William D. Gardner

UNITED STATES
DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary
BUREAU OF RECLAMATION
Wilbur Dexheimer, Commissioner
Region 2
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JAMES IRRIGATION DISTRICT

CHAPTER III

GEOLOGY

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LIST OF PLATES

CHAPTER III

G E O L O G Y

Summary

1. Three distinct stratigraphic units influence the storage and migration of ground water of the James Irrigation District. An aquiclude, the Corcoran clay, restricts vertical transfer of water at about 550 feet below the surface. Above this clay, alluvial sediments contain free water; below, similar sediments bear confined water. All of these sediments were transported by streams from the Sierra Nevada. Most of the water utilized is produced from the zone above the Corcoran clay. The average specific yield of the zone between the 1948 low water table and the top of Corcoran clay is 10.9 percent. The average specific yield of the district's shallow well field is 9 percent. The water in the northern third of the district is classified as of "bad" quality, while in the southern part it is "permissible-to-doubtful." Artificial replenishment of the ground-water supply is deemed infeasible.

General Geology

2. The San Joaquin Valley, in the trough of which the James Irrigation District lies, probably took form as a geologic entity in mid-Cretaceous[a] times, when elongate island ridges rose above the level of the sea to the

(a) Geologic terms possibly unfamiliar to the reader are briefly defined in a glossary at the end of this chapter.

west[a]. Through subsequent Tertiary times these islands changed form, alternately shrank and grew, and finally in the upper Tertiary and Pleistocene united to form the central Coast Ranges of California as they now appear. The ranges are still rising, spasmodically and locally, though at a rate imperceptible in a single human life span.

3. During much of upper Cretaceous and lower Tertiary times the area of the present Valley was broadly open to the Pacific to the southwest and northwest, through straits whose locations are well established. Sediments were continually washed in from the ancestral Sierra Nevada, and were first elevated at the end of the Jurassic and rejuvenated periodically thereafter. After the mid-Cretaceous, the growing coastal archipelago also contributed detritus, and sediments from the two sources, east side and west side, continued to mingle in the shifting central part of the Great Valley trough, as they still do. In middle and upper Tertiary times the northern (Sacramento) Valley and the northern part of the San Joaquin Valley were built permanently above sea level. This means, in effect, that the Valley was an inland sea, or gulf, open chiefly to the southwest (i. e. through what is now western Kern County) which shrank periodically in that direction.

4. As sediments were continually being poured in, the shrinking of the gulf reflects a progressive, spasmodic south-to-north diminution of the rate of downwarp of the earth's crust under the Valley area. From time to time,

(a) There is convincing evidence that this was not, in fact, an "open" sea; that an extensive mountainous tract lay west of the present coastline, at least until early Tertiary times. This, like the semi-mythical Atlantis, has long since foundered into the ocean depths.

local broad stretches of the Valley lagged behind the rest in their subsidence, and hence in reception of sediments.

5. Northerly from about the latitude of Tranquillity the crustal subsidence was in the nature of a westward tilting of a relatively rigid crustal block which included also the Sierra Nevada. Since the axis of tilt was somewhere near the present eastern margin of the Valley, the Sierras rose concurrently and spasmodically as the floor of the Valley sank, and, of course, the sinking was greatest towards the western edge of the Valley. Southerly from the latitude of Tranquillity the Sierran-Valley crustal block seems to have broken in tilting and the picture, while comparable, is less simply described. On the order of 25,000 feet of still relatively undisturbed Tertiary sedimentary beds underlie the western part of the south end of the Valley. The folded and uplifted strata of the southern part of the Temblor Range, in which direction the seas finally withdrew, are even thicker.

6. During most of the Tertiary, that is, until middle Pliocene times, the sediments as far north as Tranquillity were dominantly marine. Northward from about that latitude, "continental" deposits, such as those of river fans and floodplains, lakes and swamps, predominated, as the seas shrank southward, after the early Tertiary (Eocene). The upper Pliocene, Pleistocene, and Recent sediments throughout the Valley are, of course, of this latter sort, and this material, about 3,500 feet thick beneath the James Irrigation District, includes all sediments which are of present or possible future use as parts of the ground-water reservoir (plate 3.3). During the protracted times represented by the deposition of these continental beds the position of the trough of the Valley has been pushed to east and west according as

the volume of sediments supplied by west side or east side streams has been the greater. During this time also, the Valley floor has continued to sink, not fast enough to outrun sediment supply and permit re-entry of the sea, but at a rate sufficient that the sediments have probably never built up to elevations of more than a very few hundred feet above sea level.

