, Complaint File, Monterey Co., 27-01; CSRA:10,35-28.)

2.2 Resident's Water Committee (RWC)

On August 9, 1989 RWC filed a complaint with the Public Utilities Commission alleging that the supply of water needed to serve Cal-Am's customers exceeded available supply.[4] RWC also alleges that Cal-Am diversions from the Carmel River will reduce steelhead in the Carmel River to remnant levels. RWC recommends that Cal-Am be prohibited from serving new customers until an additional supply of water is obtained. (SWRCB:1, A-27614, Folder G.)

2.3 Ventana Chapter of the Sierra Club (Sierra Club)

On March 5, 1991, the Sierra Club filed a complaint alleging: (1) Cal-Am's pumping from the subsurface flow of the Carmel River

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[4] *A copy of the complaint was received by the SWRCB around the same time.*

is unauthorized and (2) Cal-Am's diversion from San Clemente Reservoir during low-flow periods is an unreasonable method of diversion. The Sierra Club's proposed solution includes the following: (1) Cal-Am should be enjoined from diverting water during periods of low flow, (2) Cal-Am and Water West should apply for appropriative water rights from the SWRCB, (3) Cal-Am and Water West should be required to pay for development and implementation of a program to restore public trust resources affected by their diversions,[5] and (4) Cal-Am should be required to release all diversions at San Clemente Reservoir down the Carmel River for collection at downstream wells, instead of diverting water at San Clemente. (SWRCB:1,A-27614, Folder J.)

2.4 California Department of Parks and Recreation (DPR)

On March 8, 1991, DPR filed a complaint alleging that Cal-Am's diversion of water from the underflow of the Carmel River is: (1) unauthorized, (2) results in mortality to mature riparian forests along a 4,000-foot length of river within the Carmel River State Beach, and (3) interferes with DPR's riparian right to divert water from the Carmel River for irrigation purposes. DPR's proposed solution is for Cal-Am to apply for an appropriative water right with the SWRCB and be subject to conditions to protect riparian, wetland, and aquatic resources in the lower Carmel River, and lagoon and riparian rights along the lower Carmel River. (SWRCB:1, A-27614, Folder J.)

2.5 Monterey Peninsula Water Management District

On May 5, 1992, the District petitioned to intervene in the complaints against Cal-Am because of its interest in assuring an appropriate balance between competing demands for the use of the limited water supply. (SWRCB:1, A-27614, Folder K.)

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[5] *Water West is a water company owned by Cal-Am. Water West has rights to divert and use water at about one-half mile below San Clemente Dam. The complaint was directed at only Cal-Am's diversions. Although Water West is not a party to this proceeding, its diversions are analyzed as diversions under the control of Cal-Am.*

2.6 Interested Persons

In addition to the complainants and the District, other persons participated in the hearing. Participation was directed at the effect Cal-Am diversions were having on the instream resources of the Carmel River and measures which might be taken to mitigate such effects. Such participants included the DFG, Willis Evans, John Williams, Charity Crane and others appearing on their own behalf.

3.0 DESCRIPTION OF THE WATERSHED

The Carmel River drains a 255-square mile watershed tributary to the Pacific Ocean. Its headwaters originate in the Santa Lucia Mountains at 4,500 to 5,000-foot elevations, descend and merge with seven major stream tributaries along a 36-mile river course, and discharge into Carmel Bay about 5 miles south of the City of Monterey. Above the confluence of Tularcitos Creek, the Carmel River constitutes about 65 percent of the watershed. Downstream from RM 15, the river has a 40 feet per mile gradient where the river flows to the bay are over and within an alluvium-filled Carmel Valley floor.

Carmel River flow is in a well-defined channel. The channel in the lower 15 river miles ranges from 20 to 150 feet wide. (SWRCB:19.) The channel changes progressively from cobble to gravel between RM 15 and RM 7, from gravel to sand between RM 7 and RM 2.5 and consists entirely of sand from RM 2.5 to Carmel Bay. (DFG:4,2.)

Downstream from RM 15, alluvial deposits comprise a ground water basin which underlies the river flow in the Carmel Valley portion of the watershed. The legal classification of the ground water basin is discussed in Section 3.2 *infra*. Local ground water levels within the aquifer are influenced by pumping or production at supply wells, evapotranspiration by riparian vegetation, seasonal river flow infiltration and subsurface inflow and outflow.

During the dry season, pumping of wells has caused significant declines in the ground water levels. The Carmel River surface flow decreases due to pump-induced infiltration which recharges the seasonally-depleted ground water basin. During normal water years, surface flow in the lower Carmel Valley is known to become discontinuous or non-existent. Downstream from RM 3.2, there was no river runoff between April 1987 and March 1991. (MPWMD:287, 2-8.)

3.1 Geologic Setting

The principal hydrogeologic units (from oldest to youngest) along the Carmel River alluvial basin that are significant include: (1) pre-tertiary metamorphic and igneous rocks, (2) tertiary sedimentary rocks comprised primarily of sandstone beds (Paleocene and Miocene age) and Monterey shale (Miocene age), (3) older alluvium (Pleistocene age), and (4) younger alluvium (Holocene age). (SWRCB:19.)

Metamorphic (mainly schist and gneiss) and igneous (granitic) rocks form the basement complex which is extensively exposed along or near the river upstream from RM 10 at the downstream extremity of the river narrows. Tertiary sandstone units, which overlie the basement rocks, are exposed primarily along the southern flank of the alluvial valley from about RM 1.5 to 3 and 5.5 to 12.5. The Monterey Shale formation overlies the sandstone. It is exposed extensively along the north side of the Carmel Valley alluvium from approximately RM 2 to 12 and surficially borders the southern side of the valley from about RM 3 to 5.5 (in the vicinity of Potrero Canyon) and RM 14.5 to 15.5 (in the community of Carmel Valley). The older alluvium, consisting mainly of gravel and sand, form remnant terraces which directly overlie the Monterey shale and/or basement complex rocks. These terraces are laterally discontinuous patches along the north side of the valley alluvium from RM 1 to 16 and along both sides from about RM 16.5 to 18. The basement complex and the shale formation are considered to be non-water bearing. The sandstone has no subsurface hydrologic significance and the older alluvium is found on terraces above the level of ground water. (SWRCB:19.)

The younger alluvium, which formed the valley floor, consists principally of boulders, cobbles, gravel, and sand (which contains silt and clay layers of limited horizontal and vertical extent downstream from the river narrows). This alluvium was deposited by river flows (along the lowermost 18 miles of the drainage basin) within a canyon that was incised (by earlier flows) into the shale formation, sandstone units, and basement complex rocks. Its thickness varies from less than a foot at RM 18 to approximately 200 feet in the vicinity of the river mouth. These deposits comprise the most important aquifer in Carmel Valley (MPWMD:105,3) because of their ability to transmit significant amounts of subsurface water to wells.

3.2 Physical (Hydrologic) Characteristics of the Carmel Valley Aquifer

Carmel River surface flow is generally within the well-defined 20- to 150-foot wide channel over the alluvial deposits that form the valley floor. These deposits are the younger alluvium that comprise the Carmel Valley aquifer.

On behalf of the District, Thomas M. Stetson reviewed District Exhibit 108 and SWRCB Exhibits 19, 24, 27, and 29 in connection with his evaluation of the physical aspects of the subsurface water in Carmel Valley. Mr. Stetson also reviewed hydrographs of Carmel Valley aquifer water levels obtained at numerous wells. (MPWMD:107.) In addition, he reviewed Carmel River streamflow hydrographs for the USGS Robles Del Rio and Carmel gaging stations. By superimposing surface and subsurface water level hydrographs, Mr. Stetson established that there is a direct relationship between recovery of seasonally-lowered subsurface water levels at wells and recurrent river flow increases during ensuing wet periods. On this basis, Mr. Stetson concluded that surface flow recharges river underflow and, consequently, causes a rise in Carmel Valley aquifer water levels. (MPWMD,107,4.)

Mr. Stetson provided written testimony that such underflow is only through the younger alluvium within a known and definite channel along the entire length of Carmel Valley. (MPWMD:107,4.) Mr. Stetson supported his testimony utilizing the following information: (1) essentially nonwater-bearing rocks (described in Section 3.1) border and underlie the younger alluvium or Carmel Valley aquifer and (2) the average hydraulic conductivity of the younger alluvium is about 60 feet per day (ft/day), as compared to the hydraulic conductivity of the rocks which is in the order of 0.1 to 0.0001 ft/day or less. (MPWMD:107,6.) Mr. Stetson concluded that the hydraulic conductivity difference is substantial and renders the aquifer a "pipeline" for subsurface flow. (MPWMD:107,6.)

