FIELD INVESTIGATIONS
VULNERABLE AREA, SAN JUAN BASIN
NEW MEXICO

Prepared for

New Mexico Oil Conservation Commission

Prepared by:

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WELL SITES INVESTIGATED IN
GEOSCIENCE CONSULTANTS, LTD FIELD STUDY

DETAILED FIELD STUDY SITES

McCoy "D" 1
Eaton A-1E
Payne 1

RANDOM SAMPLING FIELD INVESTIGATION OF PRODUCED WATER PITS

SAN JUAN RIVER $dh/dl = 0.002 - 0.003$

HIGH HYDRAULIC CONDUCTIVITY CASES (10,000 gpd/ft^2)

GCU 202
Totah Vista 1
GCU 170 E
GCU "1" 181 E

MEDIUM HYDRAULIC CONDUCTIVITY CASES (1,000 - 5,000 gpd/ft^2)

Gerk 1
Archuleta A3
Madsen 1
Armenta F1
Abrams L1
Sullivan A1
GCU 153 E
GCU 179 E

LOW HYDRAULIC CONDUCTIVITY CASES (10 - 100 gpd/ft^2)

GCU 169 E
Romero A1
Ulibarri 1A

ANIMAS RIVER $dh/dl = 0.004$

HIGH HYDRAULIC CONDUCTIVITY CASES (10,000 gpd/ft^2)

Marcotte 1

MEDIUM HYDRAULIC CONDUCTIVITY CASES (1,000 - 5,000 gpd/ft^2)

No cases observed

LOW HYDRAULIC CONDUCTIVITY CASES (10 - 100 gpd/ft^2)

No cases observed

VALLEY SIDE SLOPES AND TRIBUTARIES $dh/dl = 0.01$

HIGH HYDRAULIC CONDUCTIVITY CASES

McCoy D 1 E

MEDIUM HYDRAULIC CONDUCTIVITY CASES

Keyes A2
Florence 124 (630 days)
Florence 124 (1080 days)
Florence 9
GCU 169
Canaple 1

LOW HYDRAULIC CONDUCTIVITY CASES

GCU 150
Martinez F1
Valdez AIE
Pollock E1
Black 1
Irwin 1E
Heath G 1

BEDROCK MESAS CASES - Produced water can not enter ground water

- Howell 2A
- McEwen B1
- Heath WD A 3X
- Linda Nye 1
- Heath Gas COM H 1
- Nye Gas COM B 1E
- Heath WD A 10
- Heath WD A5
- Florence 32
- Florence 111
- Jacquez 1A
- Sandoval Gas COM 1 1R
- Pritchard 1A

PICTURED CLIFFS CASES - No water produced, no production equipment

- McEwen Gas COM C 1
- Wallace Gas COM 3 and 1
- Hamner 9
- Sullivan, Bruce 1
- Sullivan, Earl B, 2
- Ulibarri Gas COM 2
- Likins Gas COM B 1
- Heath Gas COM F 1
- Elliott Gas COM M 1
- Jacquez Gas COM E 1

WELL SITES VISITED WHICH WERE NOT PART OF RANDOM SAMPLE

- Sullivan Frame A1
- Linda Nye 1
- Sullivan Frame AIE
- Jacquez 2A
- Sullivan B1
- Valdez B1
- Linda Nye 1A
- Archuleta 1
- Jacquez 2
- Jacquez 1M
- Jacquez 3

Geoscience Consultants, Ltd.

WELLSITE EVALUATION

	Section	TWP	RNG
Location	______	______	______

WELL NAME ______________________________

Drainage Basin:

San Juan   La Plata   Animas   other: ______________

Description of Location:

River Bottom   Valley Slope   Dry Tributary   Mesa   Other: __________

Barrels Water/Day Produced: ______________________________

Estimated Hydraulic Gradient: ______________________________

Estimated Hydraulic Conductivity: ______________________________

Formation/Grain Size of Unsaturated Zone:

Very Fine   Fine   Med   Coarse   Very Coarse

Sorting: Poor   Fair   Good

Estimated Depth to Ground Water: ______________________________

Pit Description   Dry

Standing Water   Estimated Depth: ______________

Photographs of Site: ______________________________

Producing Formation: ______________________________

Comments: ______________________________

____

____

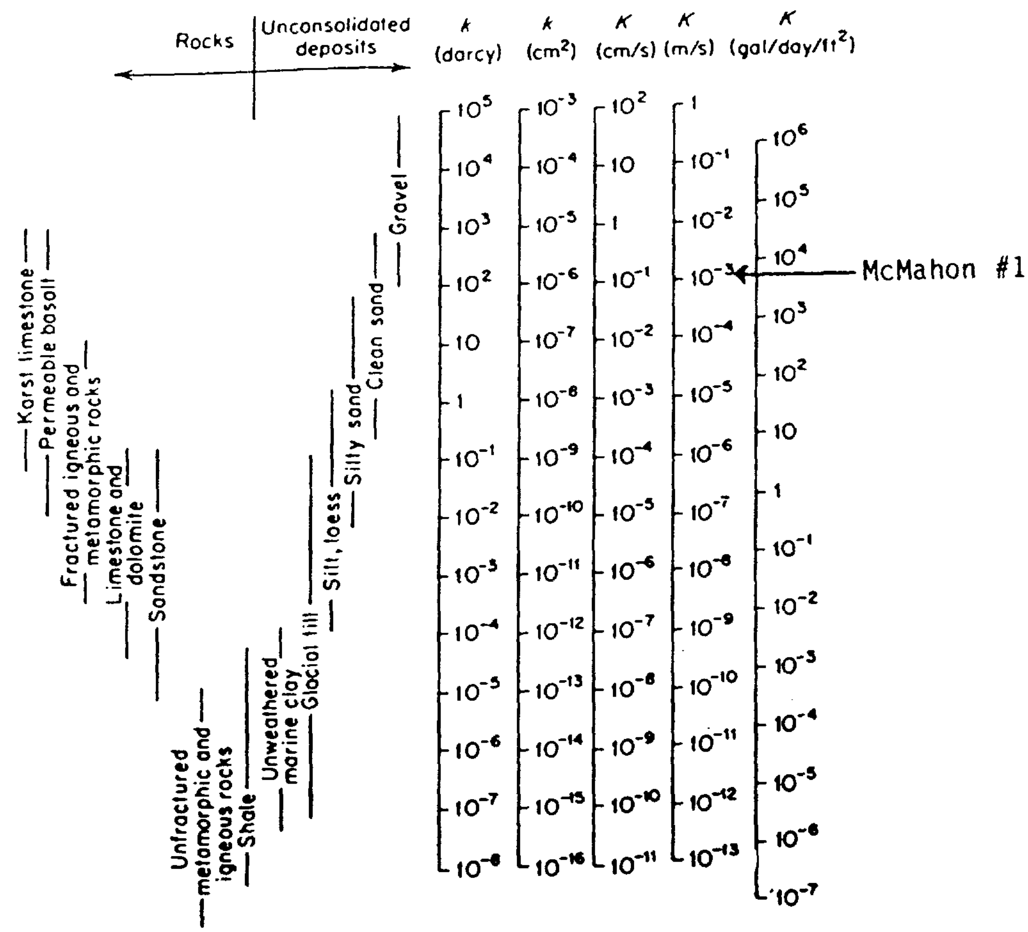
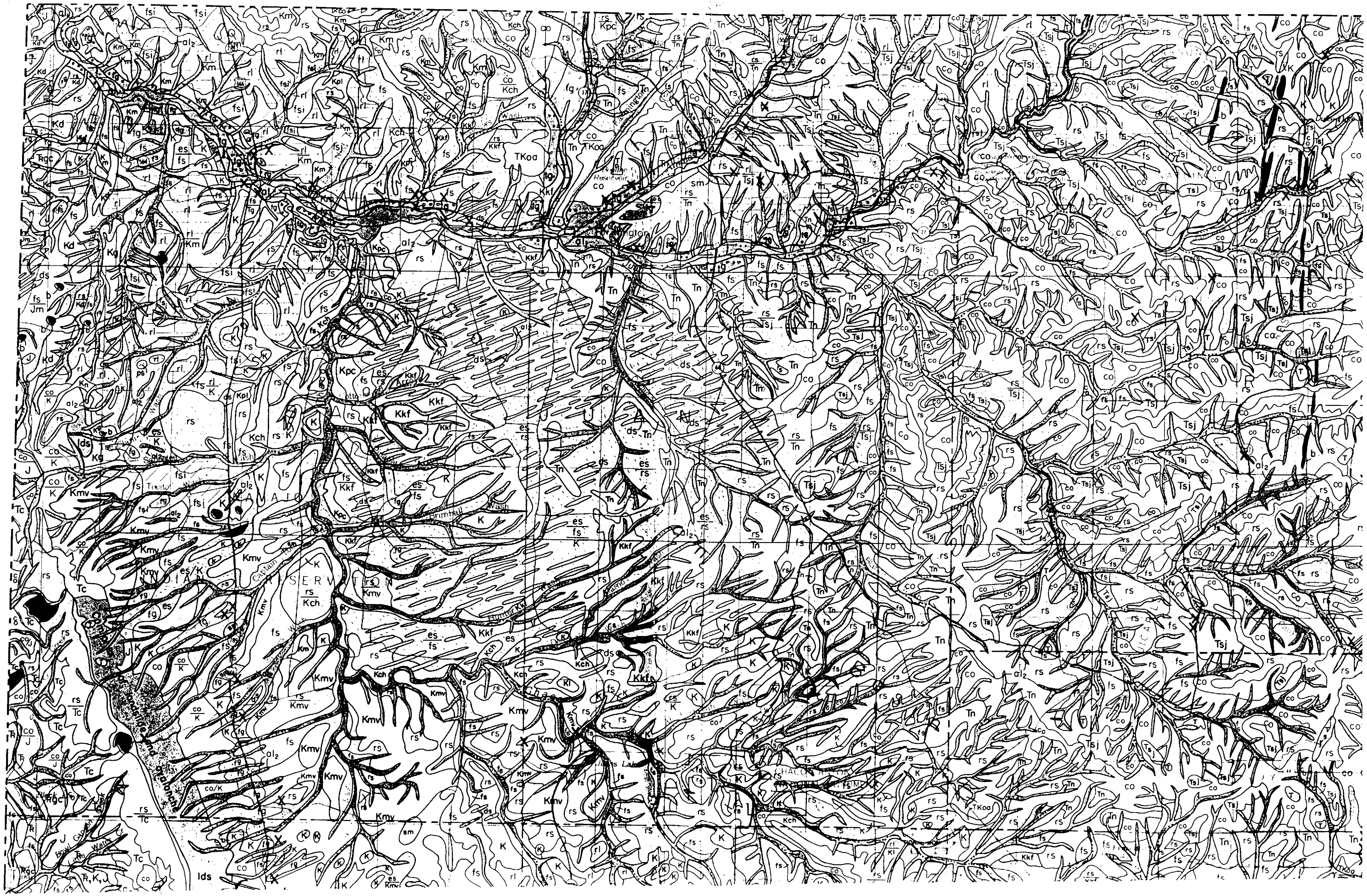


Figure C-1

RANGE OF VALUES OF HYDRAULIC CONDUCTIVITY AND PERMEABILITY (Freeze and Cherry, 1979)



NEW MEXICO BUREAU OF MINES & MINERAL R

INTRODUCTION

Surficial geology concerns the origin, distribution, and significance of deposits and soils at or near the earth's surface. Completely bare bedrock forms probably less than 5 percent of New Mexico's land surface; consequently surficial materials form by far the largest and most-used part of the ground around us. Several aspects of surficial geology that contribute significantly to an understanding of our environment are water yielding properties of the ground; its susceptibility to flooding and erosion; its susceptibility to such hazards as landslides, avalanches, and earthquakes; ease of excavation; suitability for foundations and road building; agricultural potential, including suitability for irrigation or pasturage; and mineral resources potential

Surficial materials commonly are poorly consolidated, consisting partly of bedrock weathered in situ (residuum), but mostly of sediments derived by erosion and transported by water, wind, ice, or gravity (mass wasting) to a site of temporary deposition before being further eroded and transported downslope

Four major categories of surficial materials are distinguished on the map by color: residual materials, transitional deposits, transported deposits, and miscellaneous types of ground

RESIDUAL MATERIALS

Materials generally formed in place, including: residuum, *formed in situ by weathering of a parent formation;* caliche; travertine and related spring deposits; shale or sandstone baked by coal beds burning in situ (clinker); karst and related deposits in sinks; *and the following, which are not distinguished on the map --* organic deposits; desert pavement; cave deposits; and desert varnish

RESIDUUM

In New Mexico, residuum tends to be thin, generally less than 2 ft thick -- rarely as much as 5 ft. Texture depends upon composition of parent rock, and ranges from clay to coarse sand; texture may be bouldery in granitic areas. Areas shown as residuum include small outcrops of parent rocks and some alluvial or eolian deposits either mistaken for residuum or too small to show on the map. These materials are predominantly of late Pleistocene (Wisconsinan) or Holocene age. Ground is hummocky with slopes less than 10 percent; scattered small outcrops of resistant beds form small ledges

rl — LOAMY RESIDUUM — *Texture variable -- mixed clay, silt, and sand. Thickness 1 to 5 ft. Parent formations fine grained, shallow, and identified by subscripts. Where clayey, this residuum generally contains appreciable amounts of swelling clay and is highly susceptible to sodium exchange, especially over the Chinle Formation (subscript* Trc*), Cretaceous shale (subscript* Ksh*), and Tertiary clayey volcanic formations. Slopes locally 10 percent and subject to washing. Although the unit is distinctive, the indicated boundaries are approximate*

rg — STONY RESIDUUM — *Stony residuum, with accompanying sand and silt. Thickness mostly less than 3 ft. Texture variable depending on parent material, indicated by subscript. Boundaries gradational with* co *and* fg

l/b — STONY LOAM OVER BASALT — *Lithology highly variable; locally abundant clay and silt, probably loessial; stones basaltic, mostly rough scoriae or angular blocks and flakes. Includes alluvium along small washes; numerous basalt mounds and low scarps along some washes and at edges of flows; thickness generally less than 3 ft. Surface smooth; slopes usually less than 5 percent except at sides of washes, bases of volcanic cones (including spatter cones), and edges of flows. Not subject to severe erosion. Boundaries indicated are fairly well defined despite variable lithology; boundaries with alluvium are approximate*

rs — SANDY OR SANDY LOAM RESIDUUM — *The shallow sandy or sandy silt substrates are distinguished by subscripts (e.g.,* rs/Kd, *sandy residuum over Dakota Sandstone). Thickness commonly 1 ft. Subject to wind erosion where vegetation is sparse; minimal washing. A distinctive unit with adequate boundaries, except in the San Juan Basin and along the Canadian River*

r/gyp — GYPSIFEROUS AND SANDY RESIDUUM ALONG PECOS RIVER VALLEY — *Parent material Artesia* (Pat) *and related formations. Rarely over 2 ft thick. Numerous small outcrops of gypsum thinly mantled by loose sand with or without small pebbles. A distinctive unit; boundaries are approximate*

r/ls — RESIDUUM ON LIMESTONE — *Widespread on east slope of Sacramento Mountains, Chupadera Mesa, and flanks of Zuni Mountains; less extensive on Cretaceous limestone beds south of Raton. Stony and blocky; generally well cemented with calcium carbonate; little subject to erosion. Slopes average steeper than most residuum. Thickness generally less than 2 ft, rarely as much as 5 ft. A distinctive unit; boundaries indicated are adequate*

CALICHE

ca — CALICHE — *Partly indurated zone of calcium carbonate accumulation formed in upper layers of surficial deposits; 2 to 10 ft thick; commonly overlain by windblown sand. Much caliche shown on the map consists of tough, slabby surface layers underlain by calcium carbonate nodules that grade downward to fibers and veinlets. Especially well developed in Basin and Range and Great Plains parts of the state. Thick caliches (locally >20 ft) associated with undissected High Plains surfaces of the Great Plains commonly comprise an upper sequence of several carbonate-cemented zones interlayered with reddish loamy paleosol horizons over a basal caprock zone developed on Ogallala* (To) *sediments. Forms on various types of parent formations, indicated by subscripts. The extensive caliche along Rio Salado northwest of Socorro is partly a travertine deposit. Where buried by sand, the caliche is identified by subscript* ca. *A distinctive unit; boundaries are well defined where the caliche forms rimrock and approximate where exposed in deflation hollows. Where thick and well indurated, caliche is quarried for road metal and other aggregate, subject to minimal erosion*

SPRING DEPOSITS

sp O — TRAVERTINE AND RELATED DEPOSITS — *Most deposits shown have been formed at springs discharging water hotter than 100°F (34°C). Travertine mounds and benches to 50 ft high. Deposits at east base of Mesa Lucero may not have been created by hot springs*

CLINKER

cl O — SLAGGY COAL ASH AND VITRIFIED SHALE AND SANDSTONE MASSES FUSED BY BURNING COAL BEDS — *Incompletely shown -- coal may ignite spontaneously, by lightning or ground fire. Depending on oxygen availability, the coal may burn tens of feet back into the ground. Common in coal-bearing formations of San Juan Basin and Raton district. Used for road metal*

KARST DEPRESSION DEPOSITS

kä — KARST-RELATED DEPOSITS — *Underground solution of limestone and gypsum produces caverns or smaller subsurface voids, and causes roof-rock collapse, forming closed karst depressions (sinkholes) at the surface, mantled with blocks of the roof rock. Widespread in San Andres Formation (subscript* Psa*) north of the Sacramento Mountains and on Chupadera Mesa. Sinks commonly 50 ft deep and 500 to 1,000 ft wide. Similar deposits composed of slumped gravel and alluvium along the Pecos River valley are attributed to solution of underlying gypsum or other salts. Slumped beds dip 1 to 5 degrees into the depression; may be overlain by undisturbed gravels. Thickness to 300 ft. Although these are distinctive features, extent and boundaries, largely derived from the 1/250,000 quadrangle maps, are approximate*

DESERT PAVEMENT

Not shown on map. Consists of a single layer of closely-spaced stones. angular or rounded, over a vesicular layer of loam and silt. Stones collect at the surface by a sorting action, apparently due to frost and/or salt heaving, or swelling and shrinking of clay. Silt layer beneath the pavement may be partly eolian in origin. In general, within a particular part of the state, thickness of silt increases from about 1 to 12 inches with increasing age of the surface, due to advanced weathering and rock disintegration. Some areas of desert pavement also form where wind or water removes fine-grained sediments, leaving behind the coarser lag deposits. While desert pavement favors high runoff, it protects the ground from erosion

CAVE DEPOSITS

Not shown on map. Commonly have gravel at base, recording an early stage of substantial water flow that eroded the cave. The gravel is overlain by clay or ochre deposited as the flow of water diminished, and this in turn is overlain by stalagmites. Stalagmites are overlain by dust. Fossil remains of Pleistocene animals may occur in deposits below the stalagmites; remains of Holocene animals characterize the overlying deposits. Other cave deposits occur in basaltic lavas, especially in the area southwest of the Zuni Mountains. These deposits include blocks fallen from the roofs, dust, and some ice

ORGANIC DEPOSITS

Not shown on map. Accumulations of fibrous peat in sedge marshes border many New Mexico lakes. Both fibrous and woody peat accumulated in small, poorly-drained depressions and mountain meadows. Mostly less than 15 ft

DESERT VARNISH

Not shown on map. A black stain of iron and manganese oxides on bare rock surfaces and on pebbles of desert pavement. Predates prehistoric pottery-bearing occupations of the region. Predominantly middle Holocene, partly late Pleistocene. Many of these stained surfaces have petroglyphs carved by prehistoric peoples

TRANSITIONAL DEPOSITS

Deposits transitional between those formed in situ and those transported; deposits moved downslope chiefly by gravity, particularly slow creep (colluvium). Also includes rock falls. Landslides and avalanches are shown as periglacial features

Colluvium includes the heterogenous mantle of soil and rock fragments derived from residuum, bedrock, and/or unconsolidated surficial deposits moved slowly downslope by gravitational force and sheet wash. Slopes generally steeper than 20 percent. Mass wasting, the process causing debris to move downslope, is aided by added weight and lubrication of water-saturated debris, frost heaving, alternate wetting and drying of clays, crystallization of salts, growth of roots, burrowing and trampling by animals, falling of trees, and impact of hail or rain. These, like other erosional processes, may be accelerated by man's activities

Colluvium is basically a chaotic mixture of angular rock fragments and finer grained materials. In New Mexico colluvium is generally less than 10 ft thick (rarely 25 ft or more) but may grade into thick cones of debris at bases of hillsides. In the northeast and northwest parts of the state where steep shale slopes underlie resistant caprock of sandstone or lava, two, and locally three, ages of colluvium may be distinguished. These are thought to be mid-Holocene, late Wisconsinan and early Wisconsinan, respectively. Such occurrences provide an index of retreat of cliffs. Some shale slopes are armored and protected against erosion by blocks of the caprock.

On long dip slopes such as flanks of the Zuni Mountains and east flank of the Sacramento Mountains, the colluvium is generally thin (commonly 1 to 2 ft thick) except near the base of steep hillsides and is composed of the resistant rock, forming the dip slope. Some of this colluvium could as well be mapped as stony residuum over limestone. Hillsides on granitic and volcanic rocks may also be overlain by thin but bouldery sandy colluvium. Colluvium on steep, faulted mountain fronts consists of a mixture of stones representing all the exposed formations upslope

co — COLLUVIUM — *Subscripts indicate the underlying hillside formations (e.g., co/Tv, colluvium on Tertiary volcanic rocks)*

TRANSPORTED DEPOSITS

Most surficial deposits are rocks and particles weathered from bedrock in one area, transported by water, wind, ice, or gravity to an area of deposition, and are susceptible to further erosion and transportation. These deposits are much younger than – and unrelated to – the underlying bedrock. They are classified according to their mode of transportation to the site of deposition

ALLUVIUM IN FLOODPLAINS AND STREAM CHANNELS

Well-stratified sandy and silty stream deposits with gravel lenses; gravel terraces along valley sides. Generally, alluvial deposits record complex response to Quaternary climatic shifts. In New Mexico climates were comparatively wet during the Pleistocene glacial stages. Conversely, during the interglaciations, climates were drier, with conditions similar to Holocene environments. Alluvial deposits locally contain fossils, including bones of mammals and rodents, and shells of freshwater snails and clams. Late Pleistocene deposits contain fossil remains of extinct animals such as elephants, camels, horses (not re-introduced until the arrival of the Spaniards), sloths, and long-horned bison. Archaeological remains are common in and on Holocene deposits and help date them. Three ages of alluvium generally can be distinguished -- late Pleistocene, mid-Holocene, and historic. At least three recognized types of alluvial floodplain deposits reflect relative capacity for sediment transport by the main stream and its tributaries. A fourth type, along the Pecos River in the southeastern part of the state, is characterized by saline ground. A fifth is restricted to basalt-capped mesas

FLOODPLAIN AND CHANNEL DEPOSITS ALONG MAIN STREAMS — *Ground nearly flat but includes terraces to about 10 ft high, shallow curved swales at cutoff meanders, and local stabilized dunes. Mostly sand, silt, and some layers of gravel. Caliche absent or weakly developed in thin veinlets, fibers, coatings on cracks, and soft nodules. Deposits commonly 25 ft thick. Ground water shallow; subject to pollution. Extensively farmed; subject to flooding*

FLOODPLAIN AND CHANNEL DEPOSITS ALONG GENERALLY DRY ARROYOS AND WASHES — *Includes deposits along some perennial mountain streams. Extent exaggerated to emphasize drainage patterns. Sandier than al_1, gradients 5 to 15 percent. Arroyos 10 ft deep common. Surface flat where deposit was formed by stream overflowing its banks; hummocky where built of coalescing fans at mouths of tributaries that crowd the main stream against its far bank; or V-shaped where alluvium grades laterally into fan sand washed from adjoining hillsides. Ephemeral perched water tables under some deposits. Width of deposits represented has been exaggerated but total area probably about right because small deposits had to be omitted*

COALESCING SILTY AND SANDY ALLUVIAL FANS — *Intermediate between* al *and alluvial fan deposits* fs *and* fsi

SALINE ALLUVIUM — *Borders Pecos River south of Fort Sumner*

ALLUVIUM OVER BASALT — *Restricted to basalt-capped mesas. Stony, organic-rich alluvium in old valleys; thickness commonly 10 ft or more. Acid soils*

GRAVEL TERRACES — *Well-rounded stream gravels with cobbles 6 inches or more in diameter; some terraces 250 ft higher than the streams. Especially well developed along the San Juan River, less so along the Pecos, Gila, and Canadian Rivers; most represent deposits by Pleistocene melt waters from mountains. Abundant caliche deposits, especially on the higher terraces, which may be Kansan; lowest are Wisconsinan*

ALLUVIAL FAN DEPOSITS

In alluvial fans, unlike floodplain alluvium, beds tend to be thick, massive, and highly lenticular rather than well stratified. This is characteristic of all the facies, whether boulder, gravel, sand, or silt. Beds lenticular and elongated down the slope of the fans; slopes 2 to 20 percent. Deposition mostly by flash floods, with poor sorting and mixed textures. Coarse-textured lenses commonly form ridges extending down the fan onto generally finer grained sediment. Boundaries between the textural facies of the deposits roughly parallel the fan contour, but detailed boundaries are irregularly lobate; those shown are approximations. Fan textures and slopes depend partly on composition of the parent rocks and partly on height and steepness of the bordering hill or mountain. Fans extensive in the Basin and Range part of the state where they comprise about half the total area; in other parts of the state, fans are small. On the larger fans, arroyos become shallower towards the toe; many head at low mounds that probably mark old mudflows. Ground subject to sheet flooding

fg — GRAVEL FACIES — *Bouldery towards apex of fan, grading downslope to cobble and fine gravel with increasing proportion of sand and finer grained material. Commonly dissected to form 2 to 3 levels of gravel benches up to 50 ft above present washes. A few streams (e.g., Mulligan Wash, Alamosa River, Cuchillo Negro Creek, and Rincon Arroyo are incised 100 ft below fan surfaces, On short, steep fans, depths of valleys generally decrease downslope. On the broad Palomas surface, west of the Rio Grande above Hatch, valleys maintain their depth. Except near the apex, extensive surfaces have smooth desert pavement. On short, steep fans, gravels show minimal weathering and are weakly cemented with caliche; age probably Wisconsinan and Holocene. On broad, more gently sloping fans, gravels are more weathered and commonly cemented by caliche; age probably pre-Wisconsinan. In south half of the state, gravel facies is characterized by creosote bush cover. Thin alluvial gravel covering pediments is denoted by* fg *over subscript that identifies parent formation*

fs — SAND FACIES — *Sandy alluvium with subordinate amounts of fine gravel, silt, and clay. Forms at least four kinds of ground: 1) On short, steep fans sloping from the mountains of granitic or gneissic rock (e.g., parts of the Florida Mountains), this facies may form a smooth sandy layer a few feet thick covering gravel below; slopes 5 to 20 percent; washes 1 to 10 ft deep may expose underlying gravel. 2) On other short fans, sand facies may form arcuate belt at toe of fan with slopes averaging 10 percent, commonly reworked into coppice dunes 3 to 7 ft high* (sm). *3) Other belts of smooth sandy ground commonly slope 5 percent or less and consist of sand mounds approximately 1 ft high over caliche* (fs_2). *4) Gypsiferous sand* (fs_3), *especially in the Jornada del Muerto, Tularosa Valley and east side of the Pecos Valley. Sand facies absent on the broad Las Palomas surface. Thin fan sand covering pediments is denoted by* fs *over subscript that identifies underlying formation. Boundary with residual sand, fan gravel, and fan silt is approximate*

fsi — SILT FACIES — *In Basin and Range parts of the state, toes of fans may be silty and clayey rather than sandy; surface smooth, with slopes less than 5 percent. Slow infiltration rates and low slopes result in sluggish runoff. Forms a belt below the sand facies and grades downward to playa silt* (psi) *with slopes less than 2 percent. Abundant swelling clays and exchangeable sodium. Surface layers predominantly Holocene; subject to sheet flooding, gradational with* al_3. *East and west of Sangre de Cristo Mountains, also forms fans of sandy or silty loam with little gravel in upper 3 to 4 ft, but abundant gravel below the loam. Caliche soft. Includes loess on isolated hilltops. Boundary with residual loam* (rl), *playa silt* (psi), *and fan sand* (fs) *approximate*