Geologic Features of the District

7. Topography and drainage. The slopes of the James Irrigation District, lying as they do along the trough of the San Joaquin Valley, are gentle even by Central Valley standards. In the southwestern part of the district the slope is northwesterly at a rate of 5 to 10 feet per mile; southwesterly slopes of 4 to 7 feet per mile are found along the western edge of the district. The elevation extremes are 165 feet above sea level at the northwestern tip of the district and 190 feet in the southwestern corner. Originally micro-relief of hogwallows, low hummocks, shallow depressions, and countless sloughs and overflow channels characterized the area; however, since the region has been leveled for farming, most of these features have been eliminated.

8. The principal drainage feature of this area is Fresno Slough. During flood periods, water from Kings River overflows in this area. Construction of James By-pass, in addition to large irrigation use in the upper Kings River area, has somewhat decreased the flood danger, and the menace will be further abated by the completion and operation of Pine Flat Dam. The flatness of the area creates a drainage problem, especially when associated with heavy-textured basin soils.

9. Stratigraphy. Water wells in and west of the district reach depths as great as 1,200 feet. Within this depth range the sediments may be divided into three units: (a) alluvial fan deposits above the Corcoran clay, (b) alluvial deposits beneath the Corcoran clay, and (c) the Corcoran clay. These are discussed individually in the following paragraphs.

10. Alluvial fan deposits above the Corcoran clay are of east side origin and comprise lenticular sands and silts derived primarily from granitic rocks with rare clay laminae. The sands are of very fine to medium grade; coarse sands and gravels are scarce. The deposits are, in general, progressively finer-grained from east to west, so that in the western part of the district very fine sands and silts predominate. Alluvial deposits of this character occur from the surface to depths of 500-600 feet. These are all Sierran-fluvial sediments. They represent three environments of deposition: clays, silty clays, and clayey silts were deposited in lakes or marshes; well-sorted sands and silts were deposited from water in motion, as on streambeds or lake beaches; and ill-sorted sands with appreciable silt and clay fractions signify floodplain origin.

11. A zone about 150 feet thick which immediately overlies the Corcoran clay is distinguished by a high percentage of volcanic glass. The glass, of rhyolitic composition, constitutes from 2 to 40 percent of the sand fraction of sediments in this zone, and is believed to have been carried by the San Joaquin River. This zone may be coextensive with a portion of the Friant formation as described by Macdonald[a] and the

(a) Macdonald, G. A., Geology of the Western Sierra Nevada between the Kings and San Joaquin Rivers, California: University of California Publications Bulletin of the Department of Geologic Sciences, vol. 26, No. 2, pp. 215-286, 1941.

Marliaves[a], which crops out along the San Joaquin River between Friant and Lanes Bridge and possibly as far west as Herndon. Pending confirmation of this suggested correlation, it is proposed that this zone be called the Tranquillity formation. Further studies of the hydrologic properties and petrologic character of the Tranquillity formation and the other sediments are being made at the Bureau of Reclamation Regional Laboratory, Sacramento, California.

12. Beneath the Corcoran clay a series of granitic sands, silts, and minor clays extends to depths greater than 1,200 feet. These were deposited on alluvial fans by streams debouching from the Sierra Nevada and resemble beds of similar origin above the Corcoran clay, except that their texture is generally somewhat coarser.

13. Corcoran clay. A claystone or siltstone 50 to 130 feet thick is present beneath the entire district, at depths of 500 to 600 feet. It extends a few miles to the east and apparently almost to the Coast Range foothills to the west. While the continuity of this clay has not been traced in detail southward to the Corcoran area, there is no reasonable doubt of its coextension and identity with the unit described under the same name in the Bureau's geologic report on the Alpaugh Irrigation District.

14. The claystone is greenish-gray, dense, compact, and non-laminated. The bottom 20 feet is usually silty and is a characteristic marker on electric logs of wells. A few scattered sand lenses occur; some in the

(a) Marliave, C., and Marliave, E. W., Geologic Report on a Portion of the San Joaquin Valley contiguous to the San Joaquin River between Friant and Gravelly Ford Ranch, Appendix B in Underground water supplies of lands adjacent to San Joaquin River between Friant and Gravelly Ford Canal: Water Project Authority of the State of California, Report No. 11, June 1939.

eastern portion of the district make up about a third of the thickness of the clay sequence. One or more peat beds about one foot thick have been found immediately above the claystone in each of three cored sections.