Mr. Stetson's testimony is consistent with the findings of SWRCB staff. Ms. Laudon submitted testimony and evidence that the relatively impermeable granitic and sedimentary rocks form the bed and banks of a known and definite channel which restricts the flow of subsurface water to the alluvium. (SWRCB:7&8.) This information is further supported by evidence regarding the subsurface occurrence of granitic or sedimentary rocks beneath the Carmel Valley aquifer at all well installations throughout the valley.

Except where water levels have been influenced by drawdown due to pumping, the general down valley or westerly subsurface flow direction within the aquifer is the same as that of the Carmel River flow. The subsurface flow has a pattern which demonstrates that it is within a known and definite channel rather than that of a diffused body of percolating ground water. (MPWMD:107,6.)

Cal-Am and other parties did not contest the testimony and evidence which describes the subsurface flow of the Carmel River as a subterranean stream flowing through a known and definite channel. Nor did Cal-Am or other parties offer evidence that the ground water in the alluvial basin should be classified as percolating ground water not within the SWRCB's permitting jurisdiction. Accordingly, we find that downstream of RM 15 the aquifer underlying and closely paralleling the surface water course of the

Carmel River is water flowing in a subterranean stream and subject to the jurisdiction of the SWRCB.

3.3 Location of Cal-Am Wells

The locations of Cal-Am's wells are described in the following table:

CAL-AM CARMEL RIVER WELLS (CAL-AM EXHIBIT 91)

Well Name	*Well Location*	*Depth To Water Static/ Pumping*	*Date Drilled*
Los Laureles #5	NE¼ of SE¼ of Sect.29,T16S,R2E	18 feet/44 feet	1947
Los Laureles #6	SE¼ of SE¼ of Sect.29,T16S,R2E	16 feet/43 feet	1977
Robles #3	NE¼ of NE¼ of Sect.10,T17S,R2E	12 feet/30 feet	1989
Russell #4	SW¼ of SE¼ of Sect.11,T17S,R2E	16 feet/35 feet	1947
Russell #2	SE¼ of SE¼ of Sect.11,T17S,R2E	16 feet/35 feet	1947
Scarlett #6	SW¼ of SW¼ of Sect.19,T16S,R2E	20 feet/26 feet	1963
Scarlett #8	SW¼ of SW¼ of Sect.19,T16S,R2E	20 feet/35 feet	1989
Manor #2	NE¼ of SW¼ of Sect.23,T16S,R1E	30 feet/65 feet	1989
Schulte	SW¼ of NW¼ of Sect.23,T16S,R1E	15 feet/58 feet	1967
Stanton	NW¼ of NE¼ of Sect.30,T16S,R2E	3 feet/35 feet	1977
Begonia #2	NW¼ of SW¼ of Sect.24,T16S,R1E	not listed	1990
Berwick #7	SW¼ of SW¼ of Sect.24,T16S,R1E	23 feet/63 feet	1981
Berwick #8	SE¼ of SW¼ of Sect.24,T16S,R1E	20 feet/50 feet	1986
Rancho Cañada (aka Cañada)	NE¼ of SW¼ of Sect.17,T16S,R1E	15 feet/49 feet	1981
San Carlos	NE¼ of SE¼ of Sect.17,T16S,R1E	16 feet/55 feet	1982
Pearce	SE¼ of NW¼ of Sect.22,T16S,R1E	16 feet/50 feet	1981
Cypress	SW¼ of NW¼ of Sect.22,T16S,R1E	15 feet/48 feet	1981

Continued to next page

CAL-AM CARMEL RIVER WELLS (CAL-AM EXHIBIT 91)			
Well Name	*Well Location*	*Depth To Water Static/ Pumping*	*Date Drilled*
Continued from previous page			
Panetta #1	NW¼ of NW¼ of Sect.03,T17S,R2E	13 feet/16 feet	1989
Panetta #2	NW¼ of NW¼ of Sect.03,T17S,R2E	16 feet/22 feet	1989
Garzas #3	SW¼ of SE¼ of Sect.33,T16S,R2E	13 feet/16 feet	1989
Garzas #4	NE¼ of SW¼ of Sect.33,T16S,R2E	12 feet/16 feet	1989

In addition, the location of these wells in relation to the Carmel River and the aquifer associated with the river is shown by Figure 3. The depth to water for each well is identified in the above table. Figure 3 and the table demonstrate that Cal-Am's wells are extracting water from the subterranean stream associated with the Carmel River.

4.0 ANALYSIS OF CAL-AM'S WATER RIGHTS

Among the issues noticed for hearing is the following:

> "Does [Cal-Am] have a legal right to divert water from wells located adjacent to the Carmel River?" (SWRCB 1, June 1992 Hearing Notice.)

Cal-Am extracts, on average, 14,106 afa via 21 wells from the alluvial aquifer along the Carmel River. Cal-Am claims the right to divert and use this water under pre-1914 appropriative, riparian, prescriptive, and rights acquired under License 11866. (CAL-AM:92,1,10-27; October 1, 1992 letter to SWRCB from Cal-Am transmitting supplemental exhibits.) During the hearing, Cal-Am's representatives presented testimony and numerous exhibits in support of its claimed rights to divert water from the river. The following sections analyze Cal-Am's rights to divert and use water from the Carmel River.

4.1 Applicable Water Law

The following sections set forth the law applicable to the water rights claimed by Cal-Am.

4.1.1 *Pre-1914 Appropriative Rights*

Prior to 1914, an appropriative right for the diversion and use of water could be obtained two ways.[6] First, one could acquire a nonstatutory (common law) appropriative right by simply diverting water and putting it to beneficial use. (<u>Haight</u> v. <u>Costanich</u> (1920) 194 P. 26, 184 Cal. 426.) Second, after 1872, a statutory appropriative right could be acquired by complying with Civil Code Sections 1410 et seq. (*Id.*) Under the Civil Code, a person wishing to appropriate water was required to post a written notice at the point of intended diversion and record a copy of the notice with the County Recorders Office which stated the following: the amount of water appropriated, the purpose for which the appropriated water would be used, the place of use, and the means by which the water would be diverted. (Cal. Civil Code Sections 1410-1422, now partially repealed and partially reenacted in the Water Code; Wells A. Hutchins, <u>The California Law of Water Rights</u> (1956) at 89.)

Generally, the measure of an appropriative right is the amount of water that is put to reasonable beneficial use, plus an allowance for reasonable conveyance loss. (<u>Felsenthal</u> v. <u>Warring</u> (1919) 40 Cal.App. 119, 133, 180 P. 67.) The quantity of water to which an appropriator is entitled, however, is not necessarily limited to the amount actually used at the time of the original diversion. Rather, under the doctrine of "progressive use and development", pre-1914 appropriations may be enlarged beyond the original appropriation. (<u>Haight</u>, 194 P. 26 at 28-29; Hutchins at 118; 62 Cal.Jur. at 370.)

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[6] *After 1914, an appropriative right could only be obtained by complying with the provisions of the California Water Code for the appropriation and use of water. (Water Code Section 1225; Stats. 1913, C. 586, p. 1012, Section 1(c).)*

Under the progressive use and development doctrine, the quantity of water to which an appropriator is entitled is a fact-specific inquiry. According to Haight, "this right to take an additional amount of water reasonably necessary to meet increasing needs is not unrestricted; the new use must have been within the scope of the original intent, and additional water must be taken and put to a beneficial use in keeping with the original intent, within a reasonable time by the use of reasonable diligence...." (194 P. at 29.) Thus, the progressive use and development doctrine allows an appropriator to increase the amount of water diverted under a pre-1914 right, provided: (a) the increased diversion is in accordance with a plan of development and (b) the plan is carried out within a reasonable time by the use of reasonable diligence. (Senior v. Anderson (1896) 115 Cal. 496, 503-504, 47 P. 454; Trimble v. Heller (1913) 23 Cal.App. 436, 443-444, 138 P. 376.)