EOLIAN DEPOSITS

Eolian deposits are laid down by wind, mostly as sheets of sand or silt (loess). Rarely, after prolonged drought on shale desert in the San Juan Basin, shale flakes may accumulate in rippled sheets or even small dunes, but with the next rain, these become mud. Sand dune shapes depend on topography, relative strength of the winds, supply of sand, and vegetation. Some dunes are concave towards the windward (parabolic), others are concave towards the leeward (barchans), and others are longitudinal or transverse. Some dune clusters (e.g., Great White Sands) have all four kinds. Dunes may climb a windward slope or fall on a leeward slope. Most of New Mexico's eolian sand sheets have a basal layer of weathered, partly cemented, reddish stabilized sand; some sand surfaces on such layers are smooth. In the Basin and Range and Great Plains parts of the state, these surfaces are generally underlain by caliche; in the San Juan Basin, sand sheets commonly overlie residuum, fan deposits, or bedrock. Where sand is thick, as on sand facies of fans in the Basin and Range and at climbing dunes east of the Pecos River (Mescalero Sands) the sand is in mounds (coppice dunes) with profuse growth of vegetation -- mesquite, and saltbush in the Basin and Range; sand sage, shinnery oak, small soapweed yucca, and occasional mesquite on the Mescalero Sands. Sand sheets are predominantly late Pleistocene; mounds and dunes are largely Holocene

s/b — SAND UNDERLAIN BY BASALT — *Extensive on basaltic plains south and east of Zuni Mountains and on West Potrillo Mountains. At Kilbourne Hole and Hunt's Hole, the sand is of volcanic origin*

s/ca/QTs — SAND UNDERLAIN BY CALICHE ON SANTA FE GROUP *Mostly on La Mesa and south part of the Jornada del Muerto*

s_1/ca/To — THIN SAND ON CALICHE ON OGALLALA FORMATION — *Thickness about 1 ft. Chips of caliche comprise 30 percent of the sand. Generally too shallow for farming, but good shallow source for aggregates*

s_2/ca/To — MODERATELY THICK SAND ON CALICHE ON OGALLALA FORMATION — *Sand 1 to 3 ft thick. Surface layers noncalcareous over reddish loam. Local sand mounds. Ground favored for farming. Boundaries approximate*

s_3/ca/To — THICK SAND ON CALICHE ON OGALLALA FORMATION — *Sand 3 to 5 ft thick. Local mounds. Brownish-red, fine sandy loam over reddish-brown, sandy clay loam; noncalcareous to depths of 3 ft; calcareous subsoil contains filaments of lime carbonate. Where farmed, ground is subject to wind erosion. Boundaries approximate*

sm — LOOSE SAND IN MOUNDS — *Coppice dunes, commonly 3 to 7 ft high and 25 to 50 ft in diameter; generally elongated north of east but a local exception lies east of Columbus where elongation is south of east. Age is Holocene. Boundaries fairly accurate*

es, s — SAND SHEETS — *Surfaces smooth except for ripples 2 to 3 inches high and scattered sand mounds 3 to 12 inches high, especially around small shrubs. Thickness of loose sand generally no more than about 12 to 24 inches, but commonly overlies stabilized sand. Underlying material where known identified by subscript*

ds — LONGITUDINAL DUNES — *Sand commonly 6 ft thick, locally 10 ft. Forms distinct ridges generally oriented north of east. Locations diagrammatic and width exaggerated*

ds — OTHER DUNES — ds_1, *quartzose sand,* ds_2, *gypsiferous sand*

l/b — LOAM ON OLD BASALTIC LAVA — *Probably pre-Wisconsinan loess*

si — EOLIAN SILT

EXPLANATION OF SURFICIAL GEOLOGY

by Charles B. Hunt 1977

LAKE AND PLAYA DEPOSITS

New Mexico has five kinds of lake deposits in addition to those forming today in artificial reservoirs. The most extensive deposits were laid down in Pleistocene lakes that flooded closed basins now marked by playas. Many of these deposits in the Basin and Range are alkaline flats. Most numerous are the so-called "buffalo wallows" of the Great Plains on the Ogallala Formation. Some of these wallows are deflation hollows with sand mounds on the lee side; others may be due to solution and sagging of the surface. Still others may be attributed to warping. Third are sinkholes clearly due to solution, like Bottomless Lakes; sinks at Santa Rosa, and some of the depressions (related to karst) of the San Andres Formation and caliche-covered ground north of the Sacramento Mountains. A fourth type is represented by ephemeral ponds in swales marking cutoff meanders on alluvial floodplains. A fifth type occurs only in the maar volcanoes at Kilbourne Hole, Hunt's Hole, and Zuni Salt Lake. Only the first three types appear on the map. Area of deposits represented has been exaggerated because of map scale, but total area probably about right because smaller deposits are omitted

psi — SILTY LAKE OR PLAYA DEPOSITS — *Ground mostly bare, gypsiferous deposits labeled* psi_2

ps — SANDY LAKE OR PLAYA DEPOSITS — *Gypsiferous deposits labeled* ps_2

be, bg — BEACH DEPOSITS — *Sand or gravel; sandy stretches mostly reworked into low dunes. Incompletely shown*

ev — EVAPORITES — *Saline or alkaline deposits precipitated from brines in playas having high evaporation rates, notably Estancia Valley, Animas Valley, and Zuni Salt Lake. Salts are gradational with playa silt (psi) and occur in orderly concentric zones reflecting relative solubility of the salts. Thicknesses range from 1 to several inches, but salts mixed with mud may be tens of feet deep. Efflorescent crusts subject to wind erosion contribute to salinity of ground to leeward*

GLACIAL AND PERIGLACIAL DEPOSITS

During the Pleistocene New Mexico had mountain (alpine) glaciers high on the Sangre de Cristo Range, Tusas Mountains, and Sierra Blanca Peak. The source of such glaciers was in nearly circular, steep-sided basins (cirques) at valley heads. High valleys eroded by the glacial tongues tend to be U-shaped; at lower elevations where eroded by streams, these valleys are V-shaped. Gravels deposited along each side of valley ice represent debris that rolled down the mountainside onto the ice to form lateral moraines. Hummocky ridges of sand and gravel deposited across the lower ends of the glaciers form terminal moraines. Within the cirques generally stand two ramparts of boulders. An inner rampart, forming today, is located at the lower edge of the snowbank that accumulates annually in the cirque; it represents rocks broken by frost from the headwall of the cirque, rolled down the snowbank, and collected at the ridge. These inner ridges are treeless. Farther out in the cirque -- perhaps at the mouth -- is a second ridge, forested, with firm unweathered rock darkly stained with iron and manganese oxide. These outer cirque ridges formed during the mid-Holocene "little ice age"

mg — DEPOSITS AND GEOMORPHIC FEATURES OF PLEISTOCENE MOUNTAIN GLACIERS — *Extent exaggerated*

pg — PERIGLACIAL DEPOSITS ON MOUNTAIN TOPS — *Primarily represented by boulder fields and patterned ground where frost action was intensive during the glaciations. Extent and boundaries approximate; graded laterally to stony residuum and colluvium*

av — AVALANCHE DEPOSITS — *Bouldery; some are lag concentrates of boulders where fine-grained sediments have been removed by erosion. Deposits narrow and long downslope; commonly 10 to 50 ft thick. Apparently deposited as mudflows during late Pleistocene time when there were numerous perennial mountain snowfields. Frost action at the time was vigorous; sudden thaws could trigger floods or mudflows on the mountainsides. Slow movement downslope may be reactivated in artificial cuts through these deposits if water enters the plane of slippage*

lds — LANDSLIDE DEPOSITS — *Abundant on slopes of Cretaceous shale. Whereas avalanche deposits are elongate downslope, landslide deposits are short downslope but wide along the contour. Characteristically, they retain a cap of the lava or sandstone sloping into the hillside atop a steep colluvial-covered shale slope. Stabilized landslides may be reactivated if water is allowed to enter the plane of slippage*

MISCELLANEOUS TYPES OF GROUND

BASALT — *Includes lava flows, lava cones, cones of scoriae, necks, and fields of scoriae. Predominantly Quaternary and late Tertiary; some young enough to have sustained minimal weathering and retained their original structures and shapes are commonly referred to as malpais (Spanish, bad ground). Includes some Tertiary basalt that conspicuously controls the topography. Locally covered by loam (l/b, eolian deposits, al/b, stream deposits). These older surfaces are more deeply eroded, tilted, and faulted. Individual flows generally less than 50 ft thick; locally, several flows may aggregate a few hundred feet thick. Commonly interbedded with volcanic ash (tuff). Excludes lavas mantled by loess or other sediments; such areas indicated by subscript (e.g., l b -- loam over basalt; fs/b -- fan sand over basalt). Boundaries shown are adequate*

OTHER BEDROCK — *Colluvium or other cover amounts to less than half the area. Only extensive areas are shown; age and rock type keyed by symbol to State geologic map (e.g., Kd, Cretaceous Dakota Sandstone, Ꞧs, Triassic Santa Rosa Sandstone). Many small areas omitted; indicated boundaries are approximate. Principal formations and subscripts used are:*

- Qg – *Gatuna Fm.*
- Qbt – *Bandelier Tuff*
- Qvr – *Rhyolite flows*
- QTsf – *Upper Santa Fe Group*
- QTs – *Santa Fe Group, undivided, and related formations*
- QTg – *Gila Conglomerate*
- To – *Ogallala Fm.*
- Tsa – *Lower Santa Fe Group*
- Tc – *Chuska Sandstone*
- Tu – *Alluvial and lacustrine deposits*
- Tca – *Carson Conglomerate (generally equivalent to Los Pinos Fm.*
- Tpi – *Picuris Tuff*
- Tp – *Potosi volcanic series*
- Tv – *Tertiary volcanics; largely Datil Fm. in SW; includes some pre-and post-Datil volcanic sequences*
- Tbb – *Blanco Basin Fm.*
- Tg – *Galisteo Fm.*
- Tsj – *San Jose Fm.*
- Tn – *Nacimiento Fm.*
- T – *Tertiary sedimentary formations in Raton district*
- TKpc – *Poison Canyon Fm.*
- TKa – *Animas Fm.*
- TKr – *Raton Fm.*
- TKoa – *Ojo Alamo Sandstone*
- Kv – *Volcanics of Cretaceous age; various composition*
- Kkf – *Kirtland Shale and Fruitland Fm.*
- Kpc – *Pictured Cliffs Sandstone*
- Kl – *Lewis Shale*
- Kmv – *Cretaceous sandstone and shale, mostly Mesaverde Fm.*
- Kch – *Cliffhouse Sandstone*
- Kpl – *Point Lookout Sandstone*
- Ksh – *Cretaceous shale*
- Kg – *Gallup Sandstone*
- Km – *Mancos Shale*
- Kd – *Dakota Sandstone*
- J – *Jurassic, undivided*
- Jm – *Morrison Fm.*
- Jz – *Zuni Sandstone*
- Ꞧ, J – *Triassic and Jurassic, undifferentiated*
- Ꞧ – *Triassic, undifferentiated*
- Ꞧgc – *Glen Canyon Sandstone*
- Ꞧc – *Chinle Fm.*
- Ꞧs – *Santa Rosa Sandstone*
- Pr – *Rustler Fm.*
- Pat – *Artesia Group*
- Psa – *San Andres Fm. (limestone)*
- Pg – *Glorieta Sandstone*
- Pc – *Cutler Fm.*
- Py – *Yeso Fm.*
- Pa – *Abo Fm.*
- Ph – *Hueco Fm.*
- Pal – *Paleozoic, undivided*
- Pms – *Madera Limestone and Sandia Fm., undivided*
- P, ℙ – *Permian, Pennsylvanian*
- M, D – *Mississippian, Devonian*
- S, O, Є – *Silurian, Ordovician, Cambrian*
- pЄ – *Precambrian*
- gr – *Granitic, gneissic, and intrusive rocks of various ages*

OF NEW MEXICO

EXPLANATION FOR GEOLOGIC MAPS 40, 41, 42 AND 43

D — *Disturbed ground. Mostly urban areas large enough to show on state base; farmed lands excluded. Includes airports, mined areas, tailings dumps, and feedlots. Incompletely shown*

X — *Open pits for road fill, sand, gravel, caliche, or other aggregates*

Playa-lake depressions. Mostly small closed basins produced by eolian activity and local solution subsidence

REFERENCES

Dane, C.H., and Bachman, G.O., 1965, Geologic map of New Mexico: U.S. Geological Survey, Washington, D.C.

Hawley, J.W., Bachman, G.O., and Manley, Kim, 1976, Quaternary stratigraphy in the Basin and Range, and Great Plains provinces, New Mexico and Western Texas, in The Quaternary stratigraphy of North America, W.C. Mahaney, ed: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross, p. 235-274

New Mexico State University, Agricultural Experiment Station, Research reports showing soil association and land classification for irrigation for each county

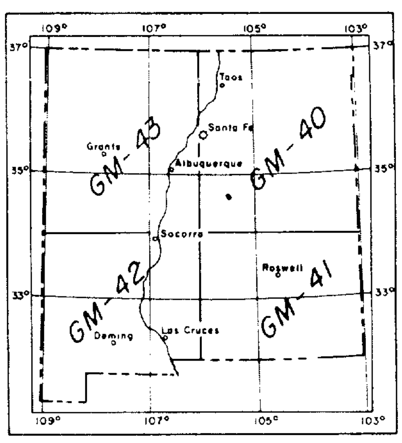
New Mexico State Highway Department supplied data for aggregate resources in New Mexico

Soil Conservation Service, 1/62,500 aerial mosaics of New Mexico Quadrangles

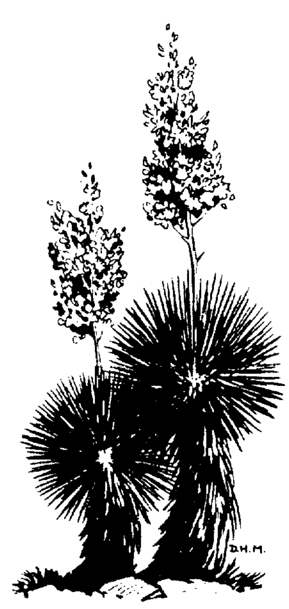
Data from these and other sources were plotted on the 1/250,000 quadrangle maps, field checked with about 40,000 mi of automobile traverses and 20 hours aerial reconnaissance over areas difficult of ground access. Mapping began spring 1974 and was completed June 1976

ACKNOWLEDGMENTS

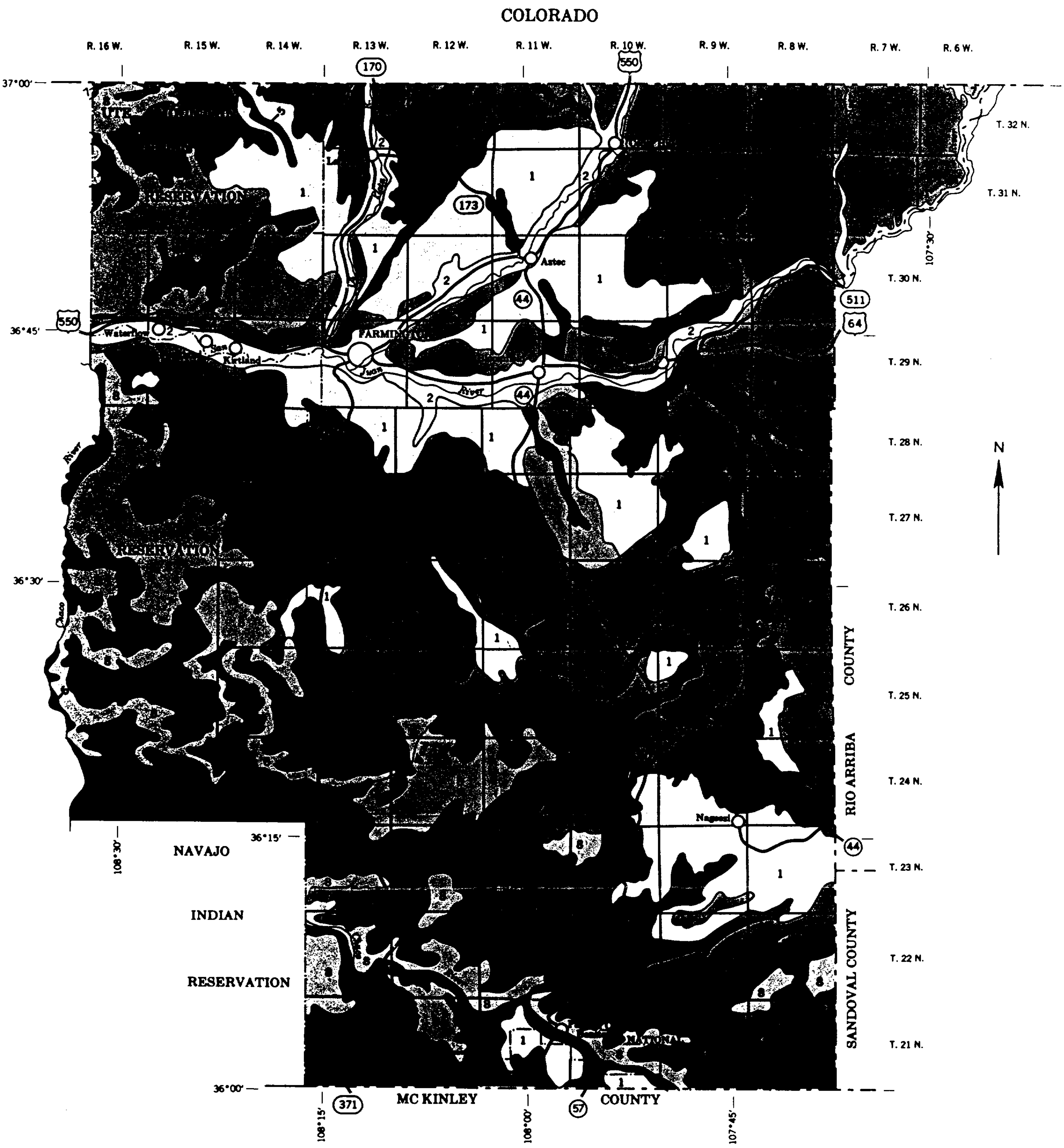
The author wishes to thank John W. Hawley and Robert H. Weber of the New Mexico Bureau of Mines and Mineral Resources for critically reviewing the maps and explanation; also Neila M. Pearson, for editing the explanation and for handling total cartographic compilation



Index map of New Mexico



YUCCA PLANTS



MAP UNITS

1	Persayo-Fruitland-Sheppard: Very shallow to deep, nearly level to very steep, well drained to excessively drained soils that formed in alluvial, residual, and eolian material; on uplands and fans
2	Fruitland-Riverwash-Stumble: Deep, nearly level to moderately steep, well drained to somewhat excessively drained soils that formed in alluvium, and Riverwash; on fans and in valleys
	Shiprock-Sheppard-Doak: Deep, nearly level to moderately steep, well drained to somewhat excessively drained soils that formed in alluvial and eolian material; on uplands
	Haplargids-Blackston-Torriorthents: Very shallow to deep, nearly level to steep, well drained to excessively drained soils that formed in alluvium and residuum; on terraces, mesas, and plateaus
	Blancot-Notal: Deep, nearly level to gently sloping, well drained to somewhat excessively drained soils that formed in alluvium; on valley sides, valley bottoms, and fans
	Sheppard-Huerfano-Notal: Shallow to deep, nearly level to steep, well drained to somewhat excessively drained soils that formed in eolian material, alluvium, and residuum; on uplands, bottom lands, and fans
	Travessilla-Rock outcrop-Weska: Very shallow to deep, nearly level to extremely steep, well drained soils that formed in alluvium, residuum, and eolian material, and Rock outcrop; on uplands
8	Badland-Rock outcrop-Monierco: Badland, Rock outcrop, and shallow, nearly level to gently sloping, well drained soils that formed in alluvial and eolian material; on uplands

Compiled 1979

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
BUREAU OF INDIAN AFFAIRS
NEW MEXICO AGRICULTURAL EXPERIMENT STATION

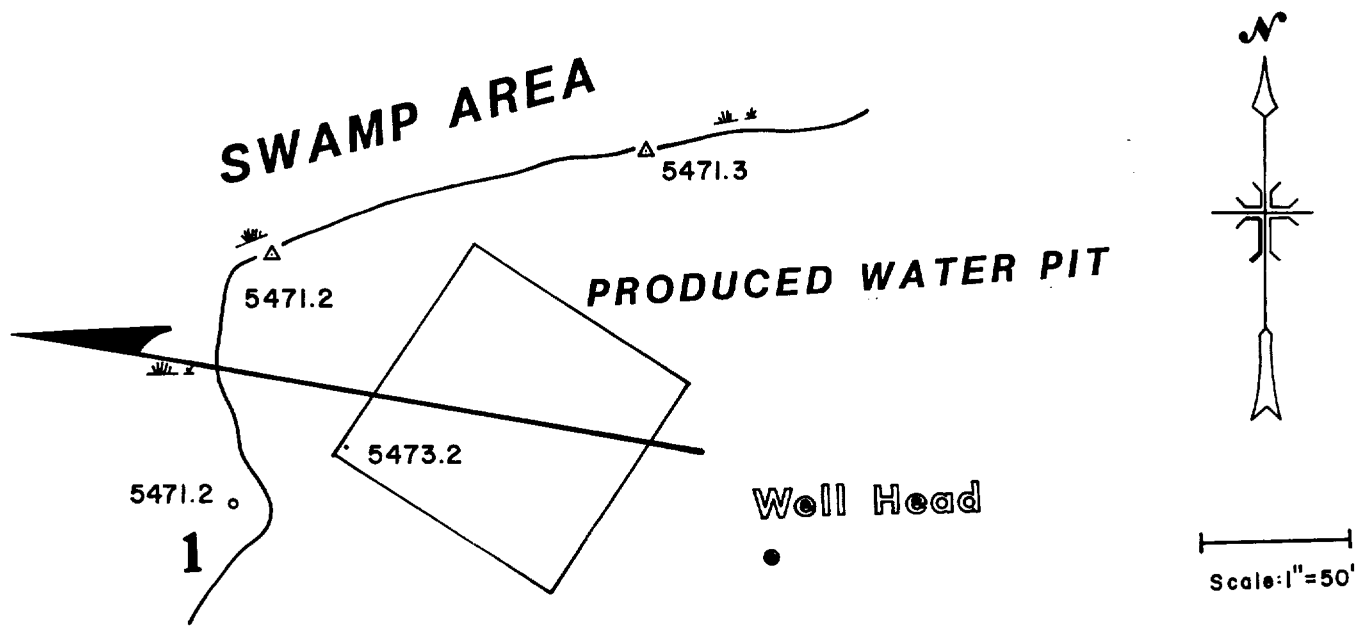
GENERAL SOIL MAP

SAN JUAN COUNTY, NEW MEXICO, EASTERN PART

Scale 1: 506,880

1 0 1 2 3 4 5 6 7 Miles

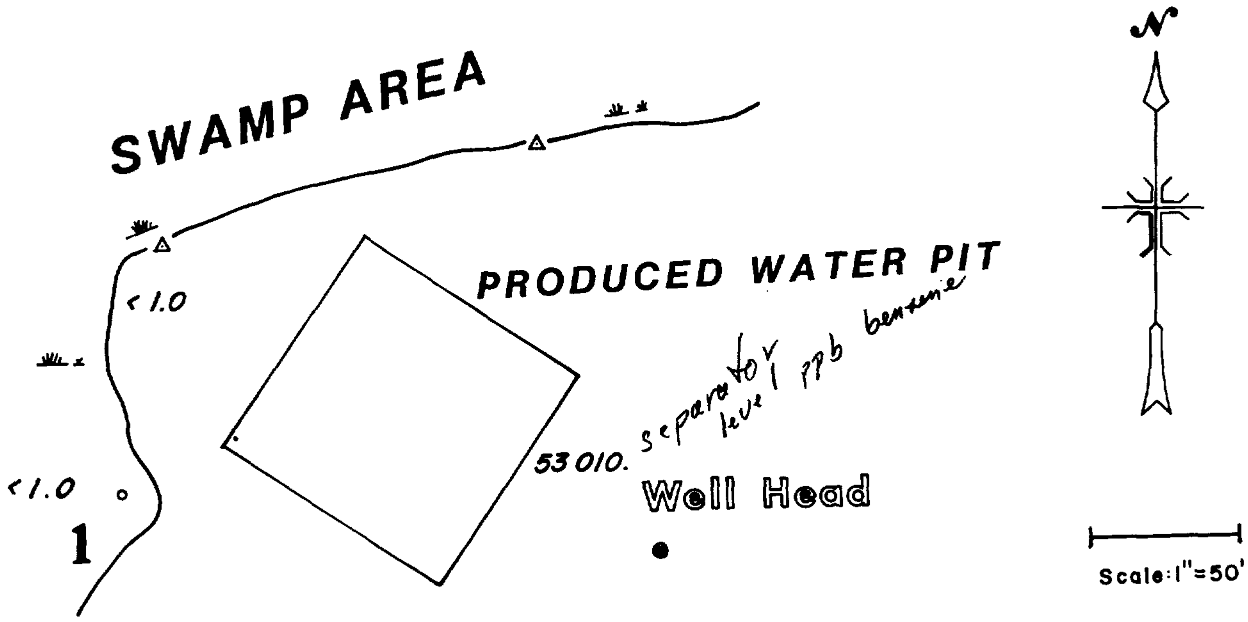
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



Note: Arrow represents direction of hydraulic gradient.