15. The Corcoran clay is of lake or swamp origin. Presumably, normal drainage was blocked by some structural or sedimentary barrier to the north or was impeded by tilting. The northward extent of the Corcoran clay has not been determined but statements of well drillers suggest that it extends at least to Tracy.

16. In the Alpaugh area report the Corcoran clay was assigned to the upper part of the Tulare formation. Probably only the highest sediments underlying the Tranquillity area classify as Recent. The alluvial fan surface of the east side seems to be associated with the older (Pleistocene?) fans of the San Joaquin and Kings River. Some of the west side sediments are Recent, but some may be older. Sediments in the trough, probably deposited by Fresno Slough, are certainly Recent in part.

17. The surface distribution of the sediments of the area are shown on plate 3.1, Geologic Map. Plate 3.2, Condensed Log of Test Hole 15-16-12B, presents the nature of the shallow, water-producing sediments. The relations of the underlying stratigraphic units are shown diagrammatically in plate 3.3, a southwest to northeast cross section normal to the Valley axis. For convenience, the vertical scale is ten times the horizontal. Only the uppermost 1,500 feet is important from the standpoint of ground water.

18. Structure. As the ground-water reservoir is chiefly in lenticular alluvial sands and silts, correlations would probably be impossible were it not for occasional moderately extensive thin clay beds. The Corcoran clay,

because of its wide extent and positive identification in electric logs, makes an excellent marker. The base of this bed is possibly the upper limit of the confined water zone. Underlying sediments are believed to have been less eroded following deposition than was the top of the Corcoran clay. The base of the clay has been contoured (plate 3.4) and is used here for structural interpretations.

19. Plate 3.4 indicates a regional west-southwesterly dip of the base of the clay. Near San Joaquin it is at -370 elevation, and slopes thence to a low of about -540 elevation in the northern half of T. 15 S., R. 13 E. This corresponds to an average regional slope of about 10 feet per mile.

20. Within the district, the clay slopes 10 to 20 feet to the mile toward the west and southwest. West of the district several northwest-southeast trending structures exist (plate 3.4) but these have little or no effect upon the hydrologic conditions of James Irrigation District. Depth to the base of the Corcoran clay is presented on plate 3.5 for easy reference in studying thickness of alluvial fill above this marker.

21. Electric logs. The cross sections presented in this report are based entirely on electric logs of wells in or near the area, furnished either by the owners of such wells, or made by the Bureau of Reclamation. The Bureau drilled and electrically logged three test bores in or near the district. The easternmost of these holes, 15-16-12B, is in the northern part of the James Irrigation District, and was cored throughout, to furnish exact correlation with the electric log. Another hole, 15-16-17E, southwest of Tranquillity, and a third hole, 15-16-28A, were cored only in the Corcoran clay, and logs of cuttings were kept for correlation with the electric log.

22. The use of electric logs allows a much more exact correlation of strata than can be attained from drillers' logs, which are accurate only to the extent of actual samples taken. Experienced drillers depend upon the speed and ease of penetration of the various strata, and on wash samples, in judging the character of the formations. The usefulness and accuracy of such logs vary widely with the ability, knowledge, and operating methods of the drillers.

23. Description of cross section. Plate 3.6 is an electric log cross section running east-west through the James Irrigation District about $1\frac{1}{2}$ miles north of the town of San Joaquin. It extends westward some $9\frac{1}{2}$ miles from the center of the district. Only a few of the thicker and more persistent beds, including a few sands and the Corcoran clay, were distinguished or correlated; thinner beds were grouped.

24. Supposed "San Joaquin Valley Fault." A fault has been postulated[a] as trending northwesterly along the trough of the valley and passing in or near the James Irrigation District. This would have a marked effect on ground-water conditions. Later geologic data have not substantiated such a hypothesis. Raisin City, Helm, and Riverdale oil fields are developed a few miles to the east and south of the district. While these fields are faulted to some extent it is understood that the major structure in each case is anticlinal. The east-west cross section (plate 3.6) shows no evidence of

(a) Forbes, Hyde, Geology of the San Joaquin Valley as Related to the Source and Occurrence of the Groundwater Supply: Amer. Geophysical Union Transactions, Part I, p. 17, 1941; also, Geology and Underground Water Storage Capacity of San Joaquin Valley: Appendix B of Calif. Dept. Pub. Works, Div. Water Resources, Bull. 29, p. 532, 1931.

faulting. A westward extension of this cross section (not presented in this report) also lacks any evidence of major faults. The fault centering in Sec. 27, T. 15 S., R. 15 E., is distinctly of local character and could not be a part of a valleywide fault system. Therefore, it is concluded that the "San Joaquin Valley Fault" is non-existent in this area. Similar and even more conclusive considerations led to the conclusion that the fault was also non-existent in the Alpaugh area[a].