4.1.2 *Riparian Rights*

The riparian doctrine confers on the owner of land abutting a watercourse the right to the reasonable and beneficial use of water on the land. California riparian rights have the following general characteristics. The riparian right is part and parcel of land which abuts a river, stream, lake, or pond. The riparian right may be used only for direct diversion of naturally occurring flow. Unless adjudicated, the riparian right is unquantified and extends to the use of as much water as can reasonably and beneficially be used on riparian lands. A riparian right is a shared right and, therefore, a riparian has a right to the use of the watercourse in common with the equal and correlative rights of other riparians. Finally, the riparian right generally is paramount to all other rights, and must be satisfied before appropriative rights are exercised. (CEB Manual, Water Rights, Water Supply, & Water Related Law (1987) at 7.)

4.1.3 *Prescriptive Rights*

Generally, "prescription" means the taking of another person's property by adverse use. With regard to water, prescription can only be accomplished by the adverse diversion and use of water that other private persons are entitled to use under the law. Subsequent to 1914, prescription will not lie against the State for the unappropriated waters of the State. (Water Code Sections 102 and 1225; Stats. 1913, C. 586, p. 1012, Section 1(c); Crane v. Stevinson (1936) 5 Cal.2d 387; People v. Shirokow (1980) 26 Cal.3d 301.)

As to private persons, prescription can be accomplished only by adverse possession that is actual, open and notorious, continuous and uninterrupted, exclusive, hostile and adverse, and under claim of right or color of title for a period of not less than five years. (Locke v. Yorba Irr. Co. (1950) 35 Cal.2d 205; City of Pasadena v. City of Alhambra (1949) 33 Cal.2d 908.) Even though some private rights may be prescripted, the unappropriated waters of the State and post-1914 appropriative water rights cannot be prescripted unless they are supported by a permit. (Shirokow.)

4.1.4 *Licenses*

Under the California permit system, once a permittee has completed construction of a diversion structure and applied the water to beneficial use, the SWRCB investigates to confirm completion and compliance. The SWRCB will issue a license confirming the amount of water found to have been perfected by reasonable beneficial use subject to the terms and conditions included in the permit and required by statute and California case law. (Water Code Sections 1600, et seq.)

4.2 Analysis of Cal-Am's Water Right Claims

Sections 4.2.1 though 4.2.4, *infra*, analyze the evidence introduced in support of Cal-Am's claimed water rights. For purposes of this order when evaluating Cal-Am's claims, the evidence in the hearing record is considered in the light most favorable to Cal-Am due to the difficulty, at this date, of obtaining evidence that specific pre-1914 appropriative claims of right were actually perfected and have been preserved by continuous use.

4.2.1 ***Analysis of Pre-1914 Appropriative Rights***

The lower Carmel River Valley, Monterey Peninsula, and surrounding areas were settled and developing before 1800. Many of Cal-Am's predecessors in interest developed or acquired appropriative water rights to divert water from the Carmel River and its subsurface waters prior to 1914. (CAL-AM:93, Attachment 1.) Cal-Am's predecessors in interest included: C.P. Huntington, Pacific Improvement Company, Monterey County Water Works, the Monterey County Water Works, Del Monte Properties Co., and California Water and Telephone Company. (*Id.*) Some of these appropriative rights were initiated and probably acquired in accordance with Civil Code Sections 1410, et seq. Other appropriative rights were acquired by the nonstatutory method of simply taking the water and putting it to reasonable beneficial use. (See 4.1.1, *supra*.)

Cal-Am submitted over 100 documents, including deeds and notices of appropriations by Cal-Am's predecessors, "which represent virtually all title documents bearing upon Cal-Am's water rights and chain of title." (CAL-AM, PHBr at 14:15-18.) Cal-Am Exhibit 93 (Attachment 1) summarizes the deeds and notices of appropriation pertaining to Cal-Am's appropriative rights. Nevertheless, Cal-Am did not present nor does the record contain any evidence which would enable the SWRCB to determine for each claimed pre-1914 appropriative right:[7] (1) whether diversion works were actually constructed, (2) whether water was ever diverted and used under any claimed right prior to 1914 or pursuant to a notice given in accordance with Civil Code Section 1410, or (3) the quantity of water which was put to reasonable beneficial use and maintained by continuous use by Cal-Am's predecessors.

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[7] *Despite the fact that Issue #2 was clearly noticed for hearing, Cal-Am asserted throughout the proceedings that the complaint proceedings were not the proper forum to evaluate Cal-Am's appropriative rights. (October 1, 1992 letter to Messrs. Stubchaer and Samaniego from Leonard G. Weiss transmitting supplemental exhibits at 1, n.1; CAL-AM Post-Hearing Brief, 13:14-18.) Nonetheless, Cal-Am submitted extensive evidence of its water rights based on deeds, notices of appropriation, and other documents.*

Cal-Am submitted two categories of documents to establish the total quantity of water used under all of its pre-1914 appropriative rights. These are:

> "(1) Direct evidence of actual usage in 1913 and earlier; and (2) Material dating back to the 1880s which demonstrate ... the existence of the water company's physical plant, dollar volumes of sales, and the like, prior to 1914." (CAL-AM, PHBr at 15:6-11; October 1, 1992 letter to SWRCB from Cal-Am transmitting supplemental exhibits.)

Several parties objected to the admissibility of the above exhibits on the ground that they are hearsay. (E.g., Carmel Valley Water Users, Closing Brief, 5-8.)

Title 23, California Code of Regulations, Section 761(d) provides, in part, that in a hearing before the SWRCB:

> "The hearing need not be conducted according to technical rules relating to evidence and witnesses. Any relevant, non-repetitive evidence shall be admitted *if it is the sort of evidence on which responsible persons are accustomed to rely in the conduct of serious affairs*. Hearsay evidence may be used for the purpose of supplementing or explaining any direct evidence but shall not be sufficient by itself to support a finding *unless it would be admissible over objection in civil actions* ...." (Emphasis added.)

Cal-Am exhibits are admissible under Section 761(d) because: (a) it is the sort of evidence on which responsible persons are accustomed to rely and (b) the exhibits would likely be admissible over objection in a civil action.[8] Moreover, these exhibits

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[8] *The SWRCB is of the opinion that those exhibits pertaining to proceedings of the California Railroad Commission would be admissible over objection in a civil trial. It is difficult to find a clear statement in the California Evidence Code or cases specifically addressing this evidentiary issue. However, there are multiple theories, including: the official notice doctrine, the official records exception to the hearsay rule, and other "residual" exceptions to the hearsay rule that support this conclusion.*

Official notice may be taken of the existence of any specific record of the California Railroad Commission. While official notice generally may not be taken of the truth of the Railroad Commission's factual findings (<u>see</u> <u>Sosinsky</u> v. <u>Grant</u> (1992) 8 Cal.Rptr.2d 552, 558-59), the factual statements within such exhibits are admissible under the official records exception to

(continued...)

likely are the best, if not the only, evidence available for events which occurred over eighty years ago. Thus, the SWRCB will allow Cal-Am's exhibits as evidence for the purpose of evaluating its pre-1914 appropriative claims.

These documents, however, do not show the amount of water that was actually used beneficially or maintained by continuous beneficial use by Cal-Am's predecessors under any specific pre-1914 appropriative rights. Thus, Cal-Am has not demonstrated that the

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[8] *(...continued)*
the hearsay rule. Section 1280 of the Evidence Code provides:

> *"Evidence of a writing made as a record of an act, condition, or event is not made inadmissible by the hearsay rule when offered to prove the act, condition, or event if:*
>
> > *(a) The writing was made by and within the scope of duty of the public employee;*
> >
> > *(b) The writing was made at or near the time of the act, condition, or event; and*
> >
> > *(c) The sources of information and method and time of preparation were such as to indicate its trustworthiness."*

In this case, those exhibits pertaining to proceedings of the California Railroad Commission generally satisfy the requirements of Section 1280. However, some courts have held that the public employee must have had personal knowledge of the act, condition, or event, or received the information recorded from someone in the agency who had personal knowledge in order for the official records exception to apply. (See People v. Parker (1992) 8 Cal.App.4th 114.) Because it is unclear whether any public official had personal knowledge of the quantity of water allegedly being used by Cal-Am's predecessor, it is possible that a court may find such information inadmissible under the official records exception. Nonetheless, the SWRCB concludes that these exhibits should be admitted under the official records exception because "the sources of information and method of time of preparation were such as to indicate [the exhibits'] trustworthiness." (See Cal. Evidence Code Section 1280(c).)