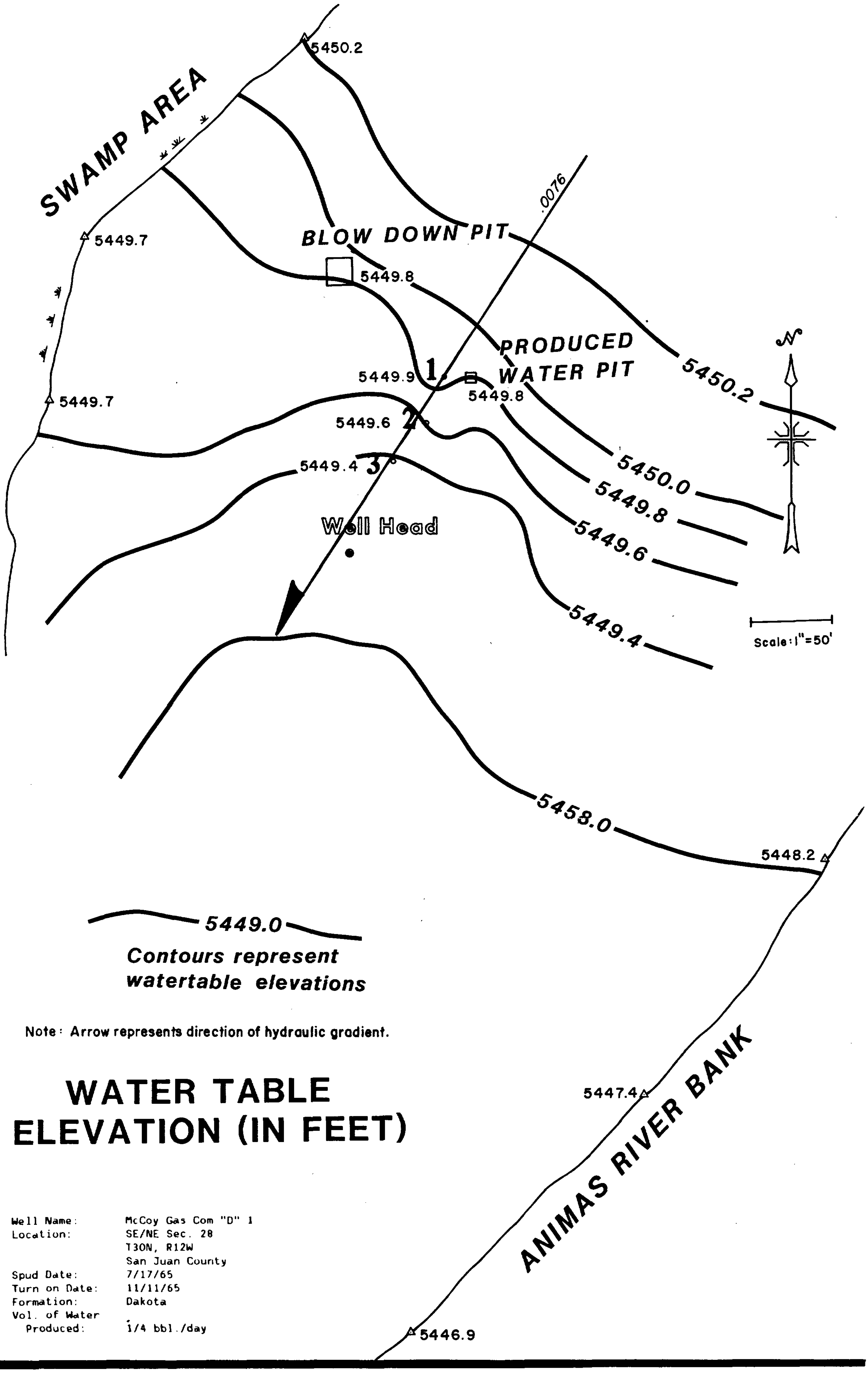
WATER TABLE ELEVATION (IN FEET)

Well Name:	Payne Gas Unit A-1E
Location:	SE/SW Sec. 19 T29N, R10W San Juan County
Spud Date:	10/23/80
Turn on Date:	6/1/81
Formation:	Dakota Mesaverde Chacra
Vol. of Water Produced:	3 bbl./day



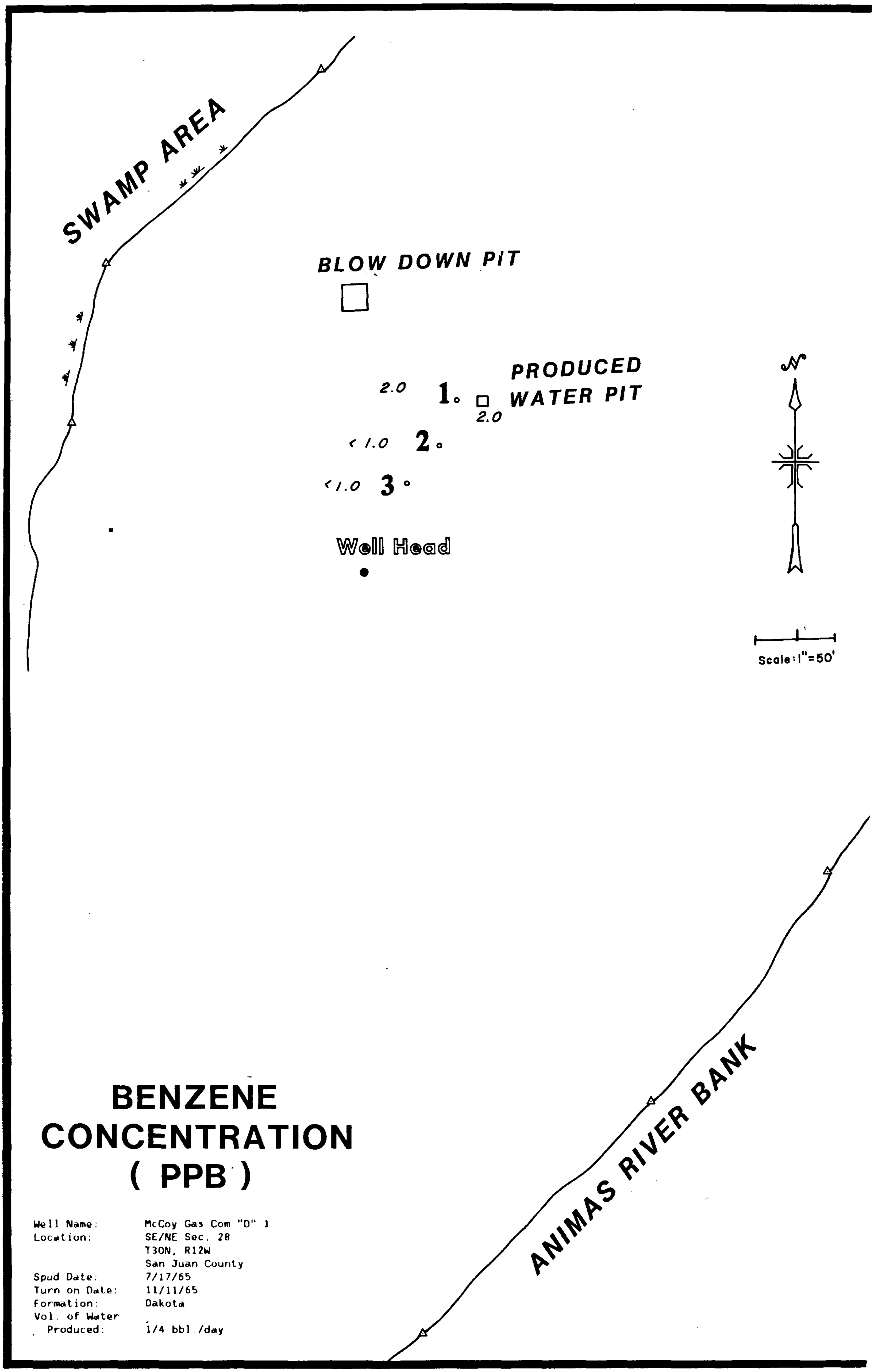
BENZENE CONCENTRATION (PPB)

Well Name:	Payne Gas Unit A-1E
Location:	SE/SW Sec. 19 T29N, R10W San Juan County
Spud Date:	10/23/80
Turn on Date:	6/1/81
Formation:	Dakota Mesaverde Chacra
Vol. of Water Produced:	3 bbl./day



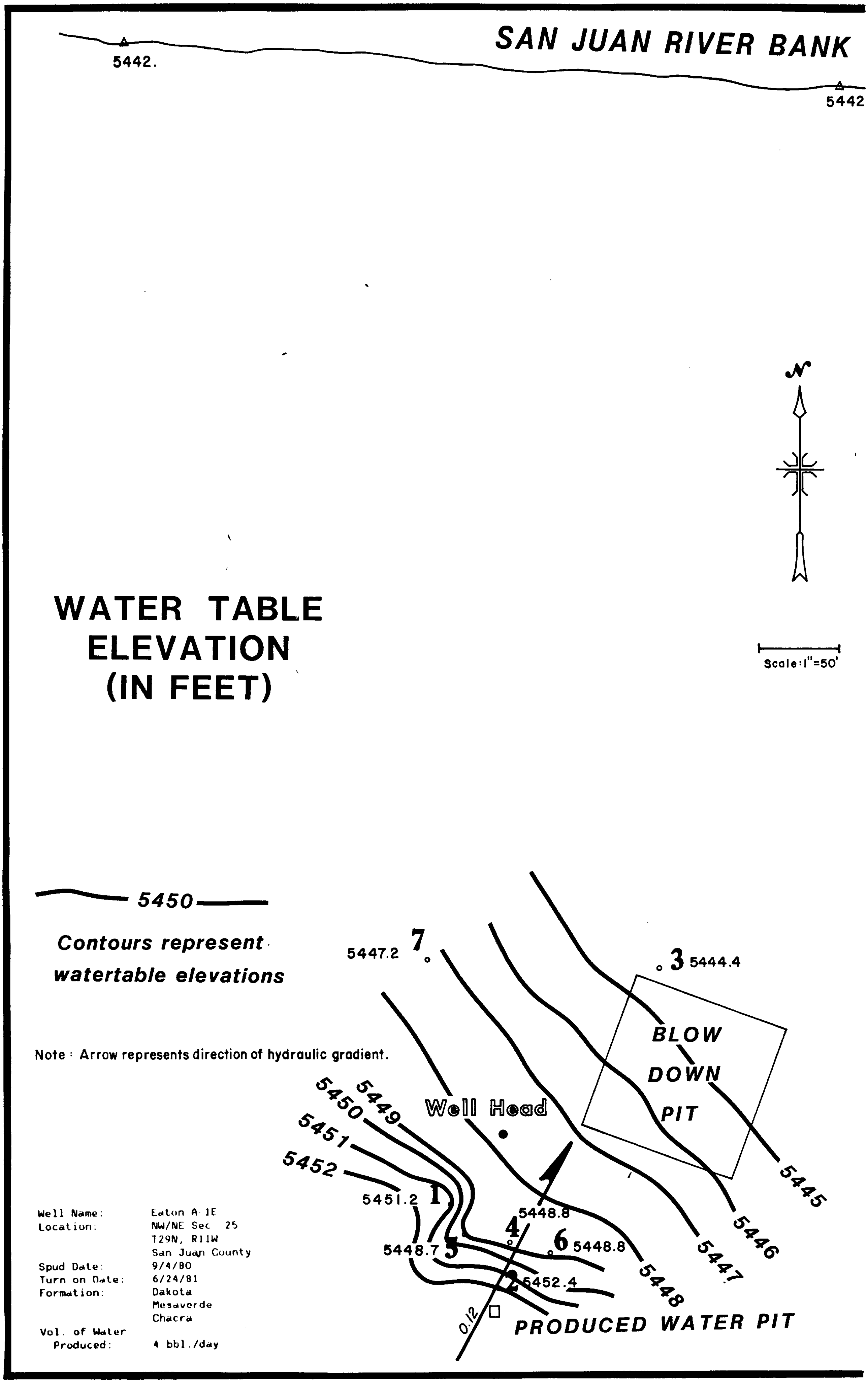
WATER TABLE ELEVATION (IN FEET)

Well Name:	McCoy Gas Com "D" 1
Location:	SE/NE Sec. 28 T30N, R12W San Juan County
Spud Date:	7/17/65
Turn on Date:	11/11/65
Formation:	Dakota
Vol. of Water Produced:	1/4 bbl./day

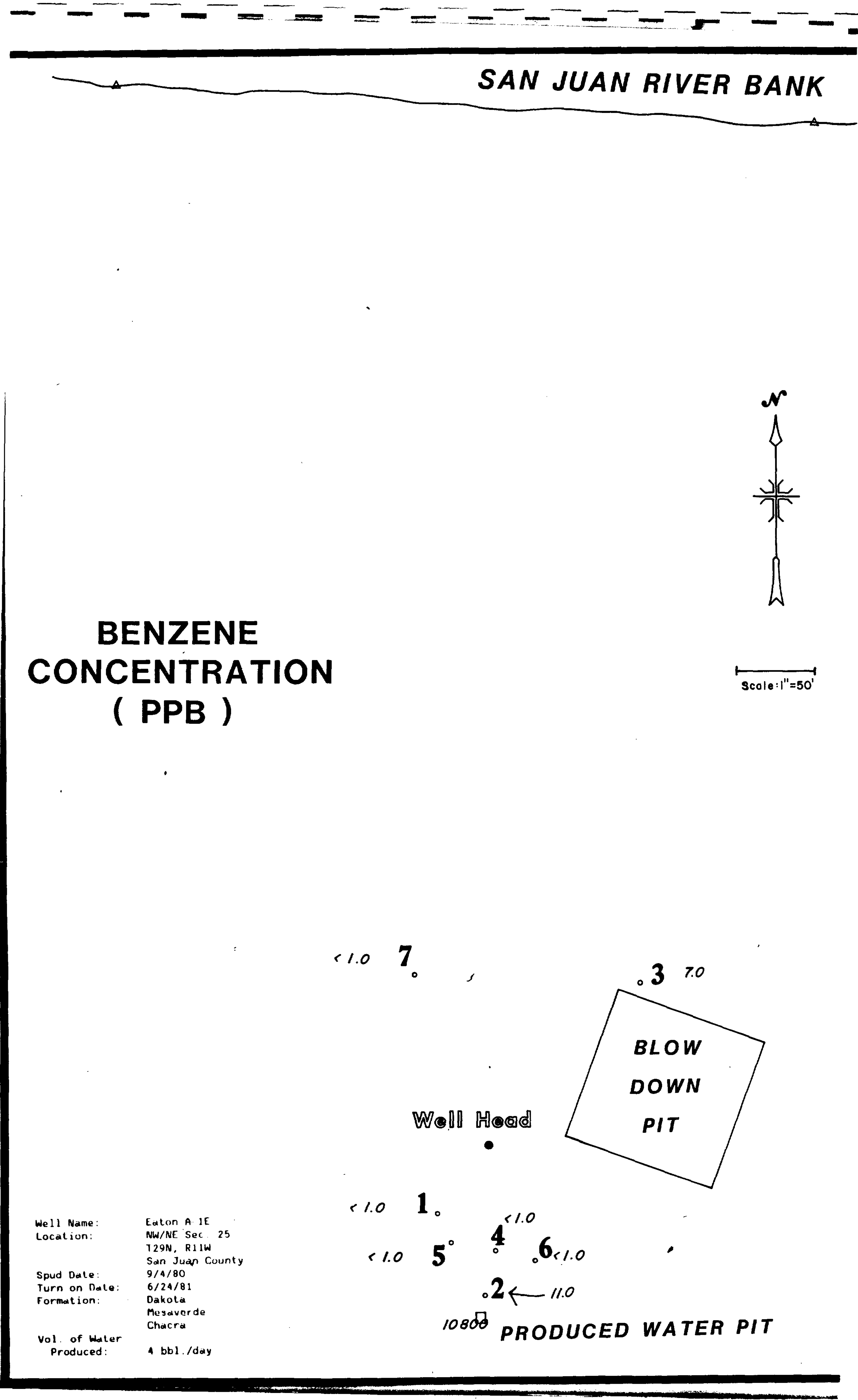


BENZENE CONCENTRATION (PPB)

Well Name:	McCoy Gas Com "D" 1
Location:	SE/NE Sec. 28
	T30N, R12W
	San Juan County
Spud Date:	7/17/65
Turn on Date:	11/11/65
Formation:	Dakota
Vol. of Water Produced:	1/4 bbl./day



SAN JUAN RIVER BANK
5442.
5442
N
WATER TABLE ELEVATION (IN FEET)
Scale: 1"=50'
5450
Contours represent watertable elevations
Note: Arrow represents direction of hydraulic gradient.
5447.2 7
3 5444.4
BLOW DOWN PIT
Well Head
5449
5450
5451
5452
5445
5446
5447
5448
5451.2 1
5448.8
4
6 5448.8
5448.7 5
2 5452.4
0.12
PRODUCED WATER PIT
Well Name: Eaton A 1E
Location: NW/NE Sec 25 T29N, R11W San Juan County
Spud Date: 9/4/80
Turn on Date: 6/24/81
Formation: Dakota Mesaverde Chacra
Vol. of Water Produced: 4 bbl./day


SAN JUAN RIVER BANK
N
BENZENE CONCENTRATION (PPB)
Scale: 1"=50'
< 1.0 7
3 7.0
BLOW DOWN PIT
Well Head
< 1.0 1
< 1.0 4
< 1.0 5
6 < 1.0
2 11.0
10800
PRODUCED WATER PIT
Well Name: Eaton A 1E
Location: NW/NE Sec. 25
T29N, R11W
San Juan County
Spud Date: 9/4/80
Turn on Date: 6/24/81
Formation: Dakota
Mesaverde
Chacra
Vol. of Water Produced: 4 bbl./day

Geoscience Consultants, Ltd. is a multidisciplinary firm offering a wide range of geotechnical and engineering services to private and governmental clients. Based in Albuquerque, New Mexico, Geoscience Consultants, Ltd. serves clients throughout the western United States. Principals in the firm have expertise in hydrogeology, hazardous waste management, environmental engineering, permitting, water quality studies, remote sensing, and energy resource evaluation.

For more information, contact:

Geoscience Consultants, Ltd.
325 Copper Square
500 Copper Avenue NW
Albuquerque, New Mexico 87102
(505)842-0001, 842-0099

TABLE 1

BENZENE CONCENTRATIONS IN PRODUCED WATER
NMOCD FIELD DATA

all in mg/l

	Separators		Pits
	14.4	Langendorf 1E	
	8.86	Gravel A-1E	4.5
		Flora Vista 1	3.2
	21.9	Valdez A-1E	
	5.4	Valdez A-1E	
	21.8	GCU 94E	
	64.6	Zachary 16	2.18
	29.7	Albright 7E	
	18.4	Albright 7E	
	13.2	Albright 7E	
		Hogback 6	ND
	29.5	Florence 2	
	15.8	Florence 37A	
	65.0	Largo Fed. 1A	4.4
		Zachary 30	0.58
		Hare 1	10.2
Mean	25.7		3.58

GEOSCIENCE CONSULTANTS, LTD FIELD DATA

10.85	Eaton A-1E	3.83
53.01	Payne 1	0.02
	McCoy B 1	0.011
	McCoy B 1	0.002

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
Case No. 8224 Exhibit No. 4
Submitted by TCO
Hearing Date 4/22/85

RANDOM WALK SIMULATIONS OF PRODUCED WATER DISPOSAL PITS VUNERABLE AREA SAN JUAN BASIN, NEW MEXICO

Prepared for:

New Mexico Oil Conservation Commission

Prepared by:

Geoscience Consultants, Ltd.
Suite 325
500 Copper Avenue NW
Albuquerque, New Mexico

Figure 1

Random Walk Simulation: Input and Output

```
---------------------------RANDOM WALK-----------------------------

   //////////BASIC TRANSPORT COEFFICIENTS\\\\\\\\\\

        TRANSMISSIVITY (GPD/FT) =  250000  GPD/FT
        STORAGE COEFFICIENT    =  .1
        HYDRAULIC CONDUCTIVITY =  10000  GPD/SQ.FT.
        POROSITY =  .25
        LONGITUDINAL DISPERSIVITY=  10
        TRANSVERSE DISPERSIVITY (FT)= 2
        RETARDATION COEFFICIENT =  1  FT
        REGIONAL X FLOW (FT/DAY) =  15.96
        REGIONAL Y FLOW (FT/DAY)=  0

   /////////////////////////\\\\\\\\\\\\\\\\\\\\\\\\\

 //////////////////////PARTICLES\\\\\\\\\\\\\\\\\\

    PARTICLES ON A CIRCLE
     CIRCLE NUMBER  1
     CIRCLE CENTER COORDINATES (X,Y) =  150 , 1500  FT
     CIRCLE RADIUS =  5  FT
  NUMBER OF PARTICLES =  10

    TOTAL SYSTEM PARTICLES =  10
```

MAP WINDOW LOCATION
LOWER-LEFT COORDINATES = 0 , 0 FT
UPPER-RIGHT COORDINATES = 3000 , 3000 FT
CELL SIZE (CDX,CDY) = 250 , 250 FT

SIMULATION TIME = 0 DAYS

	0		500		1000		1500		2000		2500		3000
3000	0	0	0	0	0	0	0	0	0	0	0	0	0
2750	0	0	0	0	0	0	0	0	0	0	0	0	0
2500	0	0	0	0	0	0	0	0	0	0	0	0	0
2250	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
1750	0	0	0	0	0	0	0	0	0	0	0	0	0
1500	0	10	0	0	0	0	0	0	0	0	0	0	0
1250	0	0	0	0	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0	0	0	0	0
750	0	0	0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0	0	0	0
250	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	0

(-1:PUMPING WELL, -2:INJECTION WELL)

PRESENT SIMULATION TIME = 0 DAYS
INCREMENTAL SIMULATION TIME = 30 DAYS
DMAX = 12.5 FT

NP= 10

TABLE 1

BENZENE CONCENTRATIONS IN PRODUCED WATER
NMOCD FIELD DATA

	Separators		Pits
	14.4	Langendorf 1E	
	8.86	Gravel A-1E	4.5
		Flora Vista 1	3.2
	21.9	Valdez A-1E	
	5.4	Valdez A-1E	
	21.8	GCU 94E	
	64.6	Zachary 16	2.18
	29.7	Albright 7E	
	18.4	Albright 7E	
	13.2	Albright 7E	
		Hogback 6	ND
	29.5	Florence 2	
	15.8	Florence 37A	
	65.0	Largo Fed. 1A	4.4
		Zachary 30	0.58
		Hare 1	10.2
Mean	25.7		3.58

GEOSCIENCE CONSULTANTS, LTD FIELD DATA

10.85	Eaton A-1E	3.83
53.01	Payne 1	0.02
	McCoy B 1	0.011
	McCoy B 1	0.002

TABLE 2

PREDICTED BENZENE CONCENTRATIONS
IN GROUND FROM
RANDOM WALK SIMULATIONS

FIELD CALIBRATION SITES

McCoy "D" 1	Uncalibrated - Calibrated
Eaton AIE	Uncalibrated
Eaton AIE	Calibrated Lower Source Term

RANDOM SAMPLING OF PRODUCED WATER PITS

RIVER VALLEY FLOOD PLAIN

SAN JUAN RIVER $dh/dl = 0.002 - 0.003$

HIGH HYDRAULIC CONDUCTIVITY CASES (10,000 gpd/ft^2)

GCU 202
Totah Vista 1
GCU 170 E
GCU "1" 181 E

MEDIUM HYDRAULIC CONDUCTIVITY CASES (1,000 - 5,000 gpd/ft^2)

Gerk 1
Archuleta A3
Madsen 1
Armenta F1
Abrams L1
Sullivan A1
GCU 153 E
GCU 179 E

LOW HYDRAULIC CONDUCTIVITY CASES (10 - 100 gpd/ft^2)

GCU 169 E
Romero A1
Ulibarri 1A

ANIMAS RIVER $dh/dl = 0.004$

HIGH HYDRAULIC CONDUCTIVITY CASES (10,000 gpd/ft^2)

Marcotte 1

MEDIUM HYDRAULIC CONDUCTIVITY CASES (1,000 - 5,000 gpd/ft^2)

No cases observed

LOW HYDRAULIC CONDUCTIVITY CASES (10 - 100 gpd/ft^2)

No cases observed

VALLEY SIDE SLOPES AND TRIBUTARIES $dh/dl = 0.01$

HIGH HYDRAULIC CONDUCTIVITY CASES

McCoy D 1 E

MEDIUM HYDRAULIC CONDUCTIVITY CASES

Keyes A2
Florence 124 (630 days)
Florence 124 (1080 days)
Florence 9
GCU 169
Canaple 1

LOW HYDRAULIC CONDUCTIVITY CASES

GCU 150
Martinez F1
Valdez AIE
Pollock E1
Black 1
Irwin 1E
Heath G 1

BEDROCK MESAS CASES - No simulations, produced water can not enter ground water

Howell 2A
McEwen B1
Heath WD A 3X
Linda Nye 1
Heath Gas COM H 1
Nye Gas COM B 1E
Heath WD A 10
Heath WD A5
Florence 32
Florence 111
Jacquez 1A
Sandoval Gas COM 1 1R
Pritchard 1A