Specific Yield

25. Available determinative methods. In order to establish the storage capacity of the underground reservoir, it is necessary to determine the specific yield of the sediments. O. E. Meinzer[b] has outlined seven methods of estimating this property. All seven methods require extensive field study and the use of specialized laboratory equipment. The Bureau of Reclamation has not been equipped or staffed to utilize any of these methods with sufficient accuracy to obtain worthwhile results. However, methods developed recently in the Regional laboratory have produced promising results which, when more data are available, may lead to some revision of the figures herein. In the meantime, it has been necessary to apply the results of investigations in other areas to the local problem.

26. One such investigation was carried on in the Mokelumne area, 115 miles to the northwest, by Piper and others[c]. Numerous tests were made by measuring the volume of material saturated and unwatered by addition and

(a) Technical Studies in Support of Factual Report, Alpaugh Irrigation District, Chapter III, Geology, Bureau of Reclamation, 1955.
(b) Meinzer, O. E., The Occurrence of Ground Water in the United States, etc.: U. S. Geological Survey, Water Supply Paper 489 - 1923.
(c) Piper, A. M. et al., Geology and Groundwater Hydrology of the Mokelumne Area, Calif.: U. S. Geological Survey, Water Supply Paper 780, 1939.

withdrawal of measured volumes of water from columns of undisturbed soil and also by determining the difference between porosity and specific retention of samples of undisturbed materials after drainage for periods as long as 390 days. The average specific yields, resulting from both of the above methods were as follows:

Material	Avg. specific yield
	%
Gravel and coarse sand	34.8
Medium and fine sand	24.2
Very fine sand, silt, and clay	4.2

27. Another investigation was carried on in the South Coastal Basin by the California Division of Water Resources[(a)]. The methods used were similar to those used in the Mokelumne area. As the results obtained in two such widely separated areas are comparable, it may be assumed that the specific yield is a function of the grain size and sorting of the sediment. Therefore, it seems justifiable to apply the specific yield values obtained in the Mokelumne area to similar sediments farther south.

28. Methods used in this study. Data for computation of the specific yield of the James Irrigation District were obtained from 40 wells in the Tranquillity and James Irrigation Districts. Depth of sediments used in the computation was from the water table for August 1948 to the top of the Corcoran clay. Specific yield contours above the Corcoran member in the shallow zone (plate 3.6) were drawn on the basis of these wells.

(a) Geology and Groundwater Storage Capacity of Valley Fill: Calif. Div. of Water Resources, Bull. 45, 1934.

29. The specific yield of the ground-water reservoir was estimated by segregating sediments recorded in drillers' water-well logs into one of the three classifications previously listed.

30. The footage of each type of material in a well below the water table was reduced to feet per hundred and multiplied by the specific yield assigned to that grade of material. The sum of these weighted figures gives an estimate of specific yield for the well under consideration.

31. It is emphasized that the specific yield figures in this report are based on correlations of sediment texture and specific yield made in another area. While it seems justifiable to apply resulting values to similar sediments here, it cannot be said with certainty that the figures are accurate. A further contribution to inaccuracy is the nature of the drillers' logs of water wells, in which occasionally depths are approximate and terminology inexact. Accurate specific yield determinations can be based only on local exhaustive, long term, tests of sediments.

32. Discussion of results. The specific yield of the wells in the district well field averages 9.0 percent. Plate 3.7 shows specific yield contours above the Corcoran clay. These contours show that the average specific yield of the zone between the 1948 low water table for shallow wells and the top of the Corcoran clay is 10.9 percent within the district boundaries. The distribution of the contours shows that in general the yields are higher to the northeast and lower toward the west. This is in accord with data which indicate coarser and more well-sorted sands to the eastward. Two tongues of high specific yield are shown fingering in from the east; the northern tongue trends southwesterly, near the town of Tranquillity and

the southern one trends westward at the southern part of the district. These represent former areas where streams depositing coarse well-sorted sediments were persistent after deposition of the Corcoran clay.

Influence of Geology on Ground Water

33. Geologic control on quality of sub-surface water. A shallow zone of highly saline water is generally present in and near the trough of the Valley and extends to depths as great as 250 feet (plate 3.6). The highly saline near-surface zone is not present near or east of Fresno Slough, due to westerly seepage and migration of water of good quality from the east side alluvial fans, which has replaced and now prevents the accumulation there of salty basin waters. Thus, well 15-16-28A (not shown on the cross section) has water of good to fair quality from the surface to 120 feet, and brackish water from 120 to 240 feet. Westward migration of east side and Fresno Slough water has there displaced or diluted the uppermost of the saline water formerly present at those depths.