Alternatively, these exhibits would likely be admissible under one of the "residual" exceptions to the hearsay rule that allow California courts to recognize hearsay exceptions "in addition to those exceptions expressed in the statutes." (In re Malinda S, 51 Cal.3d 368, 376 (1990).) For example, evidence of a statement contained in a writing more than 30 years old is admissible if "the statement has been since generally acted upon as true by persons having an interest in the matter." (Cal. Evidence Code Section 1331.)

The deeds are admissible for the purpose of demonstrating chain of title. (Cal. Evidence Code Sections 1330 and 1600.) Finally, Exhibit 93 (Schematic of Chain of Title) is also admissible, but only to the extent the information therein is confirmed by the underlying documents which it purports to summarize.

notices of appropriation were ever perfected into appropriative rights.[9]

The best evidence regarding the amount of water actually put to reasonable beneficial use prior to 1914 by Cal-Am's predecessors is found in Cal-Am Exhibits 126, 131 and 133. The following sections briefly describe these exhibits:

(a) Exhibit 126 is a copy of a "Petition of the Monterey County Water Works For an Increase of its Water Rates," (MCWW) Application No. 950, filed before the California Railroad Commission on or about January 14, 1914. Exhibit "C" of this petition shows that in 1913 the MCWW sold a total of 314,879,755 gallons (966 afa) of water to its customers.

(b) Exhibit 131 is an MCWW brief to the Railroad Commission dated June 29, 1914, supporting its position for increased water rates. Page 6 of this brief discusses various estimates of water use and presents a likely total annual water use of 370,515,000 gallons (1,137 afa).

(c) Exhibit 133 is a January 27, 1915, engineer's report to the MCWW about the impact of the Railroad Commission's Decision regarding the MCWW's petition for a rate increase. Table 1A of this exhibit presents the MCWW's annual use of water in 1913-1914 as 43,444,600 cubic feet (997 afa).[10]

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[9] *Cal-Am's claimed pre-1914 appropriative rights could not possibly have been perfected and maintained for the face value of the rights being claimed. Assuming that the appropriative rights conveyed to Cal-Am were all perfected and maintained by continuous reasonable beneficial use, the maximum quantity which could be diverted from the Carmel River would be 751,608 afa, an amount which vastly exceeds the amount of water available in the river during even the wettest years of record. (MPWMD:199, Attachment 1 (showing maximum unimpaired Carmel River flow of approximately 325,000 afa).)*

[10] *The record contains other contradictory evidence as to the amount of water used prior to 1914. For example, less than 507 afa is reported as having been used in 1916. (CAL-AM:90.)*

These exhibits shed some light on the amount of water used by Cal-Am's predecessor in interest around 1914. These exhibits are inconclusive as to the actual amount of water used by the MCWW around 1914 due to the different water use figures. For purposes of this analysis and order, the 1,137 afa figure is used because: (1) the range between the high and low values is only fifteen percent and (2) it is reasonable to use the maximum annual water use estimate of 1,137 afa to establish the baseline quantity of water being used under pre-1914 appropriative claims.

In addition to the actual quantity of water used by Cal-Am's predecessors prior to 1914, Cal-Am might have been entitled to an additional quantity of water under the progressive use and development doctrine. However, Cal-Am neither asserted such a claim nor presented evidence which might support findings that it is entitled to additional water under the doctrine.[11] In addition, the diversion of a large amount of the water currently taken from the river or its underflow was not initiated until rapid growth occurred on the Monterey Peninsula, which commenced after 1960. (T,I,48:1-9; T,I,38:12-18; CAL-AM,90.) Cal-Am drilled 18 of its 21 wells after 1960. (CAL-AM:91.) Thus, Cal-Am is not entitled to additional water under the progressive use and development doctrine. Cal-Am's pre-1914 rights, therefore, should be limited to the estimated actual use by Cal-Am's predecessors in 1913, an amount which does not exceed 1,137 afa.[12]

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[11] *Indeed, Cal-Am requested that the Board "decline to attempt to quantify Cal-Am's rights until it hears Cal-Am's pending applications for permits." (CAL-AM's Post Hearing Brief at 21:9-11.) This request is rejected because this issue was noticed for this proceeding and Cal-Am had an opportunity to present evidence on the issue.*

[12] *Pre-1914 appropriative claims for San Clemente Dam. Persons diverting water under pre-1914 claims or right are required to file Statements of Diversion and Use with the SWRCB. (Water Code Sections 5100, et seq.) Cal-Am filed its first statements for San Clemente Dam in 1975. Cal-Am contends that this right was established under four Notices filed under the Civil Code. (CAL-AM, Exhibit A, pp.3 and 4; CAL-AM exhibits 4, 5, 6 and 8.)*

The first statements included water diverted for years 1972 through 1975. The statements indicate that Cal-Am was able to divert 1,529 af to storage at San Clemente Reservoir and that Cal-Am was claiming the right to divert up to 20 cfs by direct diversion. Over succeeding years, Cal-Am has

(continued...)

4.2.2 *Analysis of Riparian Rights*

Cal-Am's riparian claims are limited to the use of water on only those parcels which adjoin the surface water course of the river or which overlie water flowing in the subterranean channel.[13] Clearly, Cal-Am wells extract water flowing in the subterranean channel. Cal-Am also presented testimony indicating that 60 afa were used to irrigate riparian habitat along the river. (T,I,54:3-10.) Nevertheless, Cal-Am did not identify any specific parcels for which riparian claims were asserted. In summary, although Cal-Am did not submit testimony or exhibits in support of any specific riparian claim, it appears that Cal-Am has riparian rights and it is not unlikely that such rights are being exercised to divert 60 af to irrigate riparian vegetation along the Carmel River.[14]

4.2.3 *Analysis of Prescriptive Rights*

Cal-Am bases its claim to prescriptive water rights on the alleged fact that the claimed combined diversions of two of Cal-Am's predecessors depleted the flow in the Carmel River (CAL-AM: October 1, 1992 letter to SWRCB from Cal-Am transmitting supplemental exhibits, pp. 7 and 8; CAL-AM:136,2) during some years and the fact that the Carmel River often has no surface flow. (CAL-AM:132,14.) Assuming the truth of these facts, Cal-Am's post-1914 claims of prescriptive rights are, nevertheless, not supported

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[12] *(...continued)*
stated that it has approximately diverted between 1,200 to 8,000 af per year under this claim. (SWRCB, Files, Statements of Diversion and Use, Statement 8538.) More recent information indicates the dam can only store between 320 and 800 af. (MPWMD:287,4-49.) Amounts which are currently directly diverted are taken at the Carmel Valley Filter Plant about one-half mile below the San Clemente Dam.

San Clemente Dam was constructed in 1921, seven years after the modern Water Code respecting appropriation became effective. No evidence was presented: (1) as to which, if any, Notice is the basis for the pre-1914 claim of right, (2) that work was commenced on facilities to divert water prior to 1914, or (3) that water was diverted and used prior to 1914 or within a reasonable time thereafter under any Civil Code Notice.

[13] *Cal-Am does not claim that water being diverted from the subterranean channel associated with the Carmel River can be served to persons on the Monterey Peninsula under riparian rights claims. (T,I,91:13-92:8.)*

[14] *Cal-Am does not claim that water served outside the valley can be diverted from the river under riparian right claims. (T,I,91:13-92:8.)*

by the record because Cal-Am failed to introduce other essential evidence necessary to support prescriptive claims. Cal-Am did not: (1) demonstrate that the basic elements of prescription were met and (2) identify any specific persons, lands, or types of water rights that were allegedly prescripted. Thus, there is no basis for finding that Cal-Am is entitled to divert any water from the river under the doctrine of prescription.

4.2.4 *Analysis of Rights Under License 11866 (Application 11674A)*

On February 14, 1986, Cal-Am was issued License 11866 (Application 11674A) to divert 3,030 afa to storage from October 1 to May 31 from the Carmel River for municipal, domestic, industrial, and recreational uses. (SWRCB:1,b.) The maximum annual withdrawal under this right, however, is 2,950 afa. The above analysis of appropriative, riparian, and prescriptive rights does not affect the rights exercised under License 11866.