PICTURED CLIFFS CASES - No simulations, no water produced

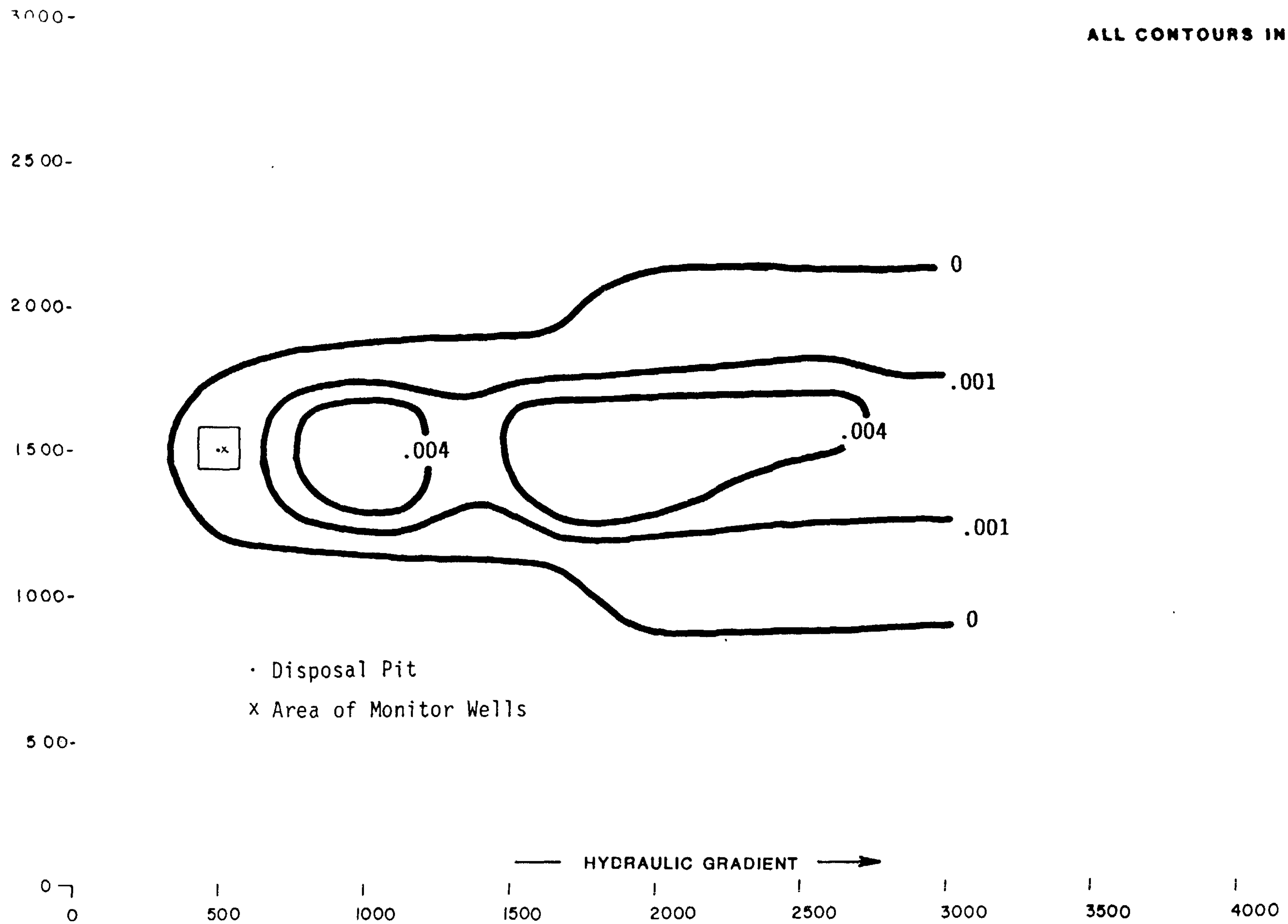
McEwen Gas COM C 1
Wallace Gas COM 3 and 1
Hamner 9
Sullivan, Bruce 1
Sullivan, Earl B, 2
Ulibarri Gas COM 2
Likins Gas COM B 1
Heath Gas COM F 1
Elliott Gas COM M 1
Jacquez Gas COM E 1

WELL SITES VISITED WHICH WERE NOT PART OF
RANDOM SAMPLE FOR SIMULATIONS

Sullivan Frame A1	Linda Nye 1A
Payne AIE	Archuleta 1
Sullivan Frame AIE	Jacquez 2
Eaton AIE	Jacquez 1M
Sullivan COM B1	Jacquez 3
Valdez B1	Jacquez 2A
Linda Nye 1	McCoy B1

FIELD CALIBRATION SITES

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-250000
Storage Coefficient -.1
Hydraulic Conductivity (GPD/FT^2)-10000
Porosity-.25
Longitudinal Dispersivity -10
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow(FT/DAY)-21.44
Regional Y Flow (FT/DAY)-0

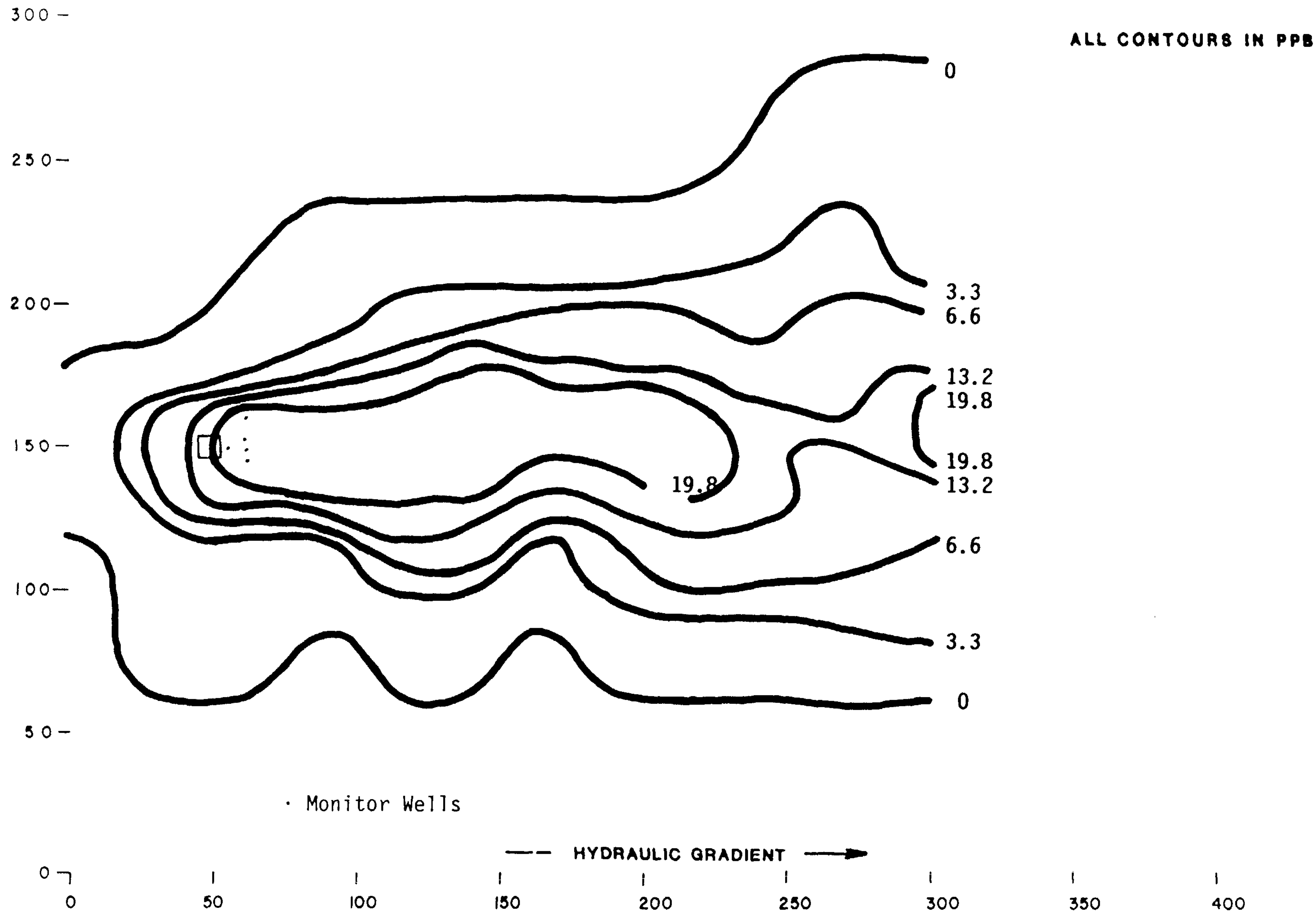
SOURCE TERM

Volume Of Produced Water (BBL/DAY) .16
Benzene Concentration (PPB) -3500

UNCALIBRATED = CALIBRATED

CASE NUMBER McCOY "D" 1

Simulation Time (DAYS)-800
SE, NE 28 30 N 12 W
ANIMAS RIVER
dh/dl = 0.004



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) 2500
Storage Coefficient 0.1
Hydraulic Conductivity (GPD/FT^2) 100
Porosity 0.25
Longitudinal Dispersivity 10
Transverse Dispersivity 2

Retardation Coefficient (FT) 1
Regional X Flow(FT/DAY) 1.74
Regional Y Flow (FT/DAY) 0

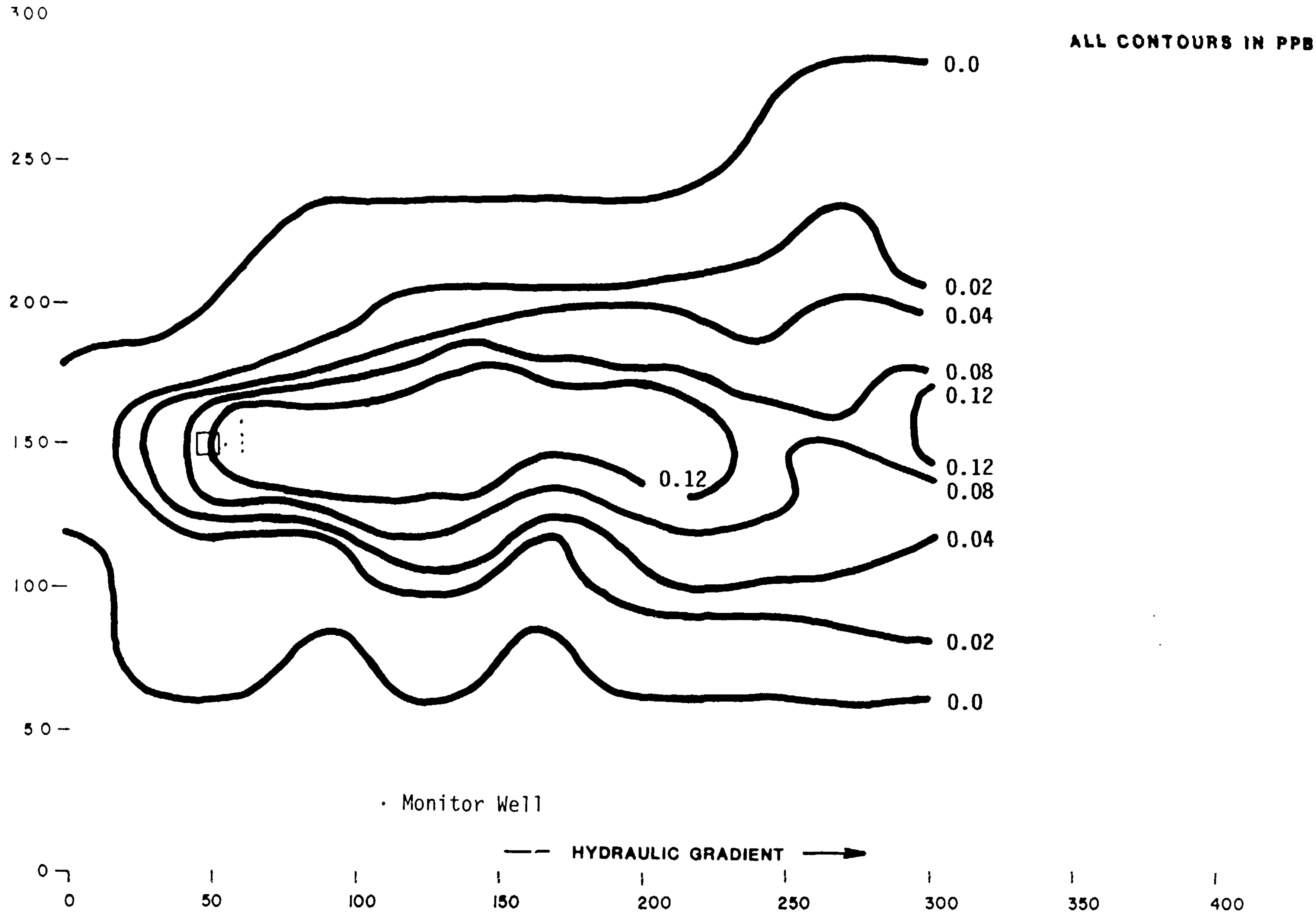
SOURCE TERM

Volume Of Produced Water (BBL/DAY) 4
Benzene Concentration (PPB) 3500

UNCALIBRATED

CASE NUMBER EATON AIE

Simulation Time (DAYS) 400
NW, NE 25 29 N 11 W
SAN JUAN RIVER
dh/dl = 0.03



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) 2500
Storage Coefficient 0.1
Hydraulic Conductivity (GPD/FT^2) 100
Porosity 0.25
Longitudinal Dispersivity 10
Transverse Dispersivity 2

Retardation Coefficient (FT) 1
Regional X Flow(FT/DAY) 1.74
Regional Y Flow (FT/DAY) 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 4
Benzene Concentration (PPB) ~~0.02~~ 20

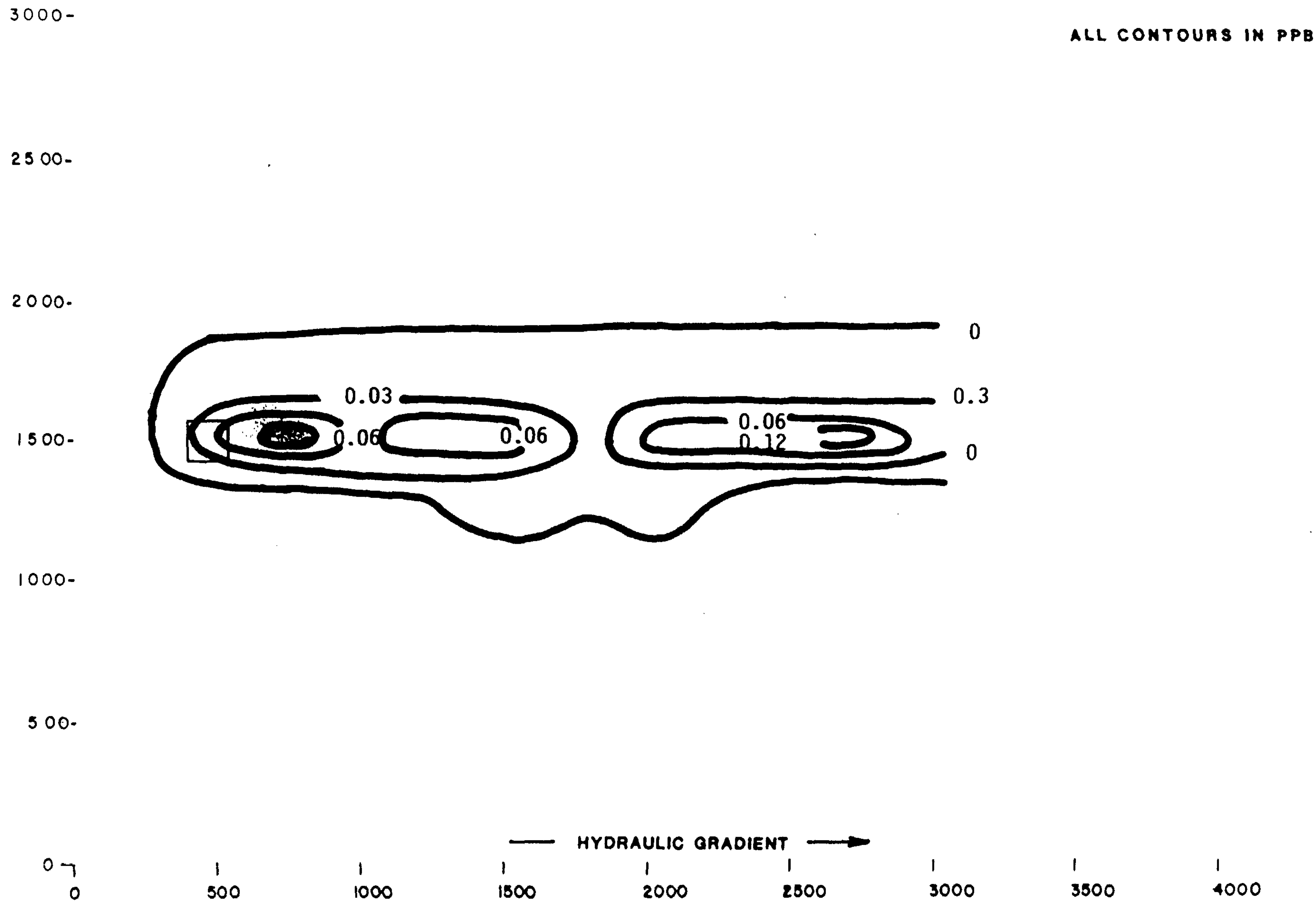
CALIBRATED LOWER SOURCE TERM

CASE NUMBER EATON AIE

Simulation Time (DAYS) 400
NW, NE 25 29 N 11 W
SAN JUAN RIVER
dh/dl = 0.03

SAN JUAN RIVER

HIGH HYDRAULIC CONDUCTIVITY CASES



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 250000
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 10000
Porosity - .25
Longitudinal Dispersivity - 10
Transverse Dispersivity - 2

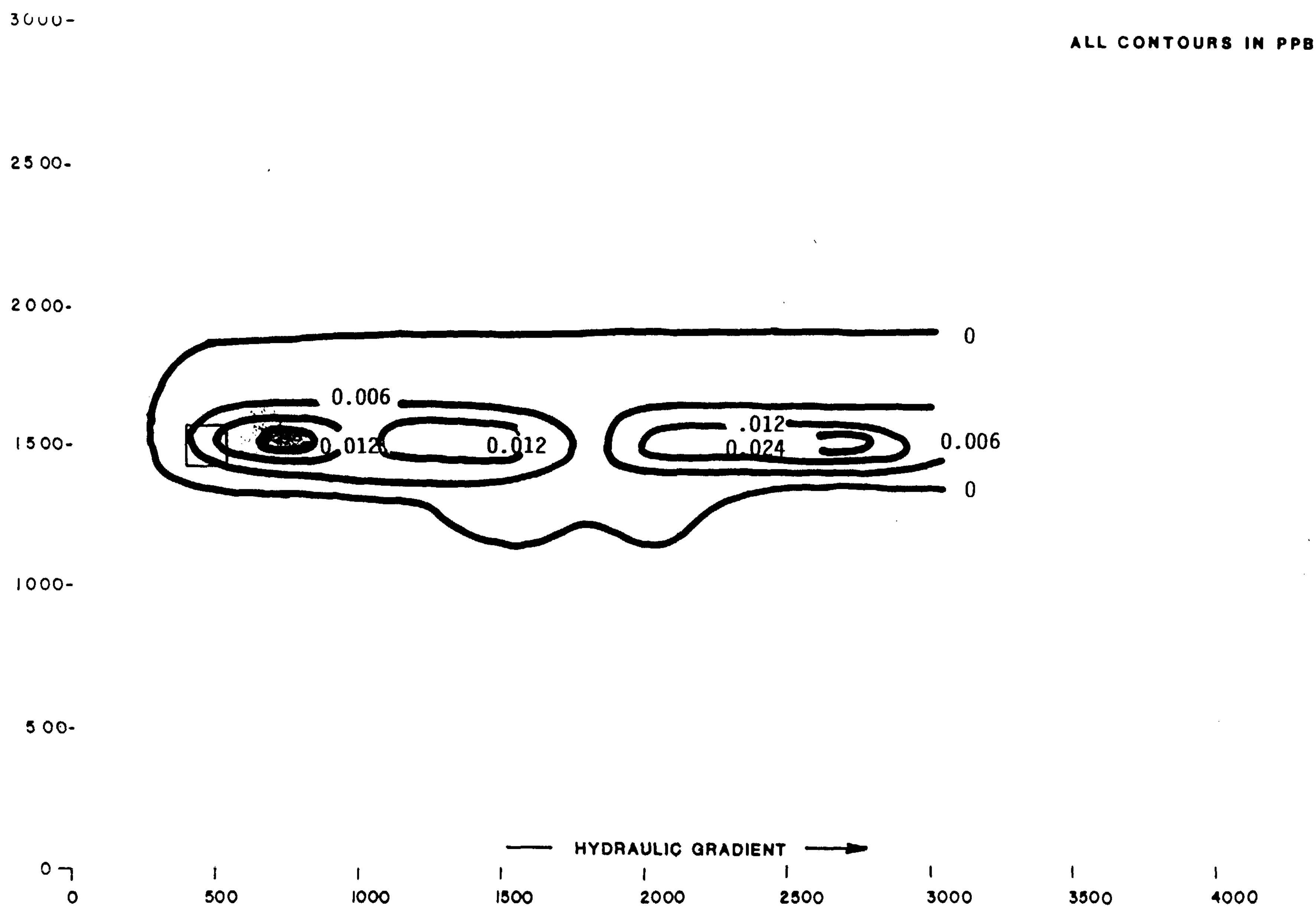
Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - 15.96
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.1
Benzene Concentration (PPB) 3500

CASE NUMBER GCU 202

Simulation Time (DAYS) - 630
NW, NE 33 29 N 12 W
SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-250000
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-10000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-15.96
Regional Y Flow (FT/DAY)-0

SOURCE TERM

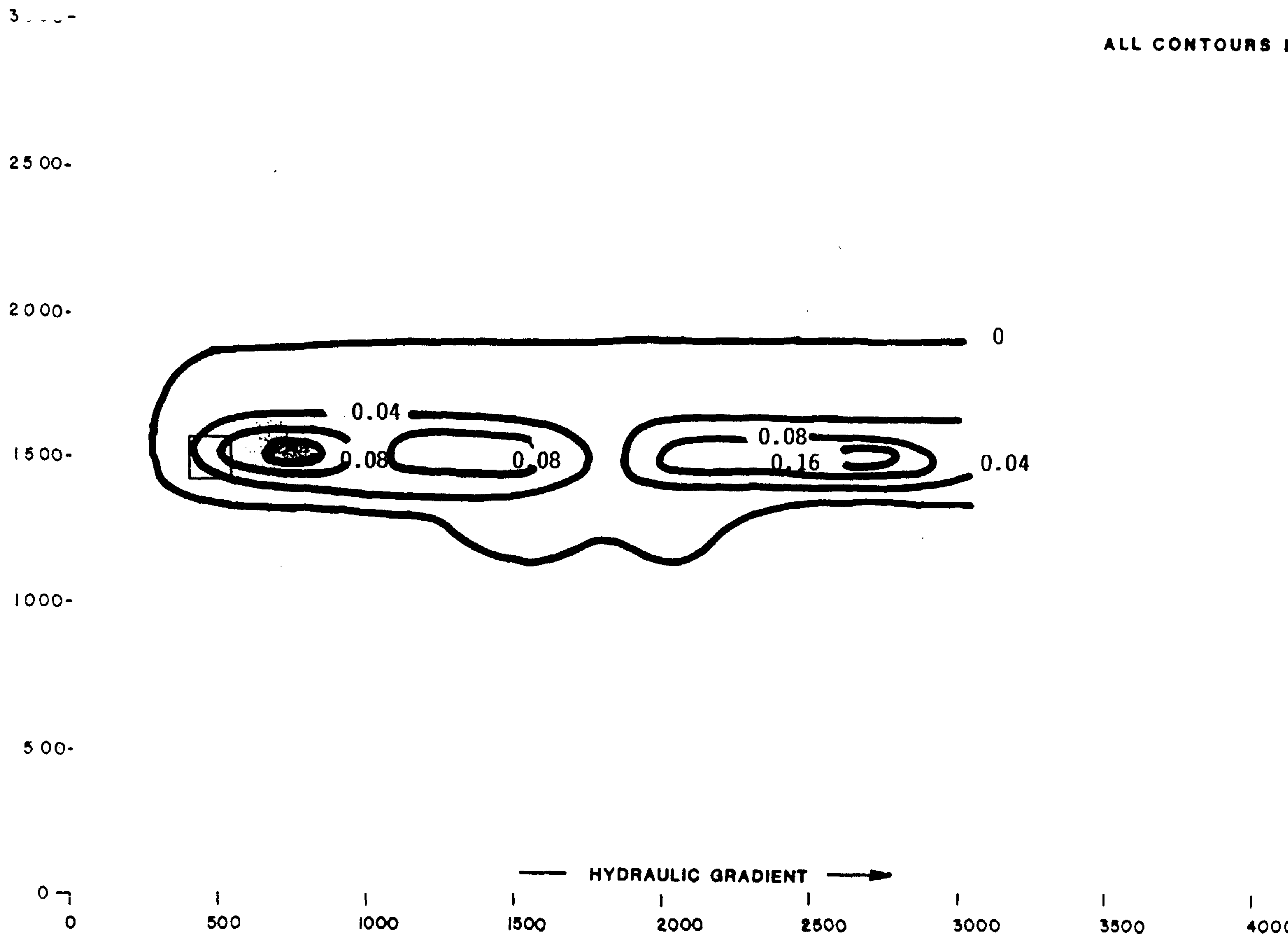
Volume Of Produced Water (BBL/DAY) 0.02
Benzene Concentration (PPB) 3500

CASE NUMBER TOTAH VISTA 1

Simulation Time (DAYS)-630
SW, SW 22 29 N 13 W

SAN JUAN RIVER
dh/dl = 0.003

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 250000
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 10000
Porosity - .25
Longitudinal Dispersivity - 10
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow(FT/DAY) - 15.96
Regional Y Flow (FT/DAY) - 0