34. Water analyses in the northern part of the district indicate poor quality both in regard to sodium content and total salts; in the southern two-thirds of the district and in the well field to the east, total salts in the water are low but high sodium content renders the water of "permissible-to-doubtful" classification[a] for agricultural use. These generalities for total salt content are verified by the few electric logs in the area.

35. Water-bearing properties of the geologic units. The hydrologic character varies somewhat in the different stratigraphic units. Alluvial

(a) Magistad and Christian, Saline Soils, their Nature and Management: U. S. Dept. Agriculture, Bureau Plant Industry, Circ. 707, 1944.

fan deposits of east side origin consist of lenticular beds of highly variable texture and specific yield, distributed seemingly at random, both horizontally and vertically. They range from coarse-grained permeable beds to fine-grained deposits of low permeability. The aquifers are sandwiched between aquicludes of sandy clays, silts, and sandy silts that retard, but do not inhibit, migration of ground water from one sand lens to another within the upper and lower zones. Thus, ground-water migration from one bed to another occurs at varying rates. As most of the water in the James area is derived from the Sierra Nevada, the ground-water migration is from east to west.

36. The Corcoran clay, only about 80 feet thick, almost entirely prohibits vertical transfer of water between the water-bearing strata above and below it and these waters therefore differ widely in hydrostatic pressure and in quality. A limited amount of water moves downward through gravel-packed wells which penetrate the clay, in the direction of decreased pressure head.

37. Recharge by spreading. The possibility of artificial recharge of the underground reservoir is controlled by local geology and soils. Spreading methods include ponding, over-irrigation, and streambed percolation. For any of these, the soils of this district are generally so heavy that percolation would be slow and impractical. The possibility of using wells for recharge has not been seriously entertained as the James Irrigation District possesses an excellent distribution system for surface transfer.

38. Percolation in ponds would remove many arable acres from production, and evaporation loss would be excessive during the hot, dry summers. Spreading by over-irrigation is dangerous on land with tight soils due to the length

of time the root zones of plants are waterlogged. Also, valuable plant nutrients may be leached from the soil and beneficial bacterial activity inhibited. Streambed percolation from Fresno Slough could be used to raise the ground-water table under the district. However, only limited quantities of water so spread would be available to the district. In any event, seepage from the surface by any means, within the district, will replenish only the unconfined strata above the Corcoran clay, except for the transfer of water from the upper to the lower zone through gravel-packed wells.

GLOSSARY

Alluvium - The deposits made by streams in their channels and over their floodplains and deltas.

Anticline - An upfold type structure.

Aquiclude - A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Aquifer - A geologic formation or structure that transmits water in sufficient quantity to supply wells or springs.

Cretaceous - The final period of the Mesozoic era about 69 million years long, ending about 60 million years ago.

Dip - The angle which a stratum, sheet, vein, fissure, fault, or similar geological feature makes with a horizontal plane, as measured in a plane normal to the strike.

Eocene - The earliest epoch of the Tertiary period about 20 million years long, ending about 38 million years ago.

Epoch - Subdivision of a period marked by minor but important changes in conditions during the period.

Era - Largest division of geologic time - classically thought of as begun and terminated by mountain building, major changes in fauna, and physical conditions.

Fault - A plan or zone of displacement along which rocks (including sediments) have been displaced.

Granodiorite - A plutonic igneous rock much like granite.

Igneous rocks - Those formed or crystallized from molten magmas arising from within the earth.

Intrusive - An igneous rock which has solidified before reaching the surface.

Jurassic - The middle period in the Mesozoic era, about 25 million years long and ending 127 million years ago.

Lithology - Rock character as seen with naked eye or hand lens.

Mesozoic - The second youngest era in geologic time - about 124 million years long - ended about 58 million years ago.

Micro-relief - Differences and changes in elevation of small magnitude.

Miocene - The third epoch in the Tertiary period, about 11 million years long; ended about 12 million years ago.

Oligocene - The second epoch in the Tertiary period, about 10 million years long.

Paleocene - Equivalent to early Eocene ending about 50 million years ago.

Permeability - Readiness with which a material transmits water.

Playa - A level or nearly level area in the lowest part of a closed desert basin in which water is ponded at irregular intervals.

Pleistocene - The epoch immediately preceding the Recent. An "Age of Glaciers." Continent was subjected to repeated advances of glaciers. Began about 1 million years ago and ended about 9,000 years ago.