4.3 Conclusions Regarding Cal-Am's Claimed Water Rights

In summary, Cal-Am has valid pre-1914 appropriative rights to divert no more than 1,137 afa, based upon the amount of water actually used by Cal-Am's predecessors prior to 1914. Cal-Am is not entitled to additional water under the progressive use and development doctrine because Cal-Am did not present evidence of a plan of development carried out within a reasonable time.

Cal-Am has riparian rights for use within the Carmel River Valley on only those parcels which adjoin the surface watercourse of the river or which overlie water flowing in the subterranean channel. It is not unlikely that such rights are being exercised to irrigate the riparian vegetation along the Carmel River. Such rights do not extend to water that is served outside the valley or water served to non-riparian parcels located within the valley.

Cal-Am is not entitled to any prescriptive water rights because Cal-Am did not identify the persons, lands, or types of water rights that are allegedly prescripted. Cal-Am has an appropriative right to divert 3,030[15] afa of water to storage in Los Padres Reservoir from October 1 to May 31 pursuant to the conditions imposed by License 11866. Thus the total quantity of water which Cal-Am is presently using under legal rights is 3,376 afa.[16]

Because the amount of water to which Cal-Am is legally entitled under the appropriation and riparian doctrines, pre-1914 storage rights, and License 11866 is much less than the amount Cal-Am presently is diverting, Cal-Am is diverting about 10,730[17] afa from the Carmel River or its underflow without a valid basis of right. Accordingly, Cal-Am should be required to diligently develop and implement a plan for obtaining water from the Carmel River or other sources consistent with California water law.

5.0 EFFECT OF CAL-AM DIVERSION ON INSTREAM BENEFICIAL USES

The following sections will discuss the effects of Cal-Am's diversions on the instream beneficial uses of the Carmel River. Such effects include the loss of riparian habitat in the lower river and the near extinction of the Carmel River steelhead run. Cal-Am diversions, standing alone, are not the sole cause of current conditions in the Carmel River. Other causes include the diversion and use of water by other persons and, significantly, a series of dry and critically dry years during the late 1980s and early 1990s. Nevertheless, Cal-Am's combined diversions from the Carmel River constitute the largest single impact to the instream beneficial uses of the river.

5.1 Vegetative Resources

Three vegetation communities are found within the Carmel River watershed: coastal wetlands within the Carmel River Lagoon,

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[15] *The actual diversion is limited to 2,179 af due to siltation.*

[16] *1,137 afa, pre-1914 appropriative + 60 afa, riparian + 2,179 afa, license 11866 = 3,376.*

[17] *10,730 afa represents Cal-Am's total diversions from the Carmel River minus that amount which appears to be legally diverted. (14,106 - 3,376 = 10,730.)*

riparian communities along the river itself, and upland vegetation on the upper alluvial terraces and hills surrounding the valley. Mature multistoried riparian vegetation supports a wide diversity of plant and animal species, including a number of which are protected pursuant to federal and state endangered species acts.

Historically, riparian vegetation was more extensive than at present, particularly in the lower nine river miles. Prior to 1956, losses were primarily attributable to agricultural development. Since that time, the decline has coincided with the increasing export of ground water to meet growing urban demand on the Monterey Peninsula. (SWRCB:17; SWRCB:42,III-28.) Were it not for the extensive riparian corridor irrigation efforts of the District and Cal-Am, it is estimated that current ground water pumping would severely stress approximately 59 percent of the existing riparian vegetation in the upper portion of Aquifer Subunit 3 (see Figure 2) in normal water years, and nearly all vegetation during critically dry years. (MPWMD:289,9G-1.)

The Carmel River Lagoon contains a mixture of freshwater and salt marsh vegetation. Coastal salt marsh is considered one of the most fragile and rapidly disappearing habitats in California. The Carmel River coastal wetland represents some of the last remaining habitat of this type on the Central Coast. (SWRCB:42,III-32.)

Upland vegetation within the watershed is composed of a mixture of coastal scrub, hardwood forest, coastal dune, chaparral, and closed-cone coniferous forest. Cal-Am's diversions have no direct effect on such resources.

5.2 Wildlife Resources

Carmel River riparian and wetland communities support a diverse group of resident and migratory wildlife. A number of amphibian and reptile species occur within the riparian and wetland zones as well, including the red-legged frog and the western pond turtle. These are, respectively, a proposed and candidate species for listing under the Federal Endangered Species Act. A more detailed description of these resources is found in the District's EIR/EIS. (MPWMD:287-290.)

5.3 Fishery Resources

The Carmel River supports populations of at least ten resident freshwater and anadromous fish species. Of these fishes, the steelhead (*Onchrhynchus mykiss*) has been considered the most important, and extensive studies have been performed to define its ecology in the river. (SWRCB:42,III-41.)

Adult steelhead live in the ocean and migrate into the upper reaches of the Carmel River to spawn. Migration may begin in the fall after the Lagoon sandbar is breached by artificial means or by the first major storm and when sufficient flow is established in the lower river to allow upstream passage.

Typically, in early January the adults spawn and migrate back to the ocean. After approximately three to eight weeks of incubation, depending on water temperature, the eggs hatch and fry soon emerge from the gravel. These fry continue development in the river until fall. By fall, fry will have developed into juveniles and begin moving downstream. They remain in the lower reaches of the river and the lagoon adapting to brackish water until late spring. In late spring, as high river flows are receding, they migrate out into the Pacific Ocean. Some juveniles and adults remain in the river for one or two additional years before migrating to the ocean, hence these life stages may be found in the river throughout the entire year. (SWRCB:42,III-42.)

5.4 Extent of the Steelhead Resource

When first seen by Spanish explorers in 1603, the Carmel River supported a spectacular steelhead run, believed to have been well in excess of 12,000 fish annually. (CSRA:5,2.) Heavy fishing in the 1850s through the 1870s diminished the fishery. Fish planting began in 1910 and continued through the 1940s. (MPWMD:289,8-8.)

When San Clemente Dam was constructed in 1921 (RM 18.5), a fish ladder was also built. (MPWMD:289,8-8.) Access to a major portion of the steelhead spawning and rearing habitat was effectively eliminated in 1949 with the construction of Los Padres Dam at RM 23.5. (CSRA:5,2.) Although a fish trap was installed downstream of the dam and captured adults transported into the reservoir, the facility proved ineffective at maintaining steelhead populations. (MPWMD:289,8-8.)

Annual counts of steelhead passing through the San Clemente fishway began in 1961. The critical dry years of 1976-77 and 1987-92, drought, and diversion by Cal-Am from its wells have combined to reduce water available to steelhead and have also reduced the steelhead population to remnant levels. Only one fish was recorded in 1991 and 15 fish in 1992. (MPWMD:337,49.) Past reviews of Carmel River environmental problems have identified flow reduction and habitat alteration as major factors associated with steelhead decline. (SWRCB:42,III-44.)

Paralleling the declining steelhead population during this period was the rising urban demand for water. Originally, the Monterey Peninsula water supply was diverted entirely from the two reservoirs and from surface flow. When demand exceeded the developed surface resources, wells drilled in the Carmel Valley alluvium aquifer were added to supplement supply. In recent times, dry season surface flows below the Narrows at RM 10 have been depleted in most years as a result of heavy ground water pumping. This results in the stranding and death of many juvenile fish as surface flow recedes. (DFG:4,32.)

5.5 The Effect of Cal-Am Diversions Should be Mitigated

To summarize, Cal-Am diversions have historically had an adverse effect on: (1) the riparian corridor along the river below RM 18.5, (2) wildlife which depend on riparian habitat, and (3) steelhead and other fish which inhabit the river. Measures should be adopted requiring Cal-Am to mitigate the effect of its diversions on the environment until such time as it is able to obtain water from the Carmel River or other sources consistent with California water law.

6.0 MITIGATING EFFECTS OF CAL-AM DIVERSIONS

The following sections identify the measures which are in effect to mitigate the effect of Cal-Am's diversions in the instream beneficial uses of the Carmel River. Many significant measures to protect the instream beneficial uses of the river have been initiated and are being carried out by the Monterey Peninsula Water Management District. In order to avoid confusion, an explanation of the District's role is necessary.

The District was created by special act of the Legislature in 1977. (Water Code Appendix Section 118-2.) The District is responsible for managing available surface and ground water sources to supply water within the District and to protect the environmental quality of the area's water resources, including the protection of fish and wildlife resources. (*Id.*; MPWMD:16,1-2.) Much of the watershed of the Carmel River is within the District's boundaries (Figure 1) and the District has broad powers over the use and distribution of water within its boundaries, including the operations of Cal-Am. (Water Code Appendix Sections 118-2, 118-102.)