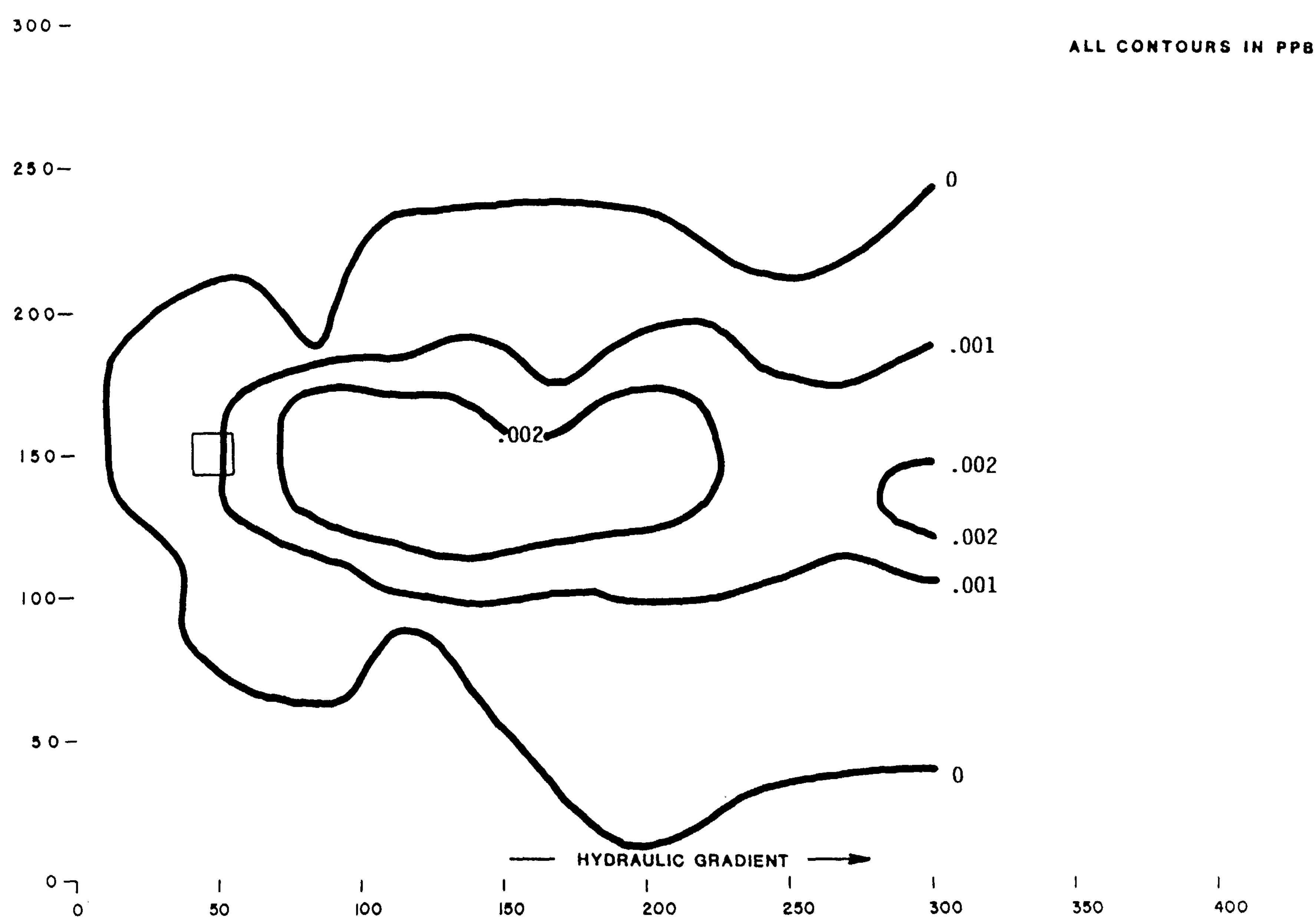
SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.13
Benzene Concentration (PPB) 3500

CASE NUMBER GCU 170E

Simulation Time (DAYS) - 630
SW, NW 35 29 N 12 W

SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 250000

Storage Coefficient - .1

Hydraulic Conductivity (GPD/FT^2) - 10,000

Porosity - .25

Longitudinal Dispersivity - 10

Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1

Regional X Flow (FT/DAY) - 12

Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - .07

Benzene Concentration (PPB) - 3500

CASE NUMBER - GCU "I" 181E

Simulation Time (DAYS) - 235

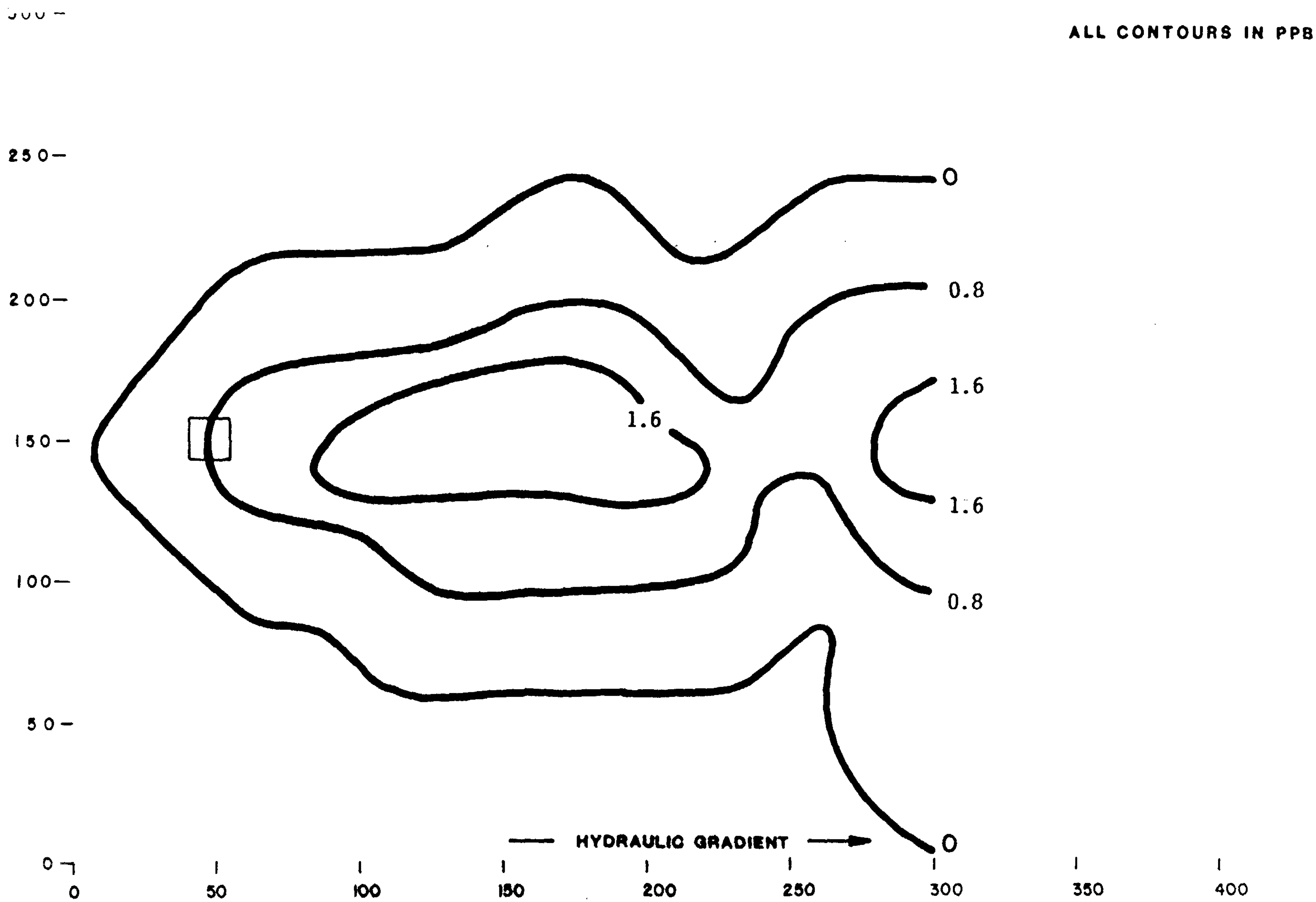
SE, NE 34 29 N 12 W

San Juan River

dh/dl = 0.002

SAN JUAN RIVER

MEDIUM HYDRAULIC CONDUCTIVITY CASES



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 25000

Storage Coefficient - .1

Hydraulic Conductivity (GPD/FT^2) - 1000

Porosity - .25

Longitudinal Dispersivity - 10

Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1

Regional X Flow (FT/DAY) - 1.5

Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - .13

Benzene Concentration (PPB) - 3500

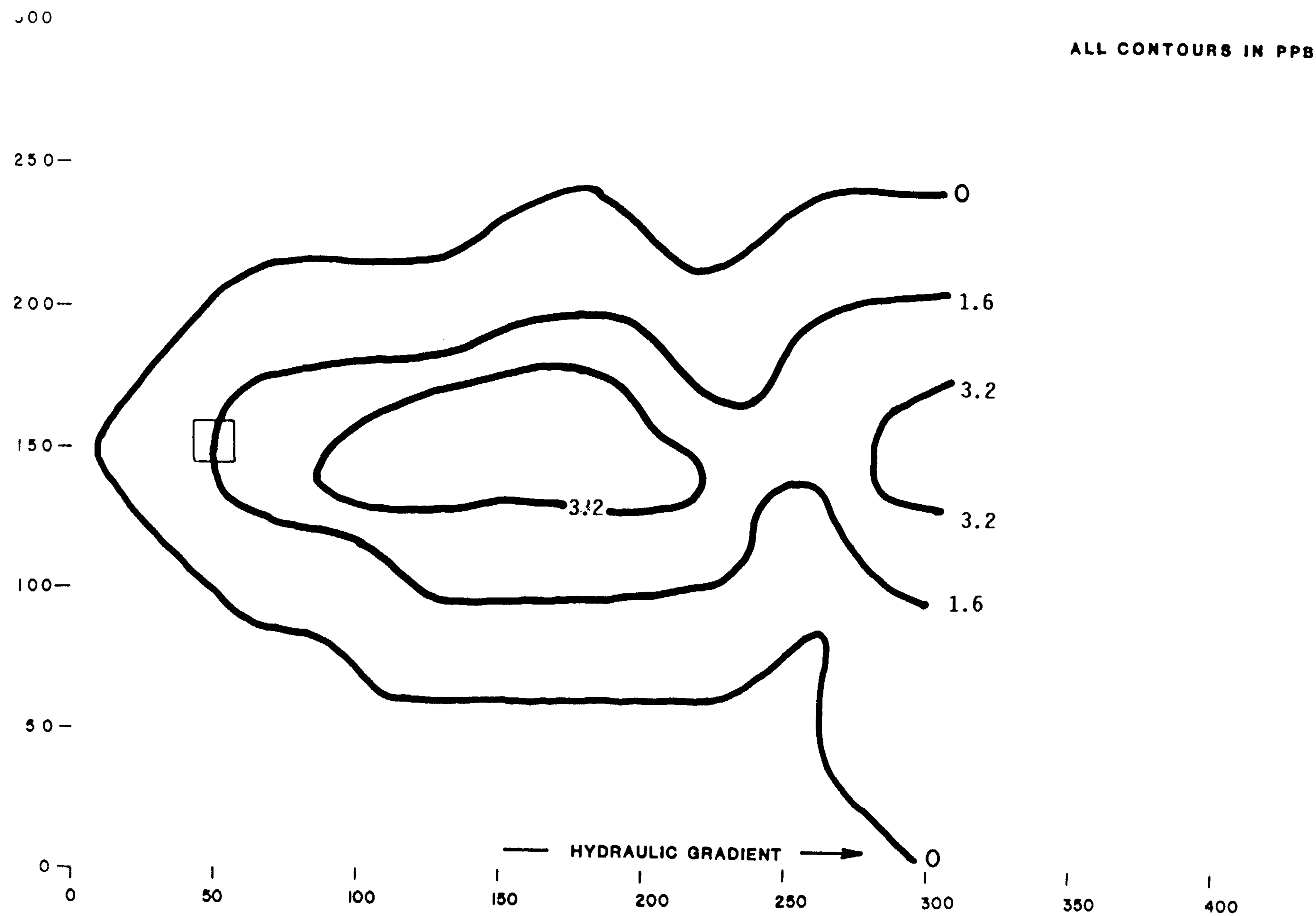
CASE NUMBER - Gerk 1

Simulation Time (DAYS) - 800

27 29 N 10 W

SAN JUAN RIVER

dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 25,000
Storage Coefficient - 0.1
Hydraulic Conductivity (GPD/FT^2) - 1000
Porosity - .25
Longitudinal Dispersivity - 10
Transverse Dispersivity - 2

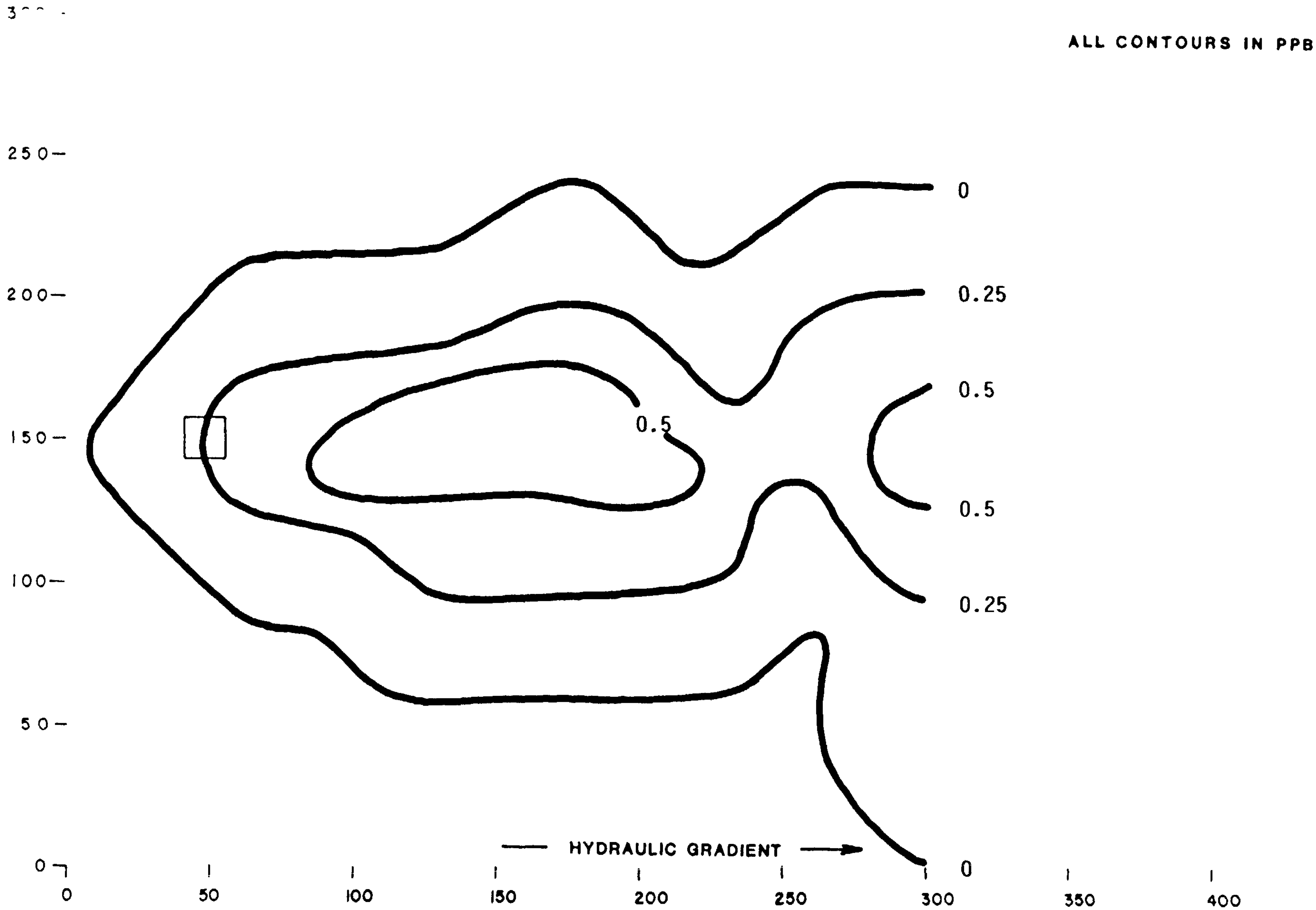
Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - 1.6
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - .23
Benzene Concentration (PPB) - 3500

CASE NUMBER - Madsen 1

Simulation Time (DAYS) - 800
NE, NE 28 29 N 11 W
SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-25000
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-1000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

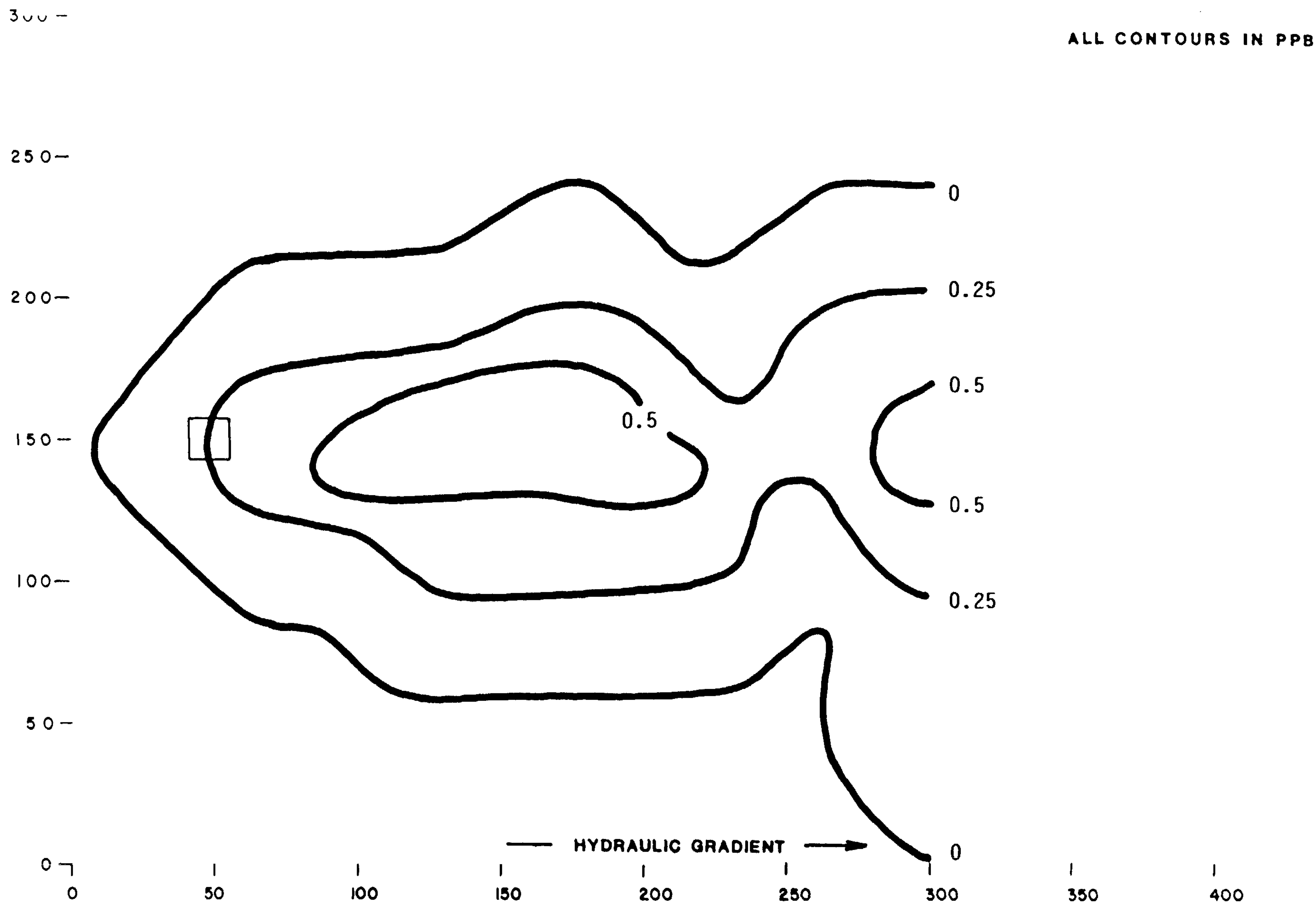
Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-1.5
Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.02
Benzene Concentration (PPB) 3500

CASE NUMBER ARCHULETA A3

Simulation Time (DAYS)-800
NE, SW 5 29 N 9 W
SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-25000
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-1000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

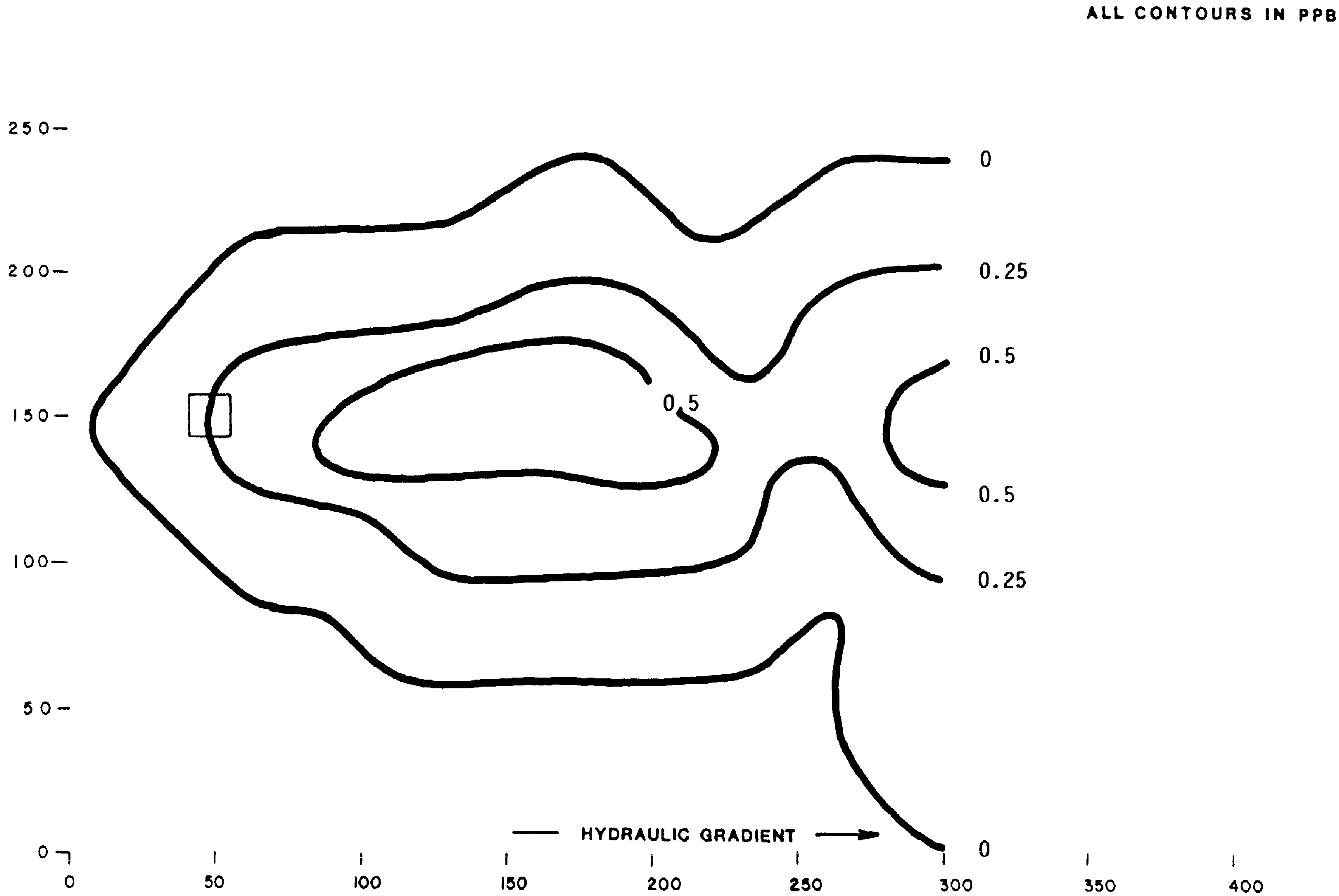
Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-1.5
Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY)	0.02
Benzene Concentration (PPB)	3500

CASE NUMBER ARMENTA F1

Simulation Time (DAYS) - 800
SE, NE 27 29 N 10 W
SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-25000
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-1000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

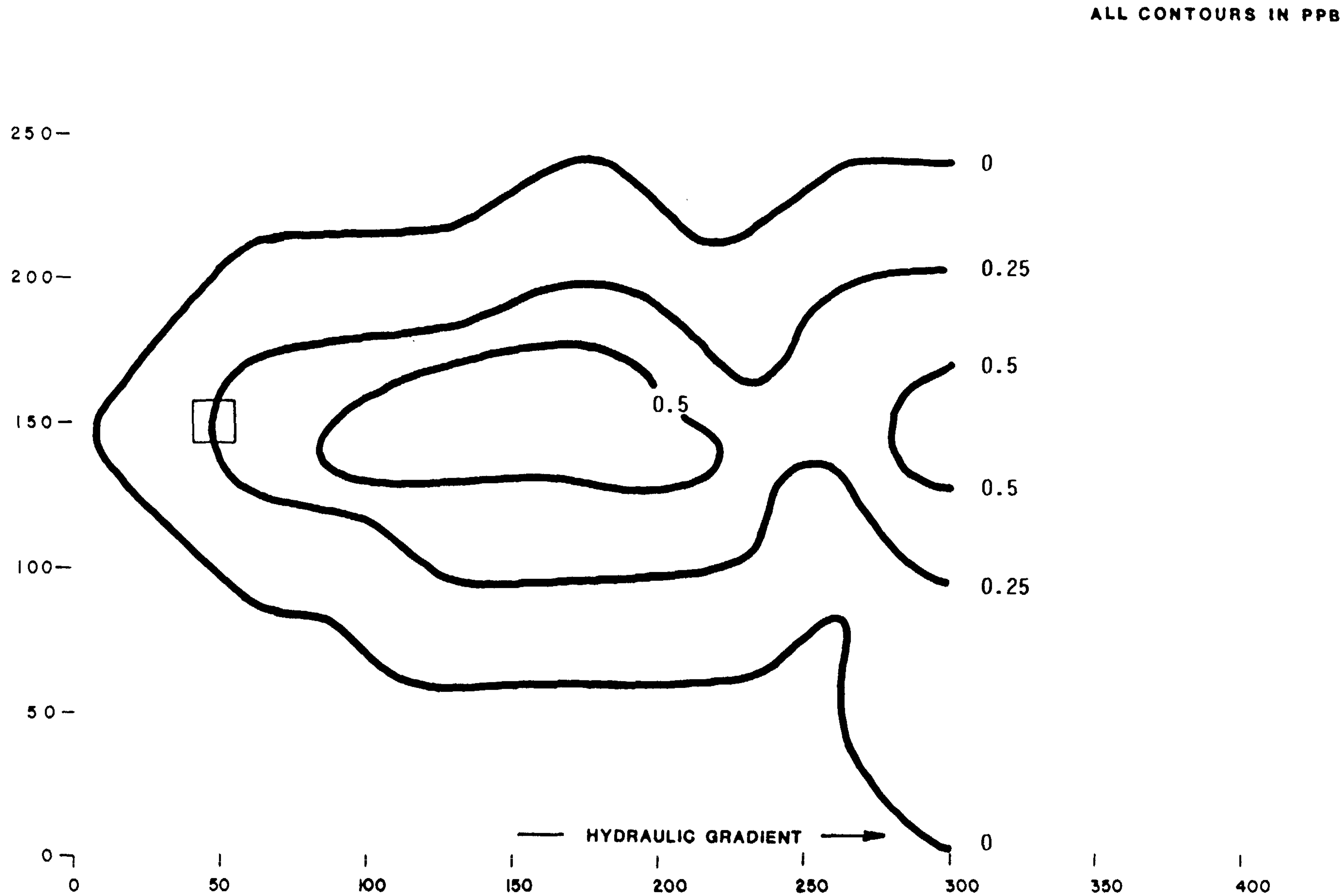
Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-1.5
Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.02
Benzene Concentration (PPB) 3500