Pliocene - The concluding epoch of the Tertiary Period, marked by beginnings of man. Ended about 1 million years ago, lasted for about 11 million years.

Porosity - The percent of voids in a rock or soil.

Recent - Geologic epoch succeeding the Pleistocene, to and including the present.

Specific retention - The ratio of the volume of water which a rock or soil will retain against the pull of gravity to its own volume.

Specific yield - The ratio of the volume of water a saturated rock or soil will yield, by gravity, to its own volume.

Strata - Layers of rock more or less similar throughout; lithologic units.

Stratigraphy - Study of sedimentary deposits and their contained organisms, involving determination of their natural units, conditions of origin, geographic distribution, age, and inter-relations.

Strike - The direction of a line formed by the intersection of a bedding plane, vein, fault, or similar geological structure, with a horizontal plane. It is at right angles to the dip.

Syncline - A downfold type structure.

Tertiary - The period in geologic time representing the early Cenozoic era about 57 million years in length; ending about 1 million years ago.

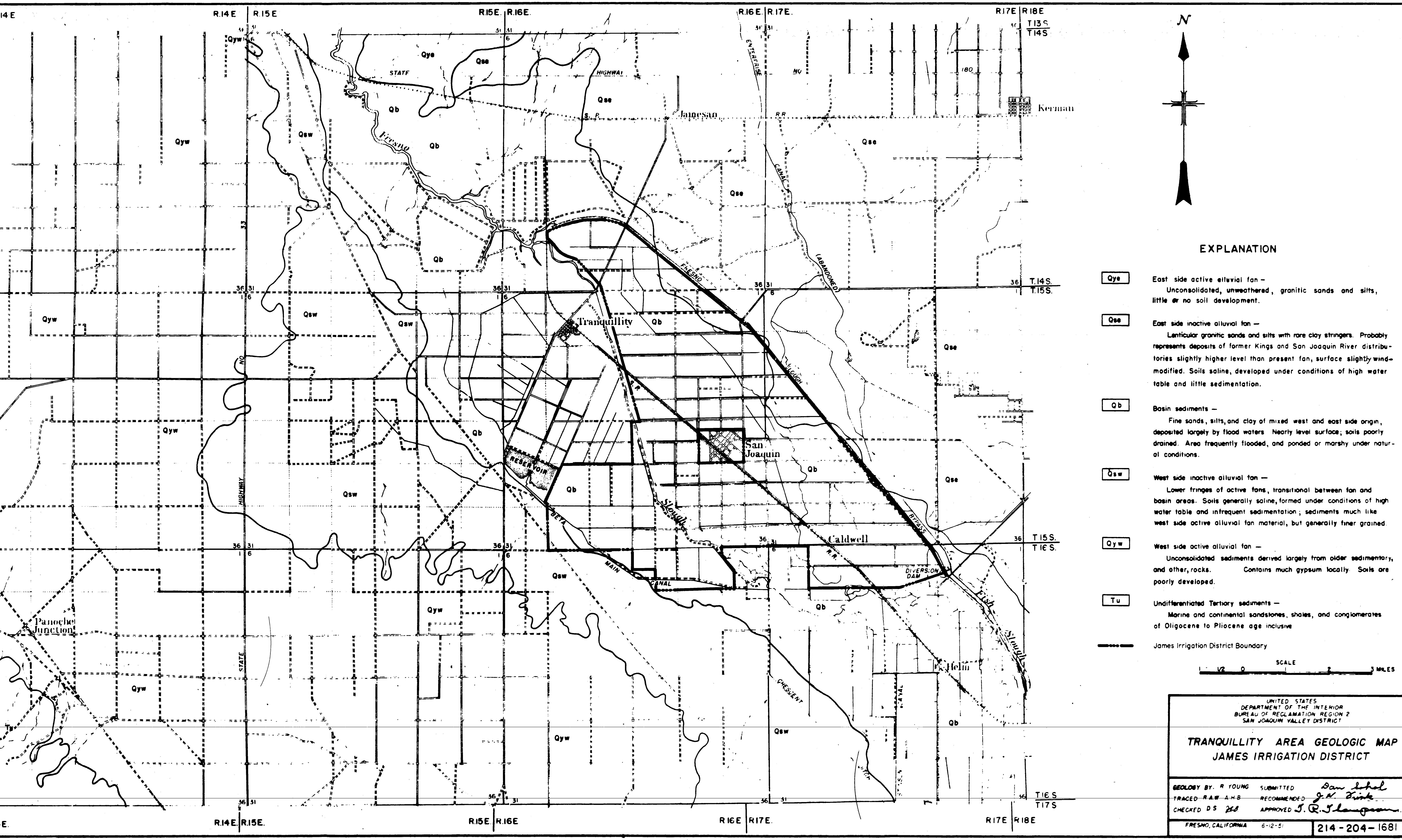
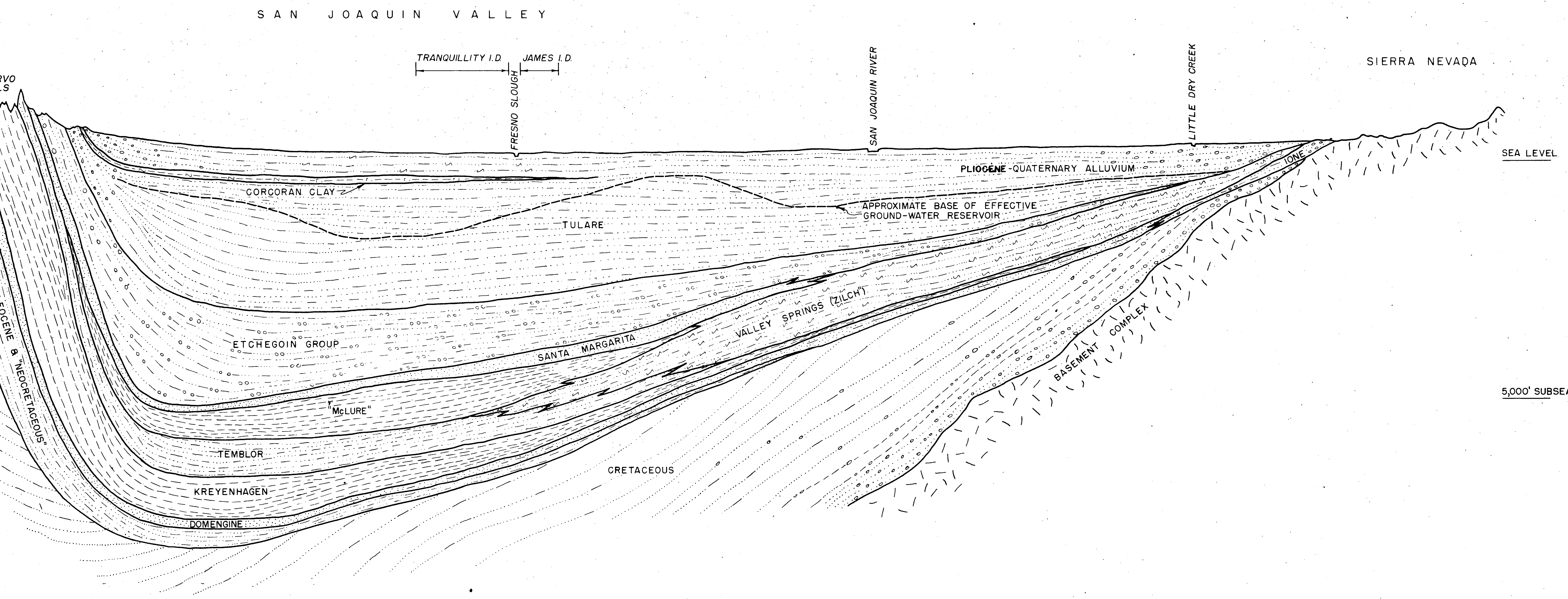