6.1 Interim Relief Program

In 1988, as a result of the complaint filed by the CRSA (Section 2.1), the District formed an Environmental Advisory Committee. The committee was composed of citizen groups and public agency representatives, including representatives from Cal-Am and DFG. (MPWMD:53;3&4.) Their efforts resulted in an Emergency Relief Program and an Interim Relief Program, both designed to address chronic environmental degradation in the lower Carmel River. (MPWMD:53.)

The focus of the Interim Relief Program was on rescuing stranded steelhead during critically dry years, preserving the riparian corridor, and enhancing aquatic habitat by increasing streamflow. Specifically, the District undertook to: (1) limit surface diversion at San Clemente Dam to 29 percent of total Cal-Am production, (2) hire fishery professionals to assess habitat and coordinate steelhead rescue efforts, and (3) monitor the health of riparian vegetation and install, operate, and maintain drip irrigation systems along the lower Carmel River. The provisions of the program expired in November 1993, but are carried forward as elements of the Water Allocation EIR mitigation program of the District. (MPWMD:53; SWRCB:42.)

6.2 Water Allocation Mitigation Program

In 1981, the District established an annual Water Allocation Program to apportion water to each of its member jurisdictions. In 1990, a Water Allocation Program EIR was completed and certified by the District. (SWRCB:42; MPWMD:16.) The EIR analyzed the environmental and socioeconomic impacts of varying levels of water production from the Monterey Peninsula Water Resource System, including the Carmel River. The document found that the amount of water which could be produced without significant environmental impact was less than previous estimates. As a result, the Cal-Am allocation was reduced from 18,600 to 16,744 afa.[18] Even at the reduced level, diversion of water from the Carmel River was found to have significant adverse environmental impacts on fisheries, riparian vegetation and wildlife, and the Lagoon. Therefore, the District also approved the Water Allocation Mitigation Program and committed itself to implement the mitigation program. The Program provides for the following mitigation measures:

Fisheries (MPWMD:16,55)

- Continue Interim Relief Program
- Expand program to capture emigrating smolts in spring
- Prevent stranding of early fall and winter migrants
- Rescue juveniles downstream of Robles Del Rio in summer

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[18] *The quantity of water which the District allocated to Cal-Am was not based on the amount of water diverted by Cal-Am and not on Cal-Am's legal right to divert water.*

- Modify spillway and transport juveniles around Los Padres Dam

Riparian Vegetation and Wildlife (MPWMD:16,64)

- Continue Interim Relief Program
- Conservation and water distribution management to retain water in the Carmel River
- Prepare and oversee a Riparian Corridor Management Plan (MPWMD:69)
- Implement the Riparian Corridor Management Plan
- Expand monitoring programs for soil moisture and vegetative stress

Lagoon Vegetation and Wildlife (MPWMD:16,72)

- Continue Interim Relief Program
- Assist with Lagoon Enhancement Plan investigations
- Expand long-term monitoring program
- Identify feasible alternatives to maintain adequate Lagoon volume

The program was adopted and funded by the District for an initial five-year period, due to expire in late 1995, after which allocations are to be reassessed based on results of monitoring studies. Annual progress reports have been prepared by the District and submitted to the SWRCB. (SWRCB:43; MPWMD:307-308.) Funded primarily by user fees and taxes, the program costs will slightly exceed $6.5 million over five years. (MPWMD:309.)

The effectiveness of this mitigation program and the degree to which the District has implemented the mitigation program was the subject of considerable testimony during the SWRCB hearing. Both the CSRA and the DFG expressed dissatisfaction with the implementation of the program. (CRSA:94-1,3; T,X,100:2.) Further, DFG stated that it was the Department's position that fish rescue is inappropriate as a long-term mitigation measure and that provision of adequate instream flow is the preferable alternative. (T,IX,8:2.)

6.3 Other District Actions

In addition to the above programs, the District has engaged in a number of other activities to lessen the impact of water extraction on the Carmel River system. These measures include:

- Limitation on total system production
- Mandatory rationing and moratoriums
- Conservation and community education programs
- Development of Seaside aquifer
- Wastewater reclamation

Although these programs have been effective in reducing demand on the Carmel River, their combined effect is inadequate to reverse severe environmental degradation. It is the position of the District and DFG wildlife experts that river flow is the critical element in reversing this degradation. The District has also concluded that a firm municipal supply and water for environmental restoration cannot be provided without additional water storage upstream of Cal-Am's existing well field. (MPWMD:287,2-8.)

6.4 Conditions On the Operation of Los Padres and San Clemente Dams

In 1948 the SWRCB adopted Decision 582 approving an appropriative right for the Los Padres Dam. The Decision and Permit 7130 require, in general, that Cal-Am maintain a flow of not less than 5 cfs in the channel of the Carmel River directly below the outlet structure of the Los Padres Dam at all times during which water is being stored under this permit.

Diverting under a claim of pre-1914 appropriative right, San Clemente Dam has no bypass requirement and, until the early 1980s, the entire summer streamflow was diverted into the filter plant downstream of San Clemente Dam. (DFG:4,8.) During the 1980s, DFG and Cal-Am began negotiating year-to-year agreements for the release of some water at San Clemente Dam to benefit fish in the river. Bypass flows have generally been in the range of 3.5 to 5 cfs. Under more normal hydrologic conditions, the bypass maintains flow in the stream to the Narrows at RM 10. This habitat below San Clemente Dam is considered significant steelhead habitat.

6.5 Interim Measures to Mitigating Effects of Cal-Am Diversions Should Continue to be Implemented

As previously stated, Cal-Am's diversions have an adverse effect on the instream beneficial use of the river. Although the interim measures discussed herein are beneficial, they are by no means sufficient to offset the total effect of Cal-Am's diversions. Thus, these measures should be continued until such time as Cal-Am is able to obtain water from the Carmel River or other sources consistent with California water law.

That most interim measures have been undertaken by the District and not Cal-Am is a matter of concern. There is no assurance that the District will indefinitely continue to mitigate the effects of Cal-Am's diversions. Furthermore, there is no basis for the SWRCB to order the District to continue implementing the interim measures on behalf of Cal-Am. Thus, a condition should be adopted requiring Cal-Am to implement these interim measures in the event the District fails to continue with its programs.

7.0 OTHER PROPOSALS FOR MITIGATING THE EFFECTS OF CAL-AM DIVERSIONS FROM THE CARMEL RIVER

In addition to the interim mitigation measures being implemented by the District, the Complainants, DFG, and Mr. Evans contend that additional mitigation measures should be implemented by Cal-Am. Some of these measures are discussed in the following sections.

7.1 Maximize Production in Seaside Aquifer, Minimize Production from Carmel River

Several parties advanced the concept that production from the Seaside aquifer should be increased and diversions from the Carmel River should be reduced. Cal-Am produces about 2,700 afa from the Seaside ground water basin from wells in Seaside, California. The Seaside northern and southern coastal ground water subbasins have a usable storage capacity of 4,700 af. (MPWMD:101,6,144.) The long-term yield of the Seaside ground water subbasin, however, is estimated to be 3,300 afa, using the practical rate of withdrawal method. (SWRCB:1, "Hydrology Update, Seaside Coastal Ground Water Basins, Monterey County, California", Staal, Gardner & Dunne, Inc., 1990, p.22.) A new well became available to Cal-Am and its customers during 1994, the Peralta Well, which is located in the Seaside aquifer. The well is capable of producing approximately 1,000 afa. The District has allocated the potential production from the Peralta Well for purposes which include water for community benefit and among eight jurisdictions for new connections, remodeling, and additions. (MPWMD,291,4:1-17; MPMD,3378,28,Figure 10.) By more fully utilizing water available in the Seaside aquifer, Cal-Am can reduce its diversions from the Carmel River and the effects of such diversions on public trust values. Thus, we find that Cal-Am should be required to maximize production from the Seaside aquifer and reduce diversions from the river to the greatest practicable extent.