CASE NUMBER ABRAMS L1

Simulation Time (DAYS) - 800
26 29 N 10 W
SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-25000
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-1000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

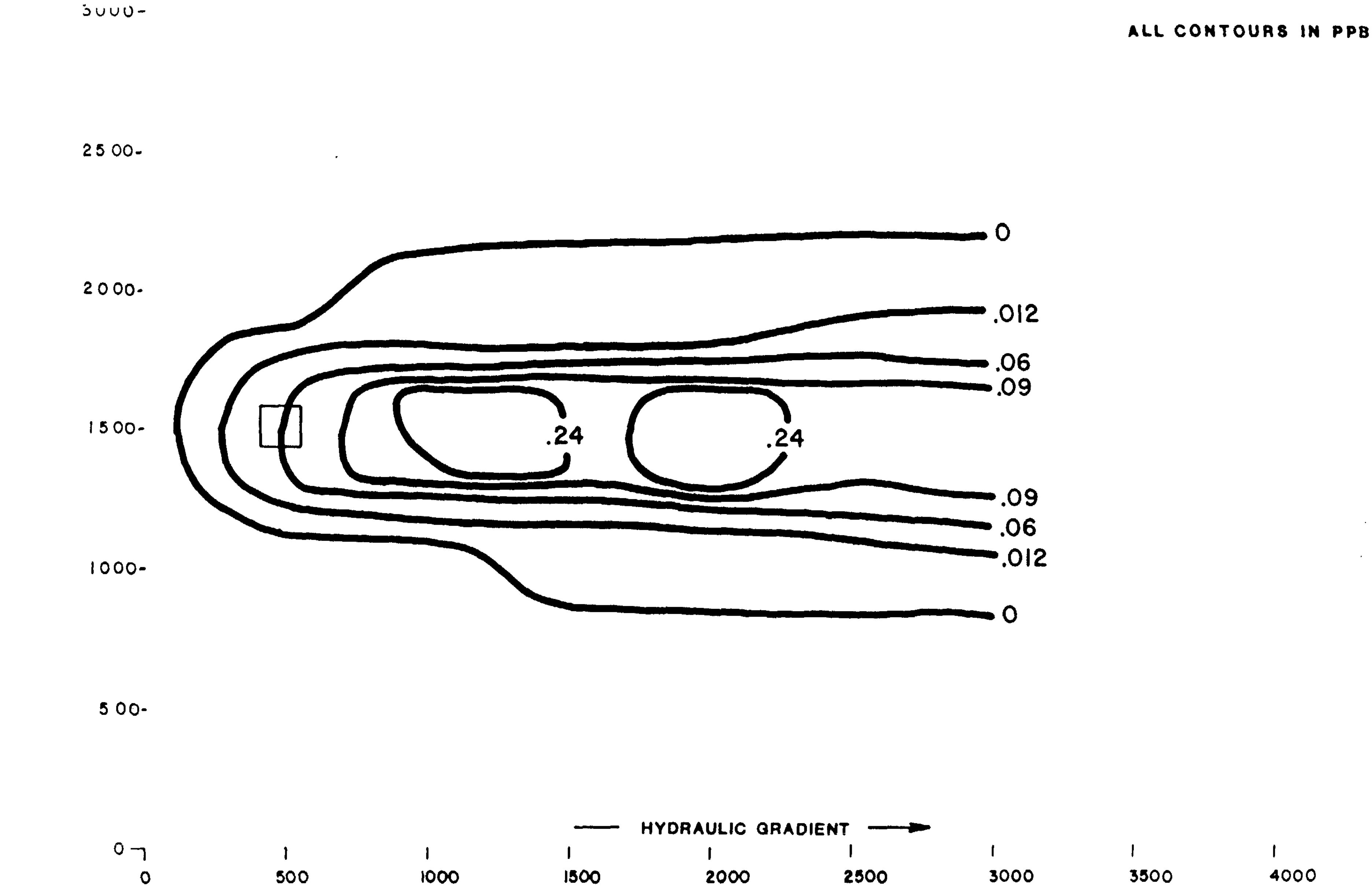
Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-1.5
Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.02
Benzene Concentration (PPB) 3500

CASE NUMBER SULLIVAN A1

Simulation Time (DAYS) - 800
NE, NW 25 29 N 11 W
SAN JUAN RIVER
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-125000

Storage Coefficient-.1

Hydraulic Conductivity (GPD/FT^2)-5000

Porosity-.25

Longitudinal Dispersivity-10

Transverse Dispersivity-2

Retardation Coefficient (FT)-1

Regional X Flow(FT/DAY)-8.04

Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY)-.33

Benzene Concentration (PPB)-3500

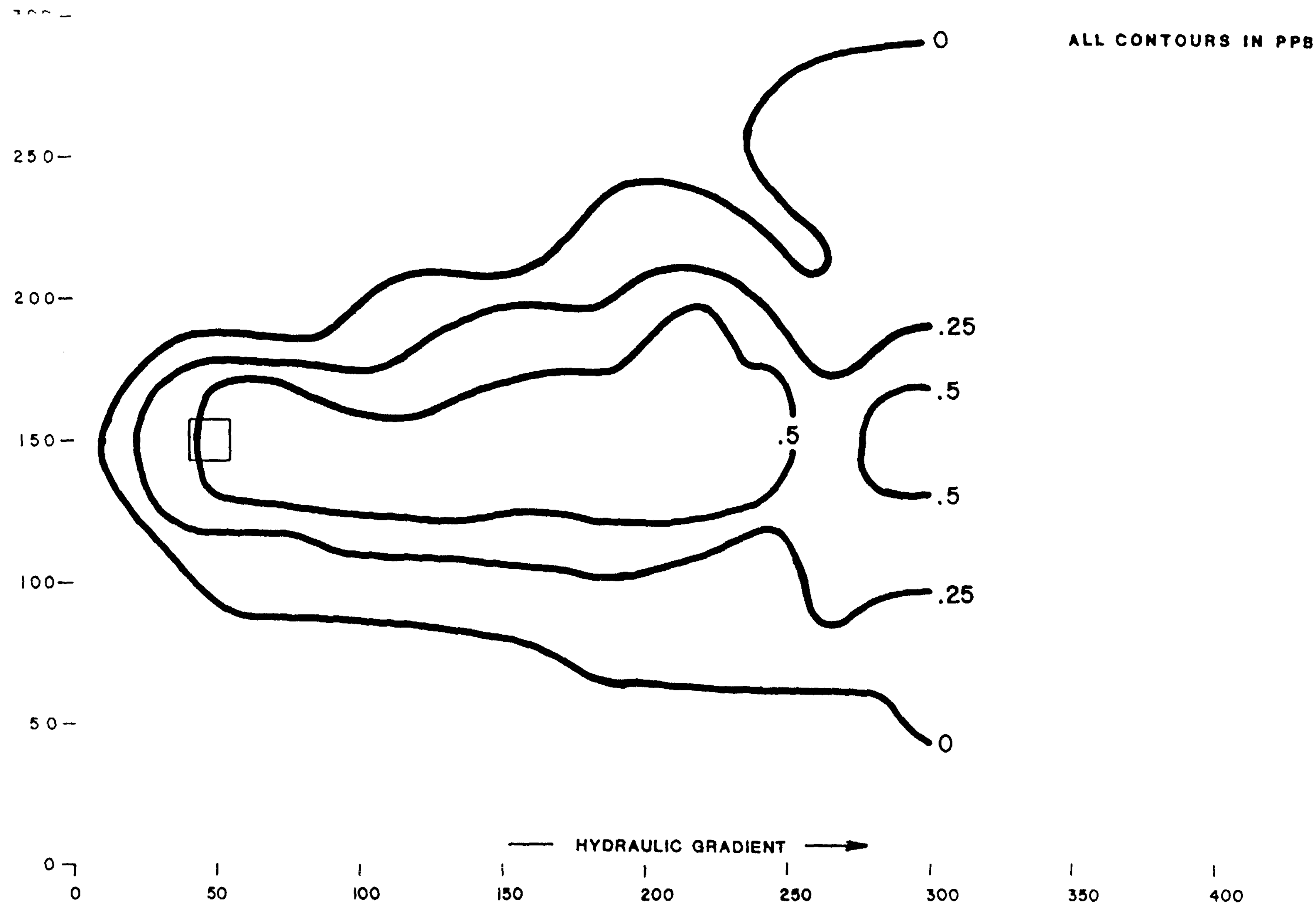
CASE NUMBER-GCU 153E

Simulation Time (DAYS)-705

NE, NW 28 29 N 12 W

SAN JUAN RIVER

dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 25000
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 1000
Porosity - .25
Longitudinal Dispersivity - 10
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - 1.07
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

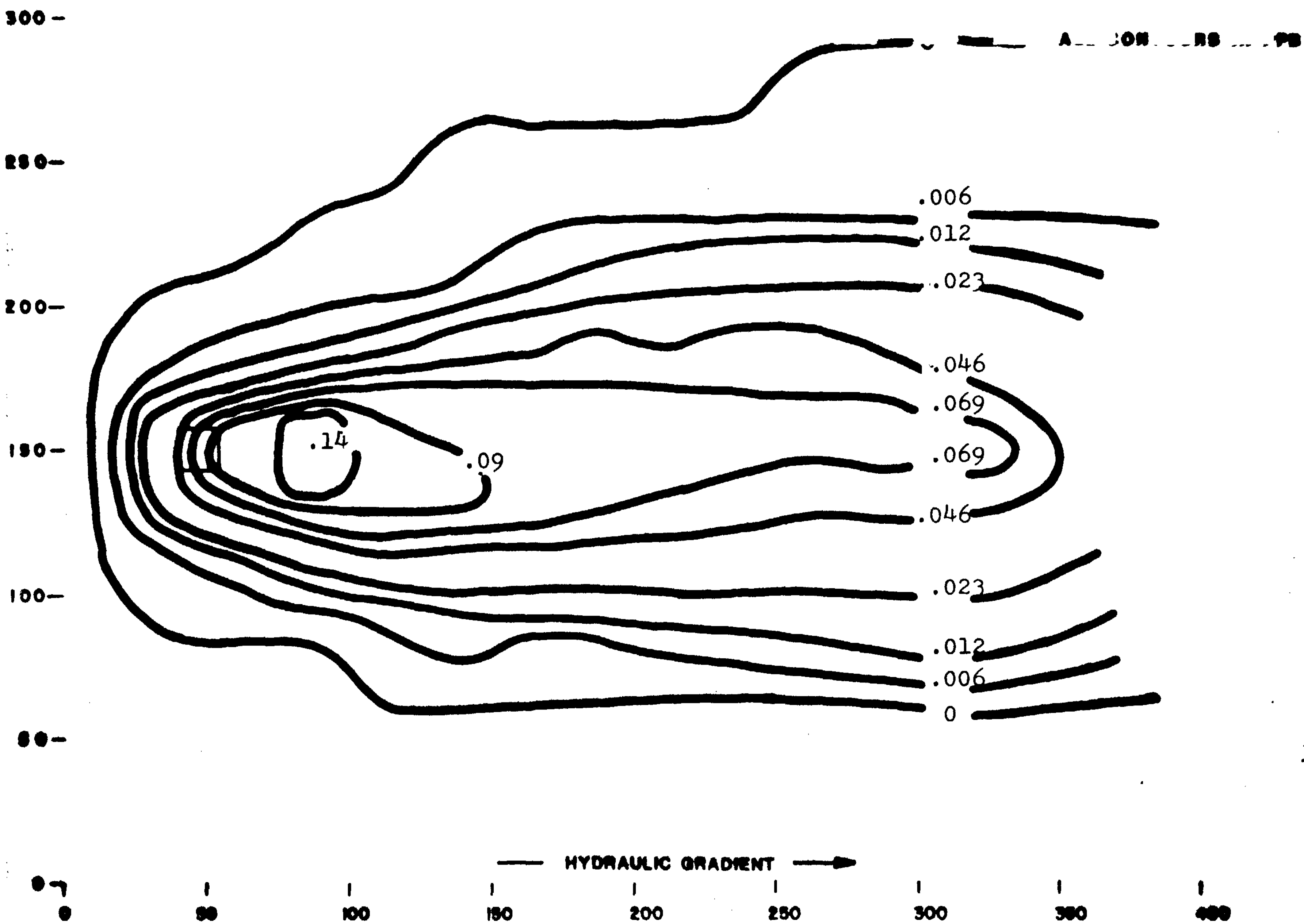
Volume Of Produced Water (BBL/DAY) - .016
Benzene Concentration (PPB) - 3500

CASE NUMBER - GCU 179E

Simulation Time (DAYS) - 960
NW, SE 26 29 N 12 W
SAN JUAN RIVER
dh/dl = 0.002

SAN JUAN RIVER

LOW HYDRAULIC CONDUCTIVITY CASES



ILLEGIBLE

MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-2500
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT²)-100
Porosity-.25
Longitudinal Dispersivity-5
Transverse Dispersivity-2

Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-.16
Regional Y Flow (FT/DAY)-0

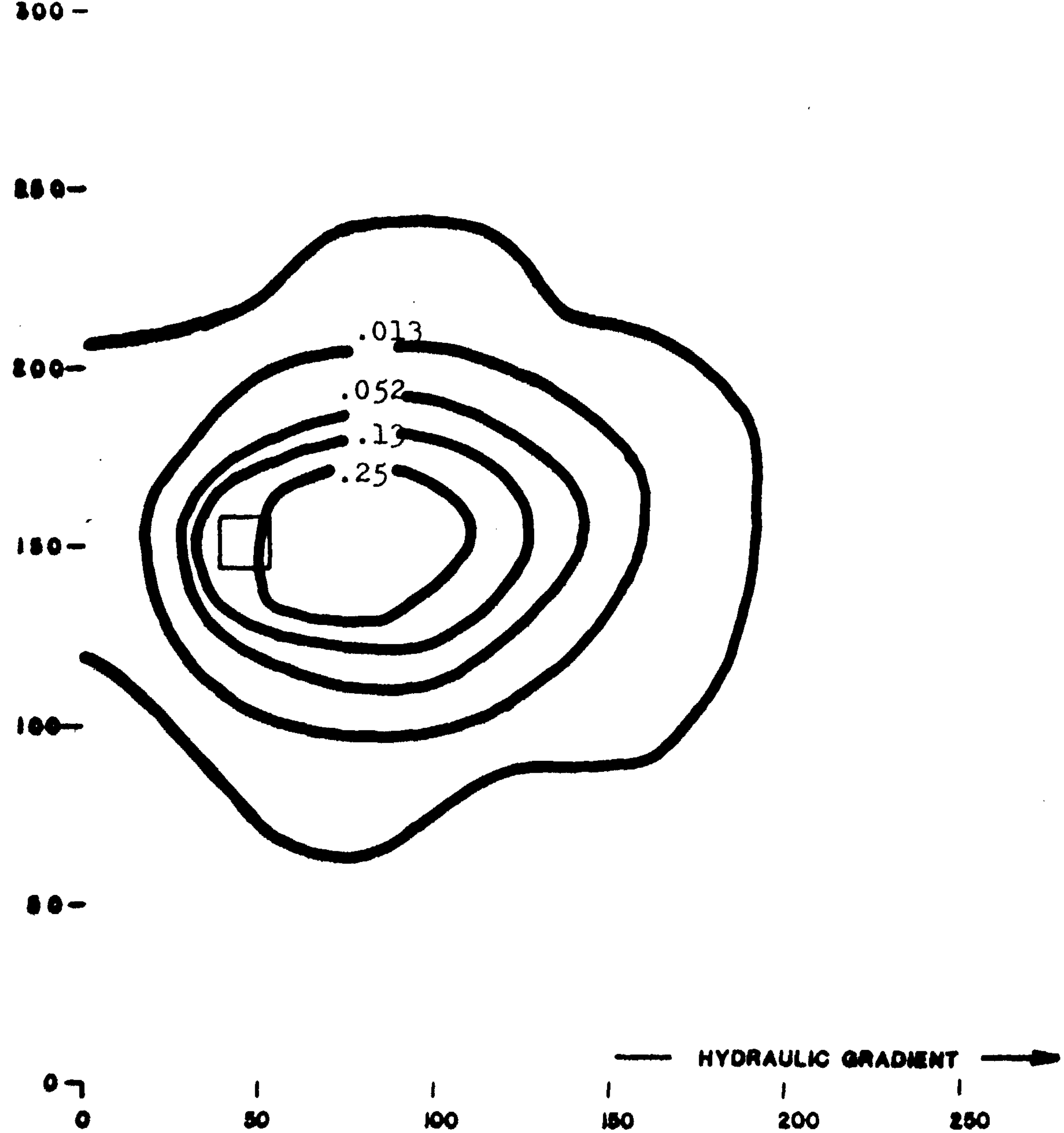
SOURCE TERM

Volume Of Produced Water (BBL/DAY)-.06
Benzene Concentration (PPB)- 20

CASE NUMBER- GCU-169E

Simulation Time (DAYS)-2940

SE, NE 35 29N 12W
San Juan River
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-250

Storage Coefficient-.1

Hydraulic Conductivity (GPD/FT^2)-10

Porosity-.25

Longitudinal Dispersivity-5

Transverse Dispersivity-2

Retardation Coefficient (FT)-1

Regional X Flow(FT/DAY)-.02

Regional Y Flow (FT/DAY)-0

SOURCE TERM

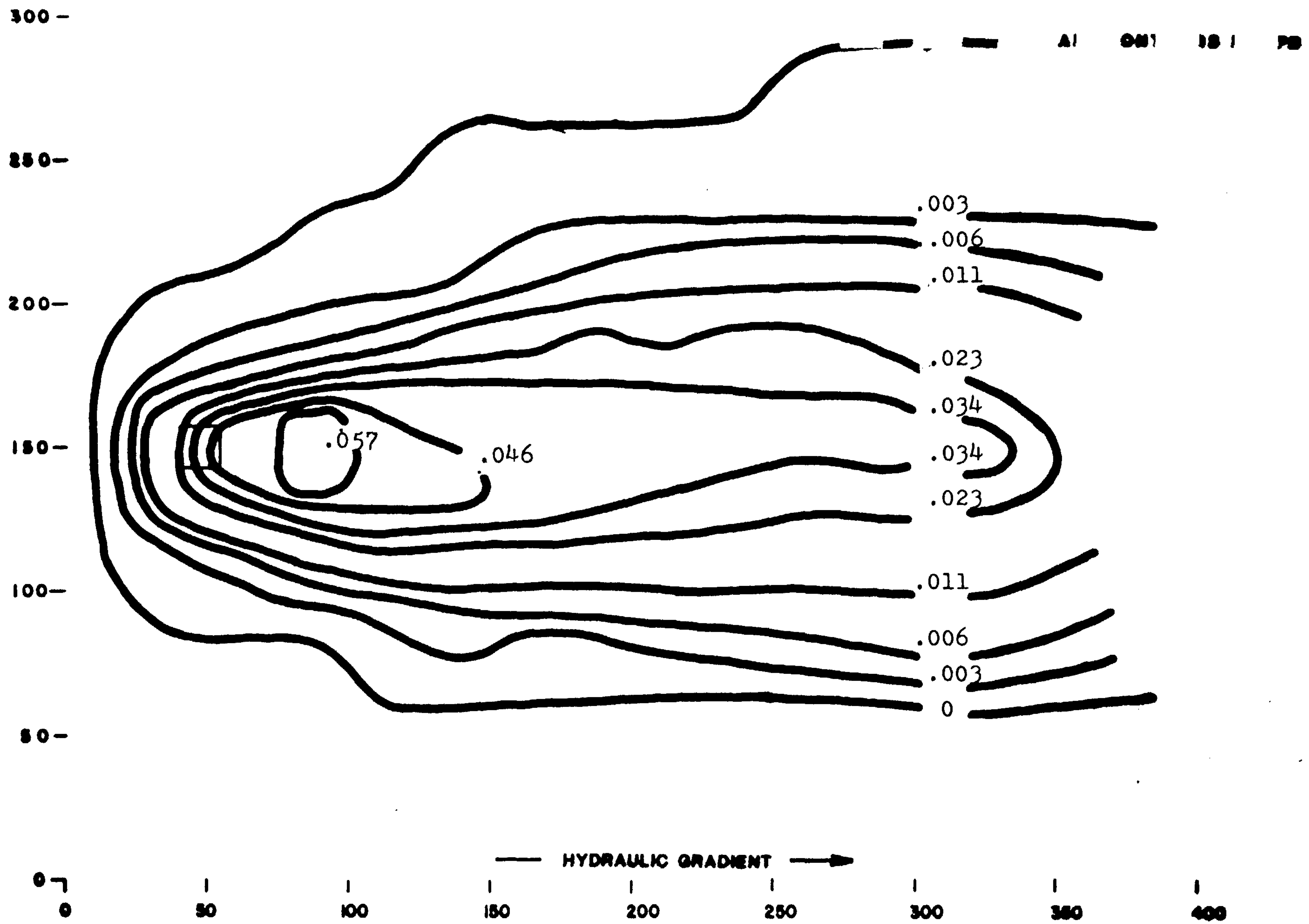
Volume Of Produced Water (BBL/DAY) .03

Benzene Concentration (PPB) 20

CASE NUMBER ROMERO GAS COM A-1

Simulation Time (DAYS)-2880

NE, SW 27 29N 10W
San Juan River
dh/dl = 0.003



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500

Storage Coefficient - .1

Hydraulic Conductivity (GPD/FT²) - 100

Porosity - .25

Longitudinal Dispersivity - 5

Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1

Regional X Flow (FT/DAY) - .16

Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - .03

Benzene Concentration (PPB) - 20

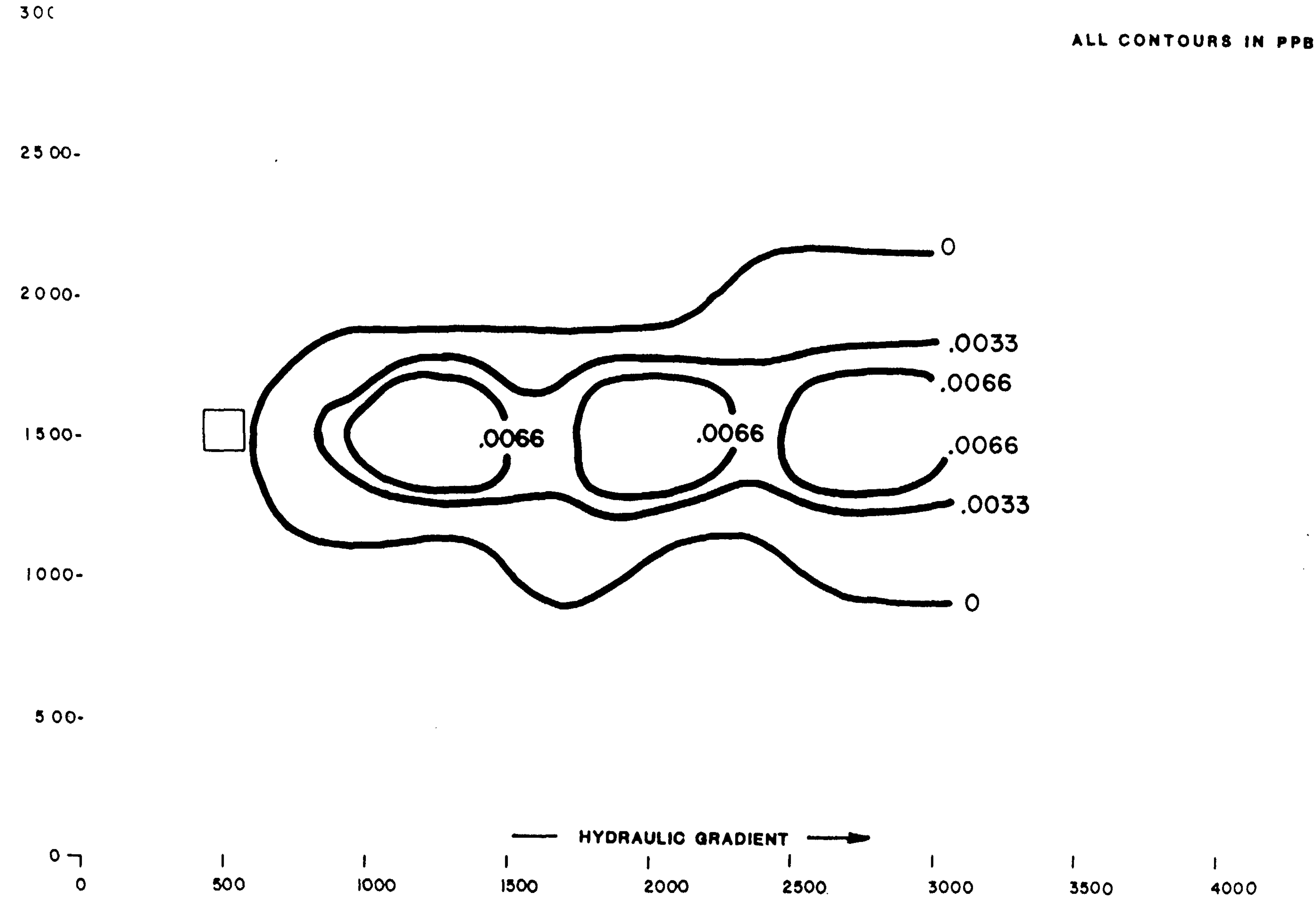
CASE NUMBER - ULIBARRI GAS COMM 1A

Simulation Time (DAYS) - 2940

SW, SE 35 30N 9W
San Juan River
dh/dl = 0.003

ANIMAS RIVER

HIGH HYDRAULIC CONDUCTIVITY CASES



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-250000
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-10000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-21.44
Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY)-.33
Benzene Concentration (PPB)-3500