R.14E. R.15E.
R.15E. R.16E.
R.16E. R.17E.
R17E R18E
T13S
T14S
T.14S.
T.15S.
T15S.
T16S.
T16S
T17S
N
Kerman
Jamesan
Tranquillity
San Joaquin
Caldwell
Helm
Panoche Junction
Fresno
STATE HIGHWAY
S.P. R.R.
ENTERPRISE CANAL
(ABANDONED)
FRESNO SLOUGH
BYPASS
DIVERSION DAM
Fish Slough
BETA MAIN CANAL
RESERVOIR
CRESCENT
Qye
Qse
Qb
Qsw
Qyw
EXPLANATION
Qye — East side active elluvial fan — Unconsolidated, unweathered, granitic sands and silts, little or no soil development.
Qse — East side inactive alluvial fan — Lenticular granitic sands and silts with rare clay stringers. Probably represents deposits of former Kings and San Joaquin River distributories slightly higher level than present fan, surface slightly wind-modified. Soils saline, developed under conditions of high water table and little sedimentation.
Qb — Basin sediments — Fine sands, silts, and clay of mixed west and east side origin, deposited largely by flood waters Nearly level surface; soils poorly drained. Area frequently flooded, and ponded or marshy under natural conditions.
Qsw — West side inactive alluvial fan — Lower fringes of active fans, transitional between fan and basin areas. Soils generally saline, formed under conditions of high water table and infrequent sedimentation; sediments much like west side active alluvial fan material, but generally finer grained.
Qyw — West side active alluvial fan — Unconsolidated sediments derived largely from older sedimentary, and other, rocks. Contains much gypsum locally. Soils are poorly developed.
Tu — Undifferentiated Tertiary sediments — Marine and continental sandstones, shales, and conglomerates of Oligocene to Pliocene age inclusive
James Irrigation District Boundary
SCALE
1 1/2 0 1 2 3 MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION REGION 2
SAN JOAQUIN VALLEY DISTRICT
TRANQUILLITY AREA GEOLOGIC MAP
JAMES IRRIGATION DISTRICT
GEOLOGY BY. R YOUNG
TRACED R.A.W. A.H.B.
CHECKED D.S.
SUBMITTED Dan Sehol
RECOMMENDED J.N. Fink
APPROVED I.R. Flanagan
FRESNO, CALIFORNIA 6-12-51
214-204-1681