7.2 Maximize Production from the Most Downstream Wells

Several parties advanced the proposal that by maximizing production from the most downstream wells that surface water in the Carmel River could be extended farther downstream.[19] The benefit of operating the wells in this manner would be to provide more habitat for fish during some years and seasons. (T,IV,248:24-251:3.) Testifying for DFG, Keith Anderson indicated that Cal-Am was already operating in this manner pursuant to an agreement with DFG. (T,IX,17:2-10.) Testimony did indicate, however, that too much pumping of wells nearer to the Lagoon might result in water quality degradation and adversely affect supply of water to other wells. Thus, we find that Cal-Am should be required to satisfy the water demands of its customers outside of the Carmel River watershed by extracting water from its most downstream wells to the maximum practicable extent.

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[19] *Some parties advocated drilling more wells farther down the river as near to the Lagoon as possible. The feasibility of this proposal was not demonstrated. Testimony and exhibits indicated that such wells and pumping could result in: (a) poorer water quality for Cal-Am customers, (b) dewatered wells used by other persons in the area, and (c) seawater intrusion into the lower aquifer. (T,IV,251:4-254:4; 258:5-269:4; 272:14-284:2.)*

7.3 Supply Water to the Carmel Village Filter Plant from Wells

The Carmel Village is supplied water from a filter plant located downstream of the San Clemente Dam. The filter plant is supplied water from the dam via a pipeline. Several parties advanced the proposal that more surface flow could remain in the river if the filter plant was supplied water from wells instead of the dam. The water diverted to storage at the dam could then be released to the river for fish and to recharge the subterranean stream from which the downstream wells extract water. No evidence was presented to demonstrate the feasibility of the proposal. Indeed the evidence indicates that it is not feasible to supply water to the filter plant from the most downstream wells. No evidence was introduced which would indicate whether the filter plant could be supplied from more nearby wells and thus keep more water at the surface of the stream for some additional distance. We find that Cal-Am should be required to conduct a reconnaissance level study of the feasibility, benefits, and costs of this proposal.[20]

7.4 Bypass Early Storm Runoff at the Dams

On behalf of DFG, Keith Anderson suggested that runoff from early storms be passed by the Los Padres and San Clemente Dams. (T,IX,21:4-22:6.) This proposal can result in recharging the subterranean stream and restoring surface water flows in the river at an earlier date. An earlier reestablishment of surface flows would increase the likelihood that steelhead could successfully migrate up and down the stream to complete their life cycle. The record does not include any evidence which demonstrates the feasibility of this suggestion; however, the storage capacity of the dams is so small that it appears likely that this suggestion could be implemented in even the driest water years and the

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[20] *The SWRCB recognizes that the wells nearest the filter plant are not the most downstream wells. The feasibility of supplying the filter plant may depend upon supplying the plant via the nearest wells. Supplying the filter plant from nearby wells would, implicitly, conflict with the principle that water be supplied to Cal-Am customers via the most downstream wells to the maximum practicable extent. Nevertheless, we find that the feasibility, benefits, and costs of this proposal should be evaluated.*

reservoirs could still be refilled. We find that Cal-Am should be required to study the feasibility of this proposal.

7.5 Modify Critical Stream Reaches to Facilitate Fish Passage

In the context of this section, a critical stream reach means any portion of the river which, due to low flow, acts as a barrier to migrating steelhead. Such barriers interfere with the ability of steelhead to successfully complete all life stages and to reproduce in the river. Testifying for DFG, Keith Anderson expressed the opinion that modifying critical stream reaches was an action which could be taken to mitigate the effect of Cal-Am's diversions from the river. (T,IX,20:24-21:3.) Thus, we find that Cal-Am should be required to conduct a study of the feasibility, benefits, and cost of this proposal.

7.6 Remove Boulder Below Los Padres Dam

A large boulder or rock outcrop is situated below the spillway of Los Padres Dam. A significant percentage of steelhead juvenile fail to survive downstream migration during low water conditions over the spillway because they fall upon the rock. Removal of the rock could improve the survival rate of steelhead juvenile moving downstream from Los Padres Dam. Accordingly, Cal-Am should be required to remove the rock or implement some other reliable measure to assure safe passage for fish over or around the rock.

8.0 ENFORCEMENT OPTIONS

Three enforcement options are available to the SWRCB for the unlawful diversion and use of water. First, Water Code Section 1052 declares that the unauthorized diversion of water is a trespass. Such diversions may be referred to the Attorney General for injunctive relief. (Section 1052(c).) Persons committing a trespass may be liable for up to $500 for each day in which a trespass occurs. (Section 1052(d).)

Second, Water Code Sections 1055 and 1052 authorizes the SWRCB to impose administrative civil liability for the unlawful diversion and use of water. Persons committing a trespass may be liable for up to $500 for each day in which a trespass occurs. (Section 1052(b).) Persons committing a trespass may be liable for up to $500 for each day in which a trespass occurs.

Finally, Sections 1825, et seq. authorizes the SWRCB to adopt cease and desist orders for violation of conditions in permits and licenses. Cease and desist orders may require compliance forthwith or in accordance with a time schedule. (Section 1831.) Diversion of water in excess of the quantity authorized by permit or license can be treated as a violation subject to enforcement under Section 1831. Persons failing to comply with a cease and desist order are liable for $1,000 for each day in which violation occurs.

This proceeding was not noticed under any of the enforcement provisions and the SWRCB cannot, at this time, proceed directly to an order under Sections 1055 or 1830. The SWRCB, however, can request the Attorney General to take action under Section 1052. Alternatively, the SWRCB can suspend such a referral provided that Cal-Am takes appropriate actions to: (a) mitigate the effect of its diversions on the environment and (b) develop and diligently pursue a plan for obtaining water from the Carmel River or other sources consistent with California water law.[21]

8.1 Considerations Mitigating Against the Use of Punitive Enforcement Options

In the short term, Cal-Am cannot significantly reduce its extraction from the wells along the Carmel River. As previously stated, most of Cal-Am's supply is obtained from the Carmel River and most of that supply is provided by the wells along the river. The people and businesses on the Monterey Peninsula must continue to be served water from the Carmel River in order to protect public health and safety.

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[21] *Cal-Am could satisfy this requirement by contracting with MPWMD for the supply from its proposed project or by proposing to develop water under applications to appropriate water from the Carmel River by storage or from other sources.*

Cal-Am introduced exhibits during the hearing which show that during 1980 and 1981, on the basis of available information, the SWRCB was not of the opinion that the water pumped by the wells would require a permit from the SWRCB. (CAL-AM, F and G.) Further, Cal-Am does not contend that the wells are not extracting water from a subterranean stream. (CAL-AM, Closing Brief, 20.) Indeed, Cal-Am has filed an application to appropriate water with the SWRCB. (Application 30215.)[22]

Cal-Am also supports the New Los Padres Project proposed by the District as one means for providing a reliable and legal water supply for its customers. (CAL-AM, Closing Brief, 2:4-12.) Finally, Cal-Am has cooperated with the District, DFG, and others to develop and implement measures to mitigate the effect of its diversions on the instream resources of the river. (MPWMD:287,2-15.)

Under circumstances such as these, the imposition of monetary penalties make little sense. Rather, the SWRCB's primary concern should be the adoption of an order which, until a legal supply of water can be developed or obtained, will require that Cal-Am: (1) minimize its diversions from the Carmel River, (2) mitigate the environmental effects of its diversions, and (3) prepare a plan setting forth: (a) specific actions to develop or obtain a legal supply of water and (b) the dates specific actions will have occurred so that progress on the plan can be objectively monitored.

9.0 SUMMARY AND CONCLUSIONS

To summarize the foregoing, we find that:

1. Downstream of RM 15 of the Carmel River, the aquifer underlying and closely paralleling the surface water course of the Carmel River is water flowing in a subterranean stream and subject to

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[22] *Administrative notice is taken that on May 29, 1992, Cal-Am submitted Application 30215 to the SWRCB. The application is for the direct diversion of 42 cfs from its wells along the river.*

the jurisdiction of the SWRCB. Cal-Am's wells are drawing water from the subterranean stream associated with the Carmel River.

2. Cal-Am is diverting about 10,730 afa from the Carmel River or its underflow without a valid basis of right. In addition, Cal-Am does not have a pre-1914 right to divert and use water at San Clemente Dam. Cal-Am should be required to diligently develop and implement a plan for obtaining water from the Carmel River or other sources consistent with California water law.