CASE NUMBER-Marcotte 1

Simulation Time (DAYS)-1830
SE, NE 5 31 N 10 W
ANIMAS RIVER
dh/dl = 0.004

ANIMAS RIVER

MEDIUM HYDRAULIC CONDUCTIVITY CASES

No cases observed

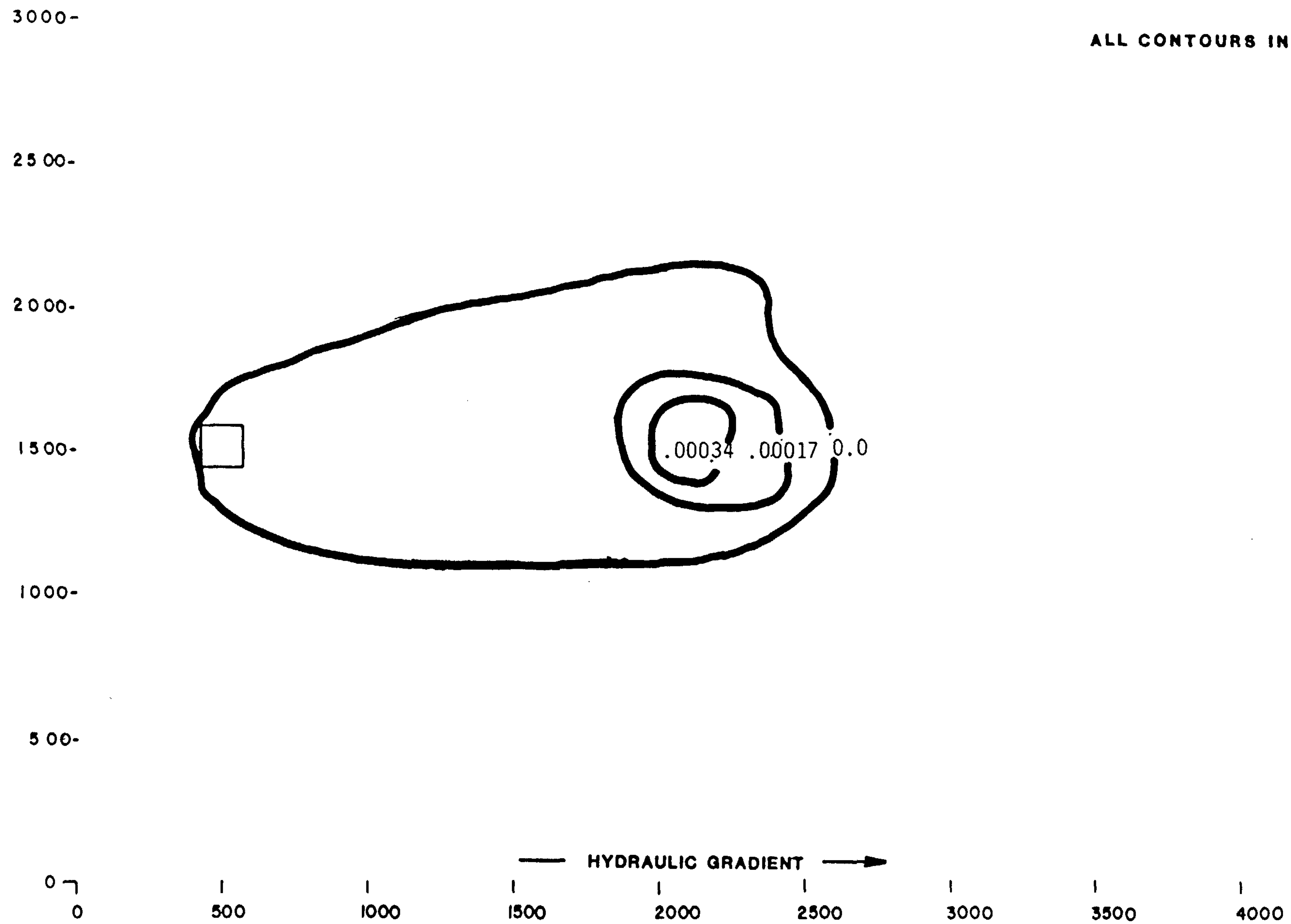
ANIMAS RIVER LOW HYDRAULIC CONDUCTIVITY CASES

No cases observed

VALLEY SIDE SLOPES AND TRIBUTARIES

HIGH HYDRAULIC CONDUCTIVITY CASES

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-25000

Storage Coefficient-.1

Hydraulic Conductivity (GPD/FT^2)-10000

Porosity-.25

Longitudinal Dispersivity-10

Transverse Dispersivity-2

Retardation Coefficient (FT)-1

Regional X Flow(FT/DAY)-53.2

Regional Y Flow (FT/DAY)-0

SOURCE TERM

Volume Of Produced Water (BBL/DAY)- 0.2

Benzene Concentration (PPB)- 0.02

CASE NUMBER- McCOY D 1E

Simulation Time (DAYS)-390

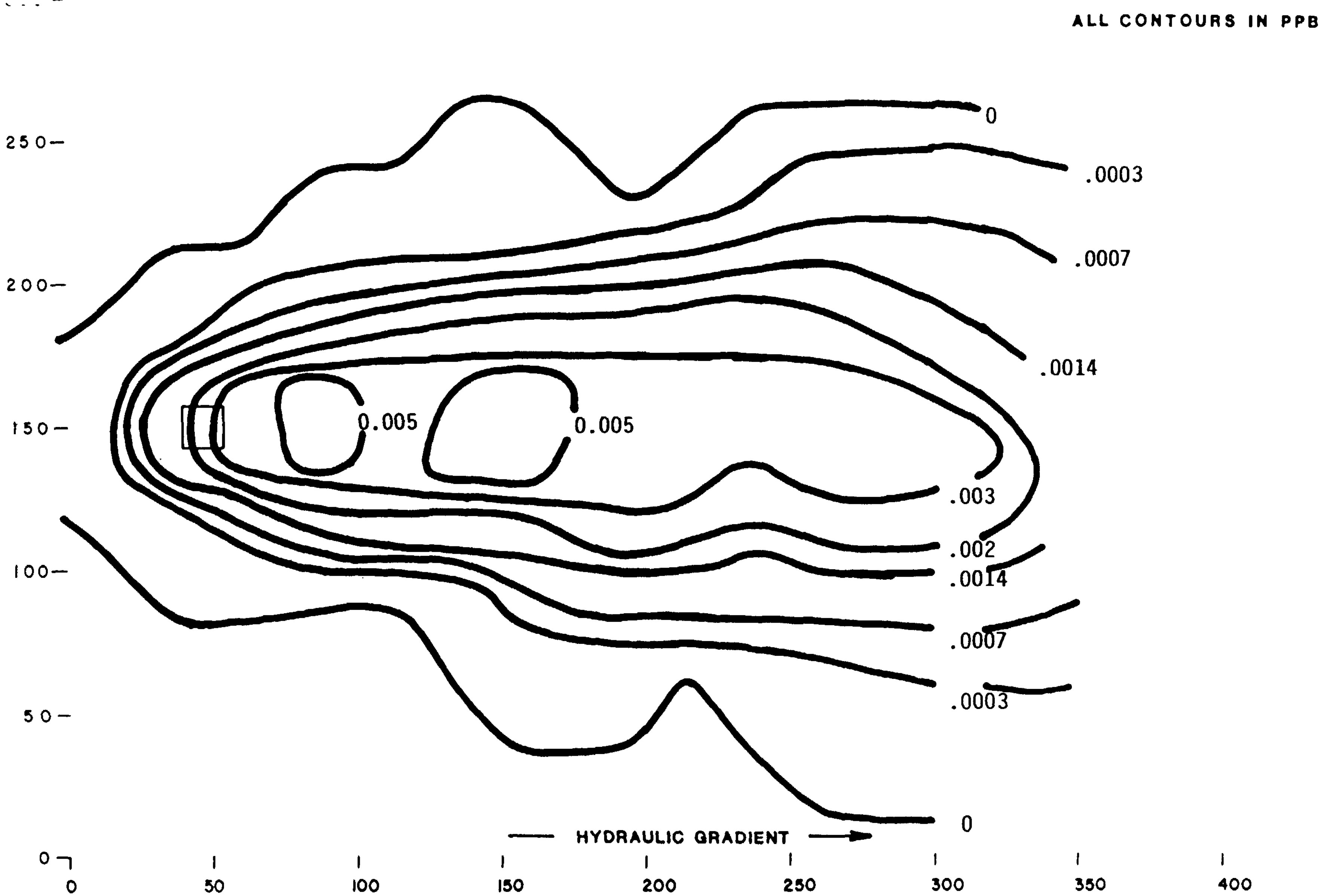
SW NW 28 30N 12W

ANIMAS RIVER BASIN

dh/dl = 0.01

VALLEY SIDE SLOPES AND TRIBUTARIES

MEDIUM HYDRAULIC CONDUCTIVITY CASES



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

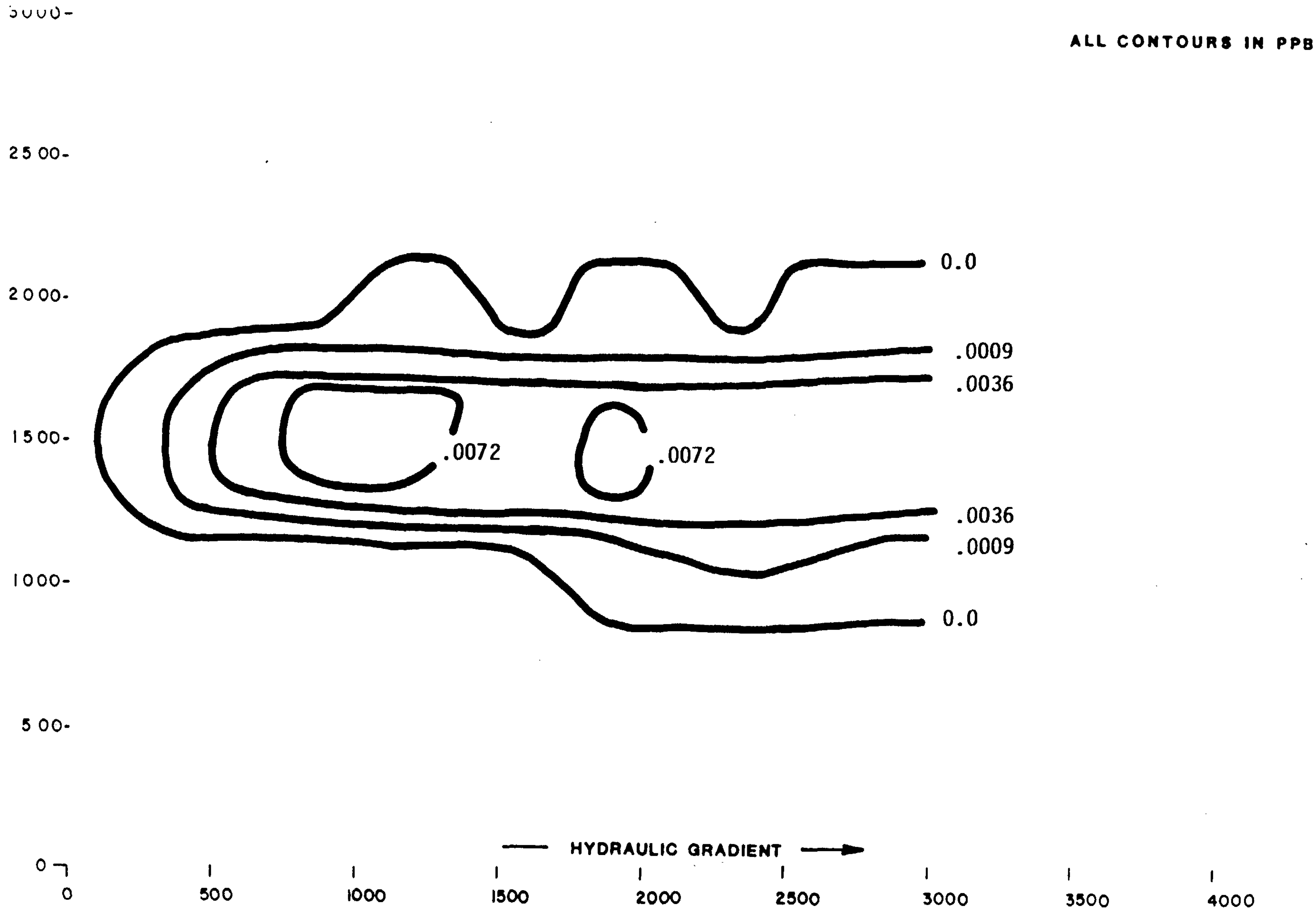
Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.02
Benzene Concentration (PPB) 20

CASE NUMBER KEYES A2

Simulation Time (DAYS) - 1110
SE, NW 27 32 N 10 W
ANIMAS RIVER BASIN
dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 25000
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT²) - 1000
Porosity - .25
Longitudinal Dispersivity - 10
Transverse Dispersivity - 2

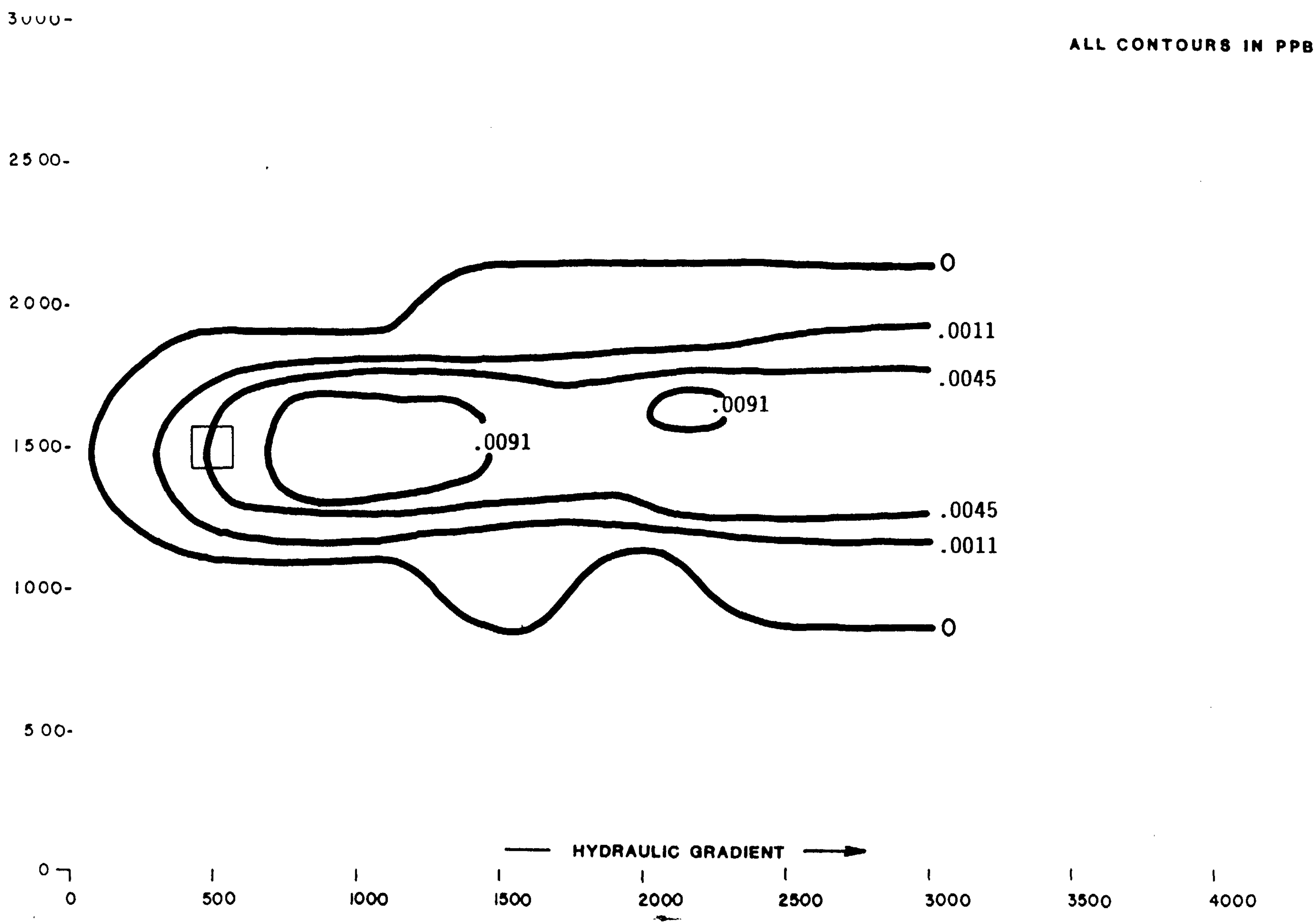
Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - 5.3
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - 1
Benzene Concentration (PPB) - 20

CASE NUMBER FLORENCE 124

Simulation Time (DAYS) - 630
NE, NW 27 29 N 9 W
LARGO BASIN
dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT)-2500C
Storage Coefficient-.1
Hydraulic Conductivity (GPD/FT^2)-1000
Porosity-.25
Longitudinal Dispersivity-10
Transverse Dispersivity-2

Retardation Coefficient (FT)-1
Regional X Flow(FT/DAY)-5.3
Regional Y Flow (FT/DAY)-0

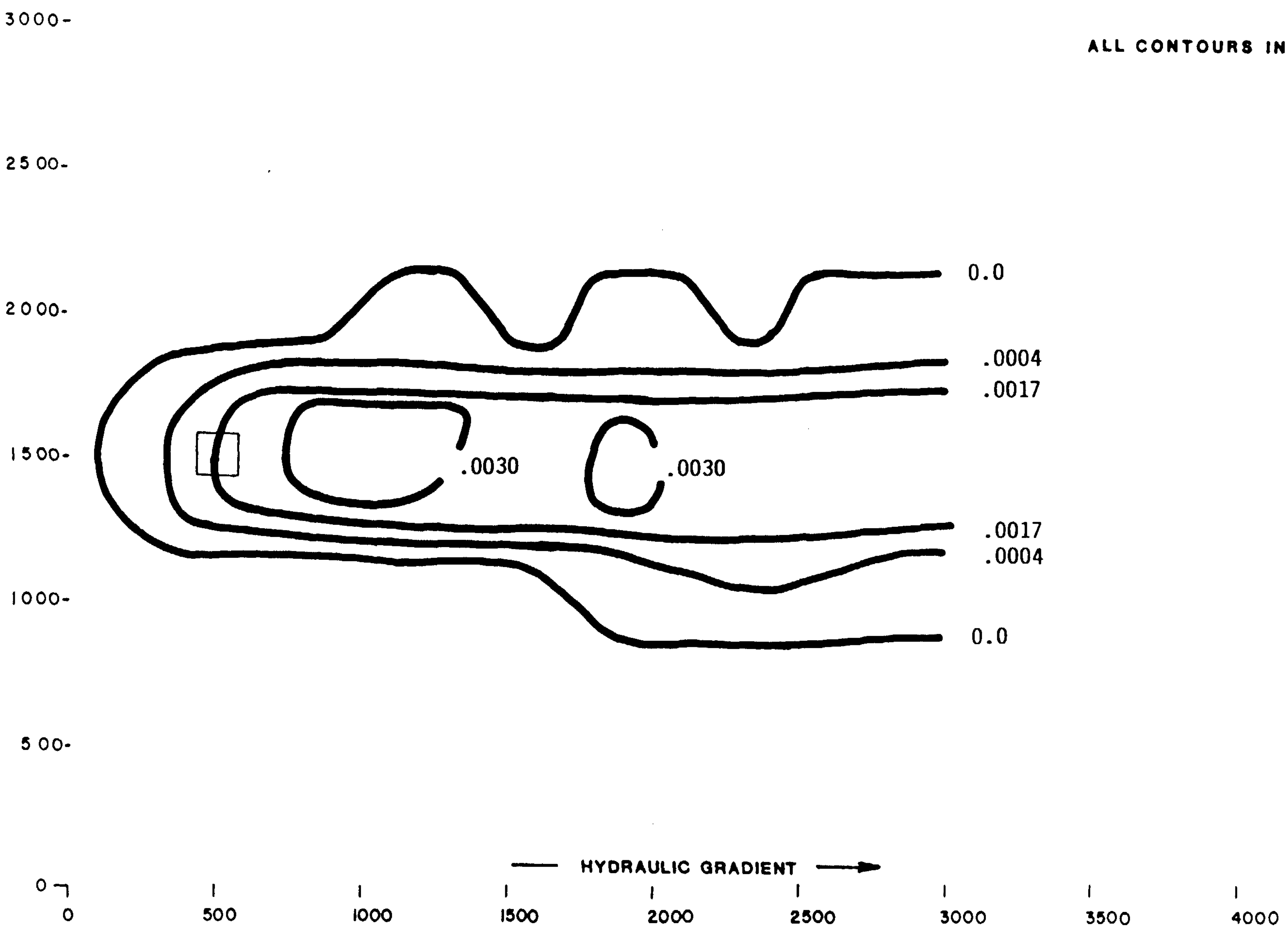
SOURCE TERM

Volume Of Produced Water (BBL/DAY)-1
Benzene Concentration (PPB)- 3500

CASE NUMBER-Florence 124

Simulation Time (DAYS)-1080
NE, NW 27 29 N 9 W
LARGO CANYON AREA
dh/dl = 0.01

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 25000
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 1000
Porosity - .25
Longitudinal Dispersivity - 10
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow(FT/DAY) - 5.3
Regional Y Flow (FT/DAY) - 0

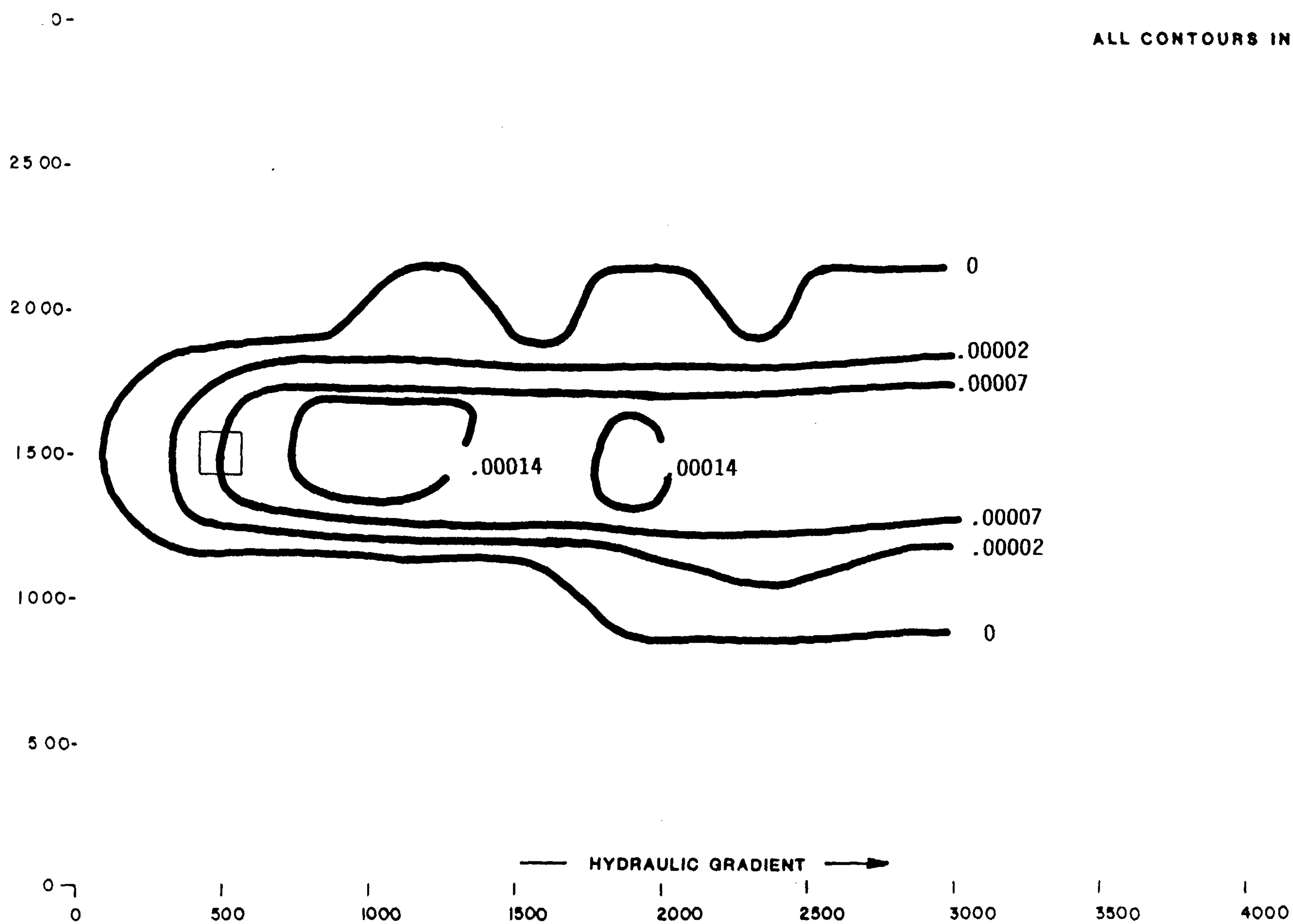
SOURCE TERM

Volume Of Produced Water (BBL/DAY) - 0.5
Benzene Concentration (PPB) - 20

CASE NUMBER FLORENCE 9

Simulation Time (DAYS) - 630
SW, SW 13 30 N 9 W
PUMP WASH
dh/dl = 0.01

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 25000

Storage Coefficient - .1

Hydraulic Conductivity (GPD/FT^2) - 1000

Porosity - .25

Longitudinal Dispersivity - 10

Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1

Regional X Flow (FT/DAY) - 5.3

Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - .02

Benzene Concentration (PPB) - 20

CASE NUMBER GCU 169

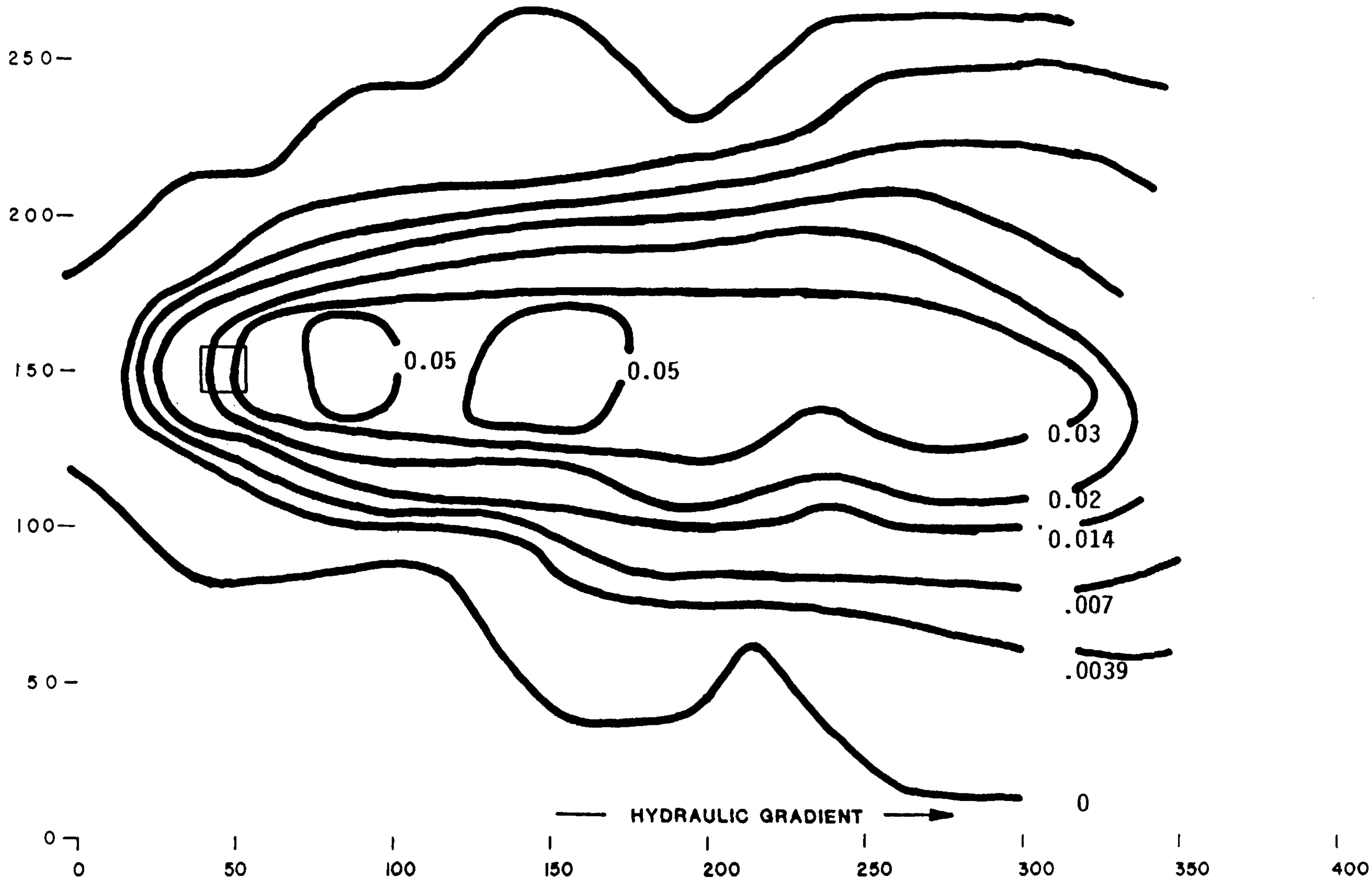
Simulation Time (DAYS) - 630

NE, SE 35 29 N 12 W

SAN JUAN RIVER BASIN

dh/dl = 0.01

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.16
Benzene Concentration (PPB) 20