PLATE 3.1



NOTE:

This drawing is generalized, and local structures have been eliminated. The vertical exaggeration is about ten times.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION REGION 2
SAN JOAQUIN VALLEY DISTRICT

JAMES IRRIGATION DISTRICT

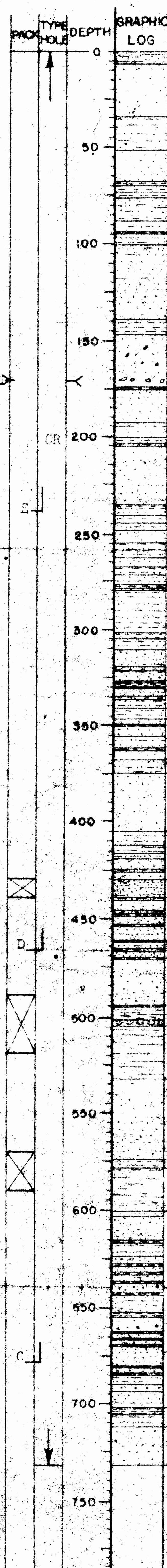
DIAGRAMMATIC GEOLOGICAL CROSS-SECTION

DRAWN J.W.F.-J.A.L.-H.A.K. SUBMITTED: John Logan
TRACED R.A.W. RECOMMENDED: J.W. Frink
CHECKED J.A.L. APPROVED: T. R. Thompson

FRESNO, CALIFORNIA 7-3-51 | 214-204-1716

PLATE 3.3

Clay and cement packer
B Bottom of piezometer tube and its suffix number
SL Sea level
CR Core
CT Cuttings
D Driller's log
Gravel
Sand
Silt
Clay



DESCRIPTION

Clay silt - green-grey.

Medium well-sorted sand.

Silty sand - fine to coarse.

Coarse sand.

Silt - yellow-grey, compact.

Silty sand - green-grey, moderately firm, moderately sorted.

Fine to coarse sands - moderately sorted, friable, green-grey.

Blue-grey silt to clay.

Arkosic sand - moderately well-sorted, loose.

Silty sands and Arkosic sands - moderately well-sorted, loose.

Silty blue clay.

Arkosic sand - medium-coarse, poorly to medium sorted.

Sandy to clayey silts - greenish-grey, interbedded with arkosic sand, fine to medium.

Clay silt.

Interbedded sandy silts and sands.

Fine to coarse sand - friable, well-sorted.

Sandy silts and sand - medium to well-sorted.

Silts - sandy silt.

Sands - medium grained, friable, interbedded with sandy silts, firm, poorly sorted.

Sandstone - green-grey, coarse, loose, moderately sorted.

Silty clay - dark green-grey, firm.
Peat bed.

Claystone - dark green-grey, small calcareous nodules, breaks into layers.

Medium to fine sands - green-grey, loose to firm, well sorted.

Silty clay.

Claystone - dark green-grey.

Sand - loose, poorly sorted, yellow-green, interbedded with sandy silts with some clay beds - firm, moderately sorted, yellow-grey.

Silty clay - yellow-grey.

Sand - very coarse, friable, moderately sorted.

Location: 0.94 miles north, 0.30 miles east of southwest corner of Section 12, T. 15 S., R. 12 E., MDBM