3. Cal-Am diversions are having an adverse effect on: the riparian corridor along the river below San Clemente Dam at RM 18.5, wildlife which depend on instream flows and riparian habitat, and steelhead which spawn in the river. Interim measures mitigating the effects of Cal-Am diversions undertaken by the District should continue to be implemented. Cal-Am should be required to implement interim measures in the event the District fails to continue with its program. In addition, Cal-Am should be required to implement other mitigation measures. Cal-Am should be required to mitigate the effect of its diversions until such time as it is able to obtain water from the Carmel River or other sources consistent with California water law.

4. The SWRCB can request the Attorney General to take action under Section 1052. Alternatively, the SWRCB can suspend such a referral provided that Cal-Am takes appropriate actions to: mitigate the effect of its diversions on the environment and develop and diligently pursue a plan for obtaining water from the Carmel River or other source consistent with California water law. The SWRCB's primary concern should be the adoption of an order requiring Cal-Am to: (1) prepare a plan setting forth (a) specific actions which will be taken to develop or obtain a legal supply of water and (b) the dates specific actions will have occurred so that progress on the plan can be

objectively monitored, (2) minimize its diversions for the Carmel River, and (3) mitigate the environmental effects of its diversions.

ORDER

NOW THEREFORE, IT IS HEREBY ORDERED that Cal-Am shall comply with the following conditions:

1. Cal-Am shall forthwith cease and desist from diverting any water in excess of 14,106 afa from the Carmel River, until unlawful diversions from the Carmel River are ended.

2. Cal-Am shall diligently implement one or more of the following actions to terminate its unlawful diversions from the Carmel River: (1) obtain appropriative permits for water being unlawfully diverted from the Carmel River, (2) obtain water from other sources of supply and make one-for-one reductions in unlawful diversions from the Carmel River, provided that water pumped from the Seaside aquifer shall be governed by condition 4 of this Order not this condition, and/or (3) contract with another agency having appropriative rights to divert and use water from the Carmel River.

3. (a) Cal-Am shall develop and implement an urban water conservation plan. In addition, Cal-Am shall develop and implement a water conservation plan based upon best irrigation practices for all parcels with turf and crops of more than one-half acre receiving Carmel River water deliveries from Cal-Am. Documentation that best irrigation practices and urban water conservation have already been implemented may be substituted for plans where applicable.

   (b) Urban and irrigation conservation measures shall remain in effect until Cal-Am ceases unlawful diversions from the Carmel River. Conservation measures required by this Order in combination with conservation measures required by the District shall have the goal of achieving 15 percent conservation in the 1996 water year and 20 percent conservation in each subsequent year.[23] To the extent that this requirement conflicts with prior commitments (allocations) by the District, the Chief, Divison of Water Rights shall have the authority to modify the conservation requirement. The base for measuring conservation savings shall be 14,106[24] afa. Water conservation measures required by this order shall not supersede any more stringent water conservation requirements imposed by other agencies.

4. Cal-Am shall maximize production from the Seaside aquifer for the purpose of serving existing connections, honoring existing commitments (allocations), and to reduce diversions from the Carmel River to the greatest practicable extent. The long-term yield of the basin shall be maintained by using the practical rate of withdrawal method.

5. Cal-Am shall satisfy the water demands of its customers by extracting water from its most downstream wells to the maximum practicable extent, without degrading water quality or significantly affecting the operation of other wells.

6. Cal-Am shall conduct a reconnaissance level study of the feasibility, benefits, and costs of supplying water to the Carmel Valley Village Filter Plant from its more nearby wells downstream of the plant. The objective of supplying water from the wells is to maintain surface flow in the stream as far downstream as possible by releasing water from San Clemente Dam for maintenance of fish habitat. The results

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[23] *Each water year runs from October 1 to September 30 of the following year.*

[24] *14,106 afa represents Cal-Am's total diversions from the Carmel River.*

of the study and recommendations shall be provided to the District and DFG for comment.

7. Cal-Am shall evaluate the feasibility of bypassing early storm runoff at Los Padres and San Clemente Dams to recharge the subterranean stream below San Clemente Dam in order to restore surface water flows in the river at an earlier date. The results of the study and recommendations shall be provided to the District and DFG for comment.

8. Cal-Am shall conduct a study of the feasibility, benefits, and costs of modifying critical stream reaches to facilitate the passage of fish. The study shall be designed and carried out in consultation with DFG and the District. The results of the study and recommendations shall be provided to the District and DFG for comment.

9. The studies required by conditions 6, 7, and 8 shall be carried out by persons with appropriate professional qualifications. The studies required by condition 7 shall be completed and submitted to the Chief, Division of Water Rights, within 5 months from the date of this order. The Chief, Divison of Water Rights may extend the time for performing the study required by condition 8 upon making a finding that adequate flows were not available to perform the study. The studies required by conditions 6 and 8 shall be completed and submitted to the Chief, Division of Water Rights, within 12 months from the date of this order. The Chief, Division of Water Rights may extend the time for performing the study required by condition 8 upon making a finding that adequate flows were not available to perform the study. The report (or reports) transmitting the results of the study (or studies) shall describe the action (or actions) which Cal-Am will undertake to correct the problems addressed by the studies. Cal-Am shall provide a written response to any comments received on the study. If no action (or actions) will be taken to correct the underlying problem (or problems),

Cal-Am's report shall provide written justification why corrective action is not appropriate. Based upon the results of the studies, recommendations, comments by the District and DFG, and Cal-Am responses, the Chief, Division of Water Rights, shall determine what actions shall be taken by Cal-Am consistent with this Order and establish reasonable times for implementation.

10. Cal-Am shall remove the large rock immediately below the spillway of the Los Padres Dam which results in substantial loss of juvenile steelhead or implement some other reliable measure (or measures) to assure safe passage for fish over or around the rock. Prior to removing the rock Cal-Am shall consult with DFG and obtain any streambed alteration permit required by Fish and Game Code Section 1601. If Cal-Am leaves the rock in place, it shall consult with DFG when evaluating what other measures can be used to assure safe fish passage. Cal-Am shall comply with this measure within 4 months.

11. Cal-Am shall be responsible for implementing all measures in the "Mitigation Program for the District's Water Allocation Program Environmental Impact Report" not implemented by the District after June 30, 1996.[25] Not later than August 30, 1996, Cal-Am shall submit a report to the Chief, Division of Water Rights, identifying mitigation measures which the District does not continue to implement after June 30, 1996. At the same time, Cal-Am shall submit a plan for the approval of the Chief, Division of Water Rights, detailing how it will implement mitigation measures not implemented by the District. The Chief, Division of Water Rights, may excuse Cal-Am from implementing specific mitigation measures only upon making a finding that Cal-Am has demonstrated that it does not have

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[25] *On November 5, 1990 the District adopted a mitigation program to be carried out for five years. The plan is summarized in Section 6.2, infra. There is no assurance the District will continue with any or all of the elements of its mitigation program after November of 1995. (MPWMD:289, Vol. III, Appendix 2-D.)*

adequate legal authority to implement the ability to finance such measures or demonstrates that such measures are demonstrably ineffective.

12. Within 90 days of the date of this order, Cal-Am shall submit for the approval of the Chief, Division of Water Rights:

    (a) A compliance plan detailing the specific actions which will be taken to comply with condition 2 and the dates by which those actions will be accomplished;

    (b) An urban water conservation plan; and

    (c) An irrigation management plan.

13. Starting with the first full month following adoption of this order, Cal-Am shall file quarterly with the Chief, Division of Water Rights:

    (a) Reports of the monthly total amounts being: (1) pumped from wells; and (2) diverted from the Carmel River,

    (b) Reports of the progress being made in complying with the schedule submitted to comply with condition 11, and

    (c) Reports of the progress being made in complying with conditions 6, 7, 8, and 9.

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14. The Chief, Division of Water Rights, is authorized to refer any violation of these conditions to the Attorney General for action under Section 1052 or to initiate such other enforcement action as may be appropriate under the Water Code.

CERTIFICATION

The undersigned, Administrative Assistant to the Board, does hereby certify that the foregoing is a full and correct copy of an order duly and regularly adopted at a meeting of the State Water Resources Control Board held on July 6, 1995.

AYE:	John P. Caffrey Mary Jane Forster Marc Del Piero James M. Stubchaer John W. Brown
NO:	None
ABSENT:	None
ABSTAIN:	None

Maureen Marché

Maureen Marché
Administrative Assistant to the Board