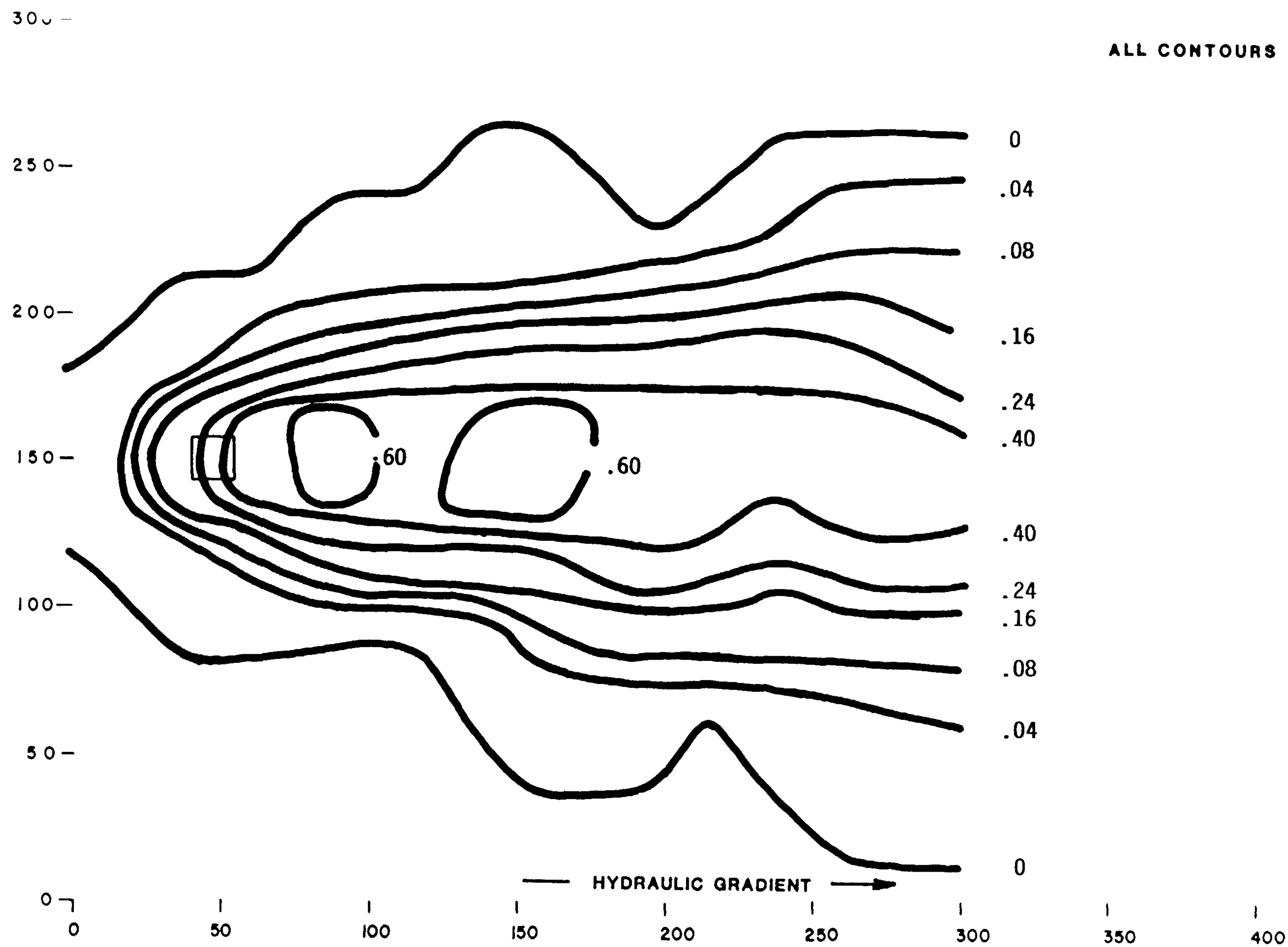
CASE NUMBER CANEPLE 1

Simulation Time (DAYS) - 1110
SW, SW 18 31 N 10 W
ANIMAS RIVER BASIN
dh/dl = 0.01

VALLEY SIDE SLOPES AND TRIBUTARIES

LOW HYDRAULIC CONDUCTIVITY CASES

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500

Storage Coefficient - .1

Hydraulic Conductivity (GPD/FT^2) - 100

Porosity - .25

Longitudinal Dispersivity - 5

Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1

Regional X Flow(FT/DAY) - .5

Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) - .86

Benzene Concentration (PPB) - 20

CASE NUMBER GCU 150

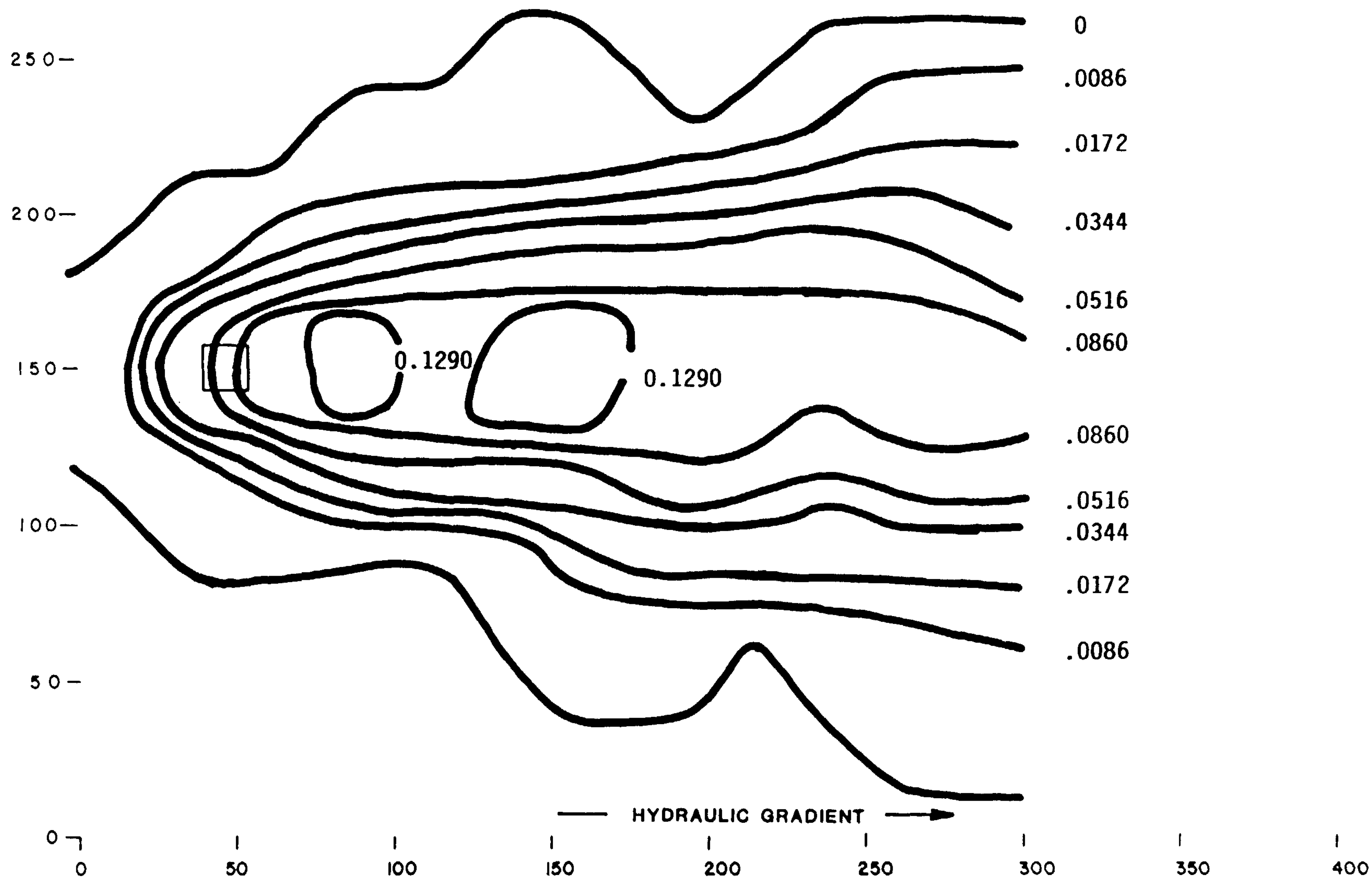
Simulation Time (DAYS) - 1110

SW, SW 22 29 N 12 W

SAN JUAN RIVER

dh/dl = 0.01

ALL CONTOURS IN PPB



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

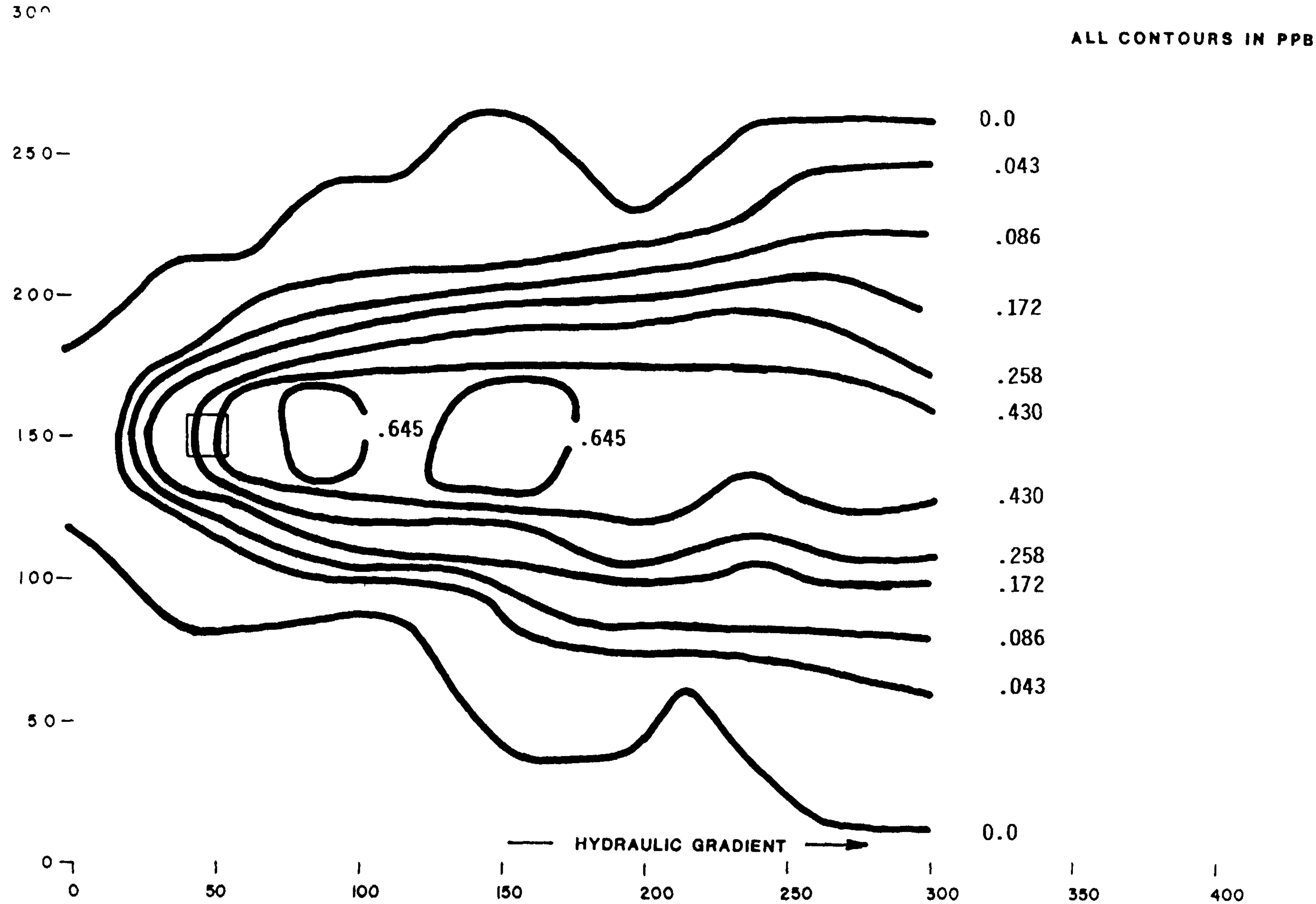
Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.2
Benzene Concentration (PPB) 20

CASE NUMBER MARTINEZ F1

Simulation Time (DAYS) - 1110
NW SW 24 29 N 10 W
SAN JUAN RIVER
dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

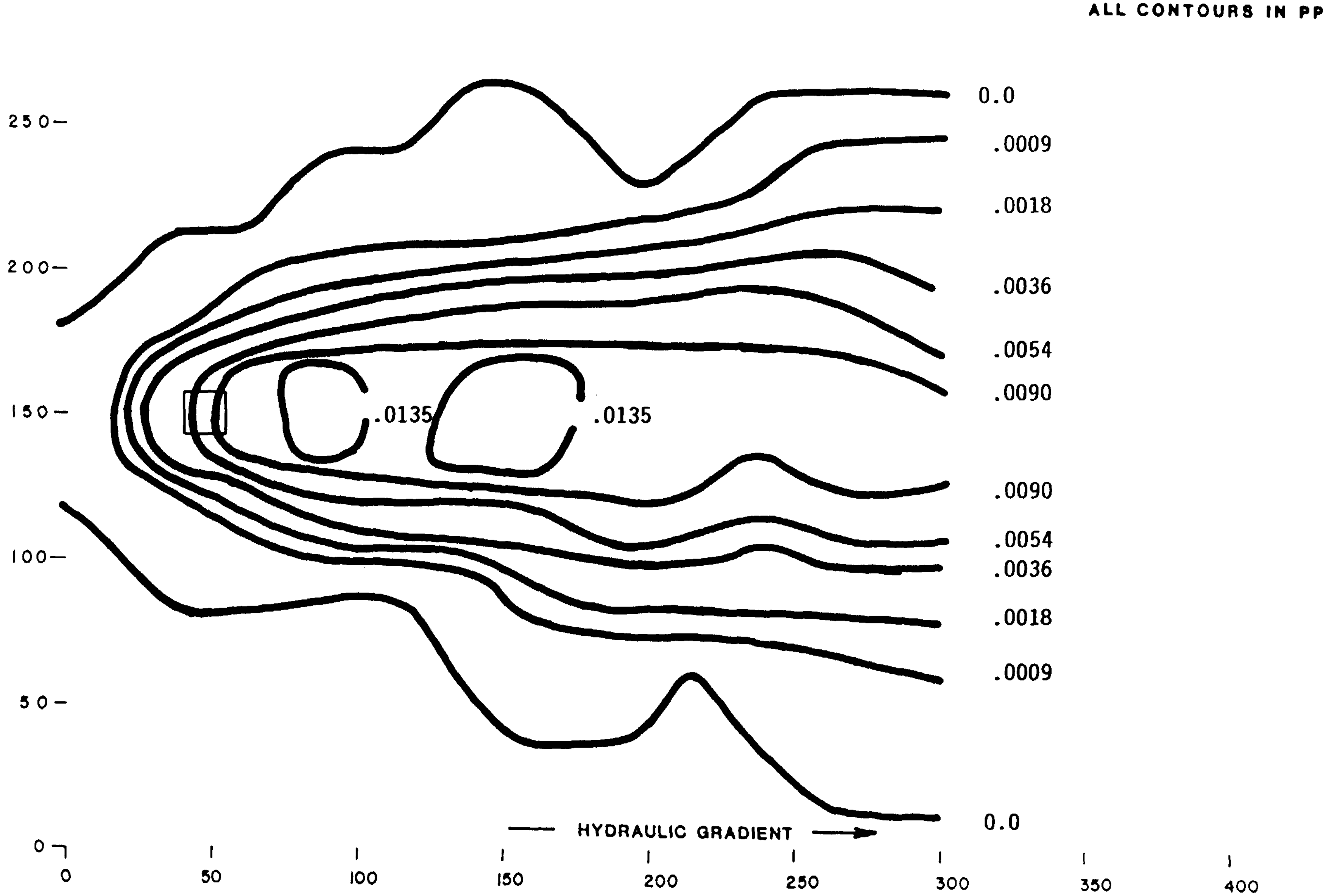
Retardation Coefficient (FT) - 1
Regional X Flow(FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 1
Benzene Concentration (PPB) 20

CASE NUMBER VALDEZ AIE

Simulation Time (DAYS) - 1110
SW, NE 24 25 N 11 W
SAN JUAN RIVER
dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

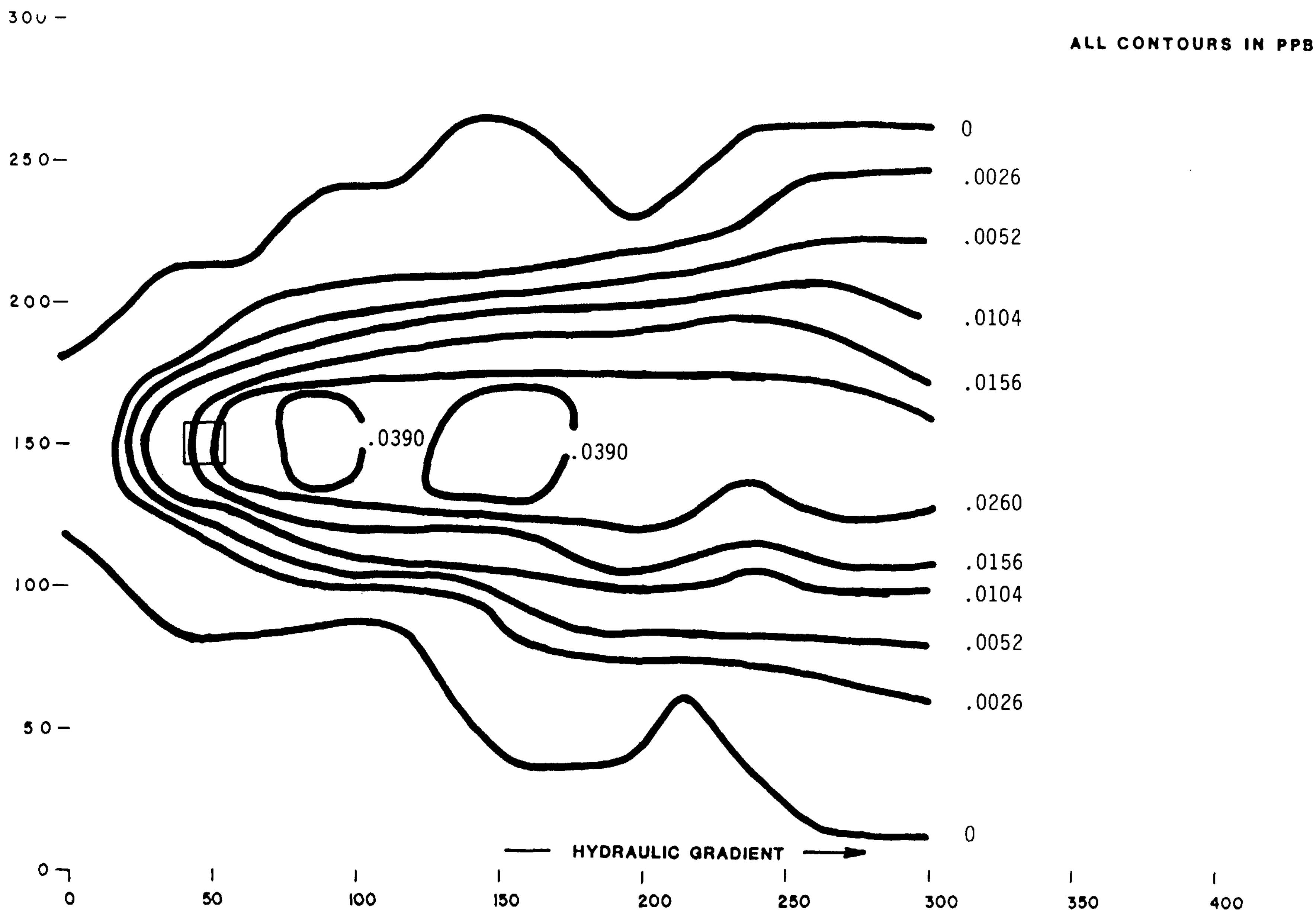
Retardation Coefficient (FT) - 1
Regional X Flow(FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.02
Benzene Concentration (PPB) 20

CASE NUMBER POLLOCK E1

Simulation Time (DAYS) - 1110
28 29 N 10 W
SAN JUAN RIVER
dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

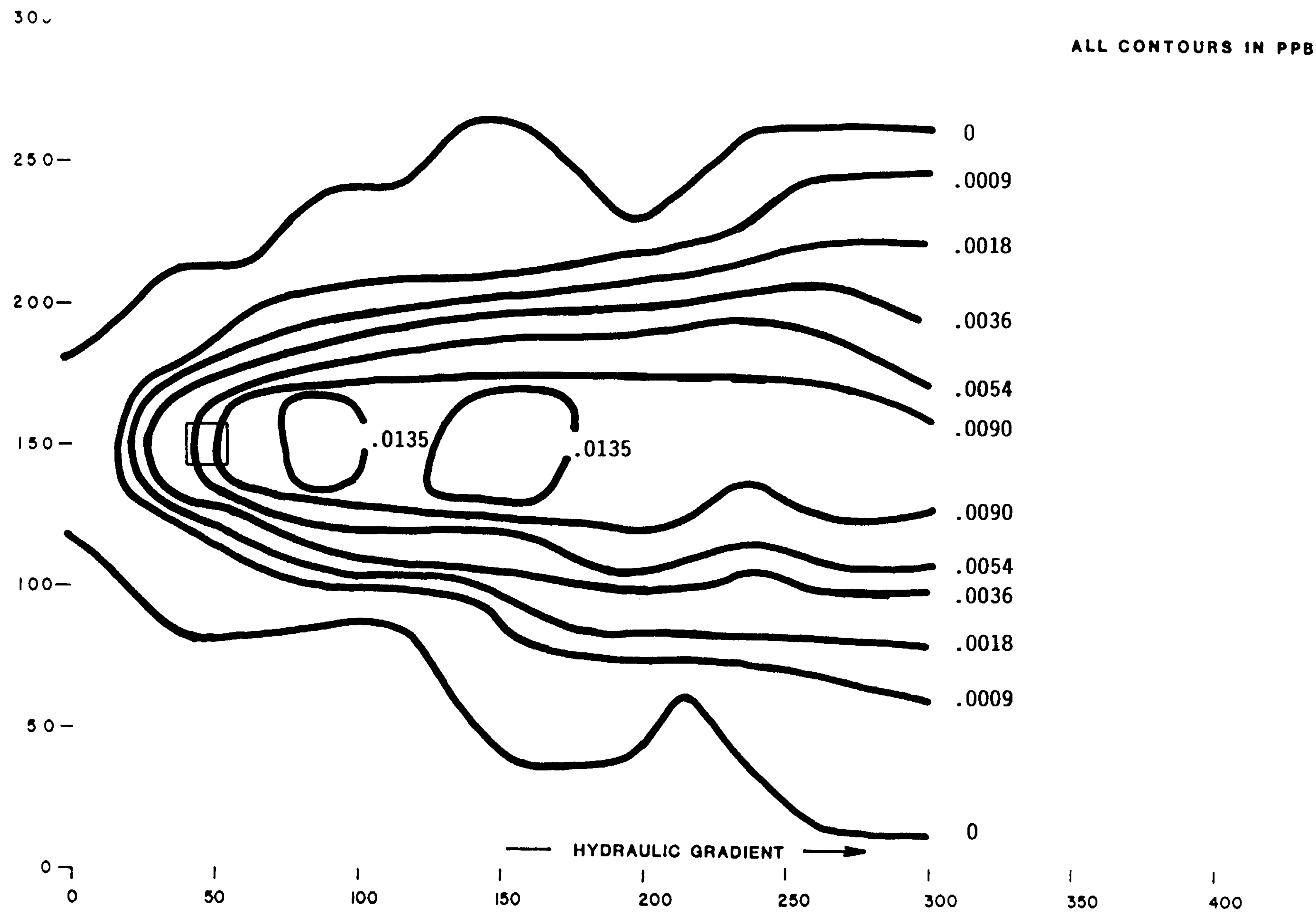
SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.06
Benzene Concentration (PPB) 20

CASE NUMBER BLACK 1

Simulation Time (DAYS) - 1110

NE, NW 29 29 N 10 W
SAN JUAN RIVER
dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500

Storage Coefficient - .1

Hydraulic Conductivity (GPD/FT^2) - 100

Porosity - .25

Longitudinal Dispersivity - 5

Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1

Regional X Flow (FT/DAY) - .5

Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.02

Benzene Concentration (PPB) 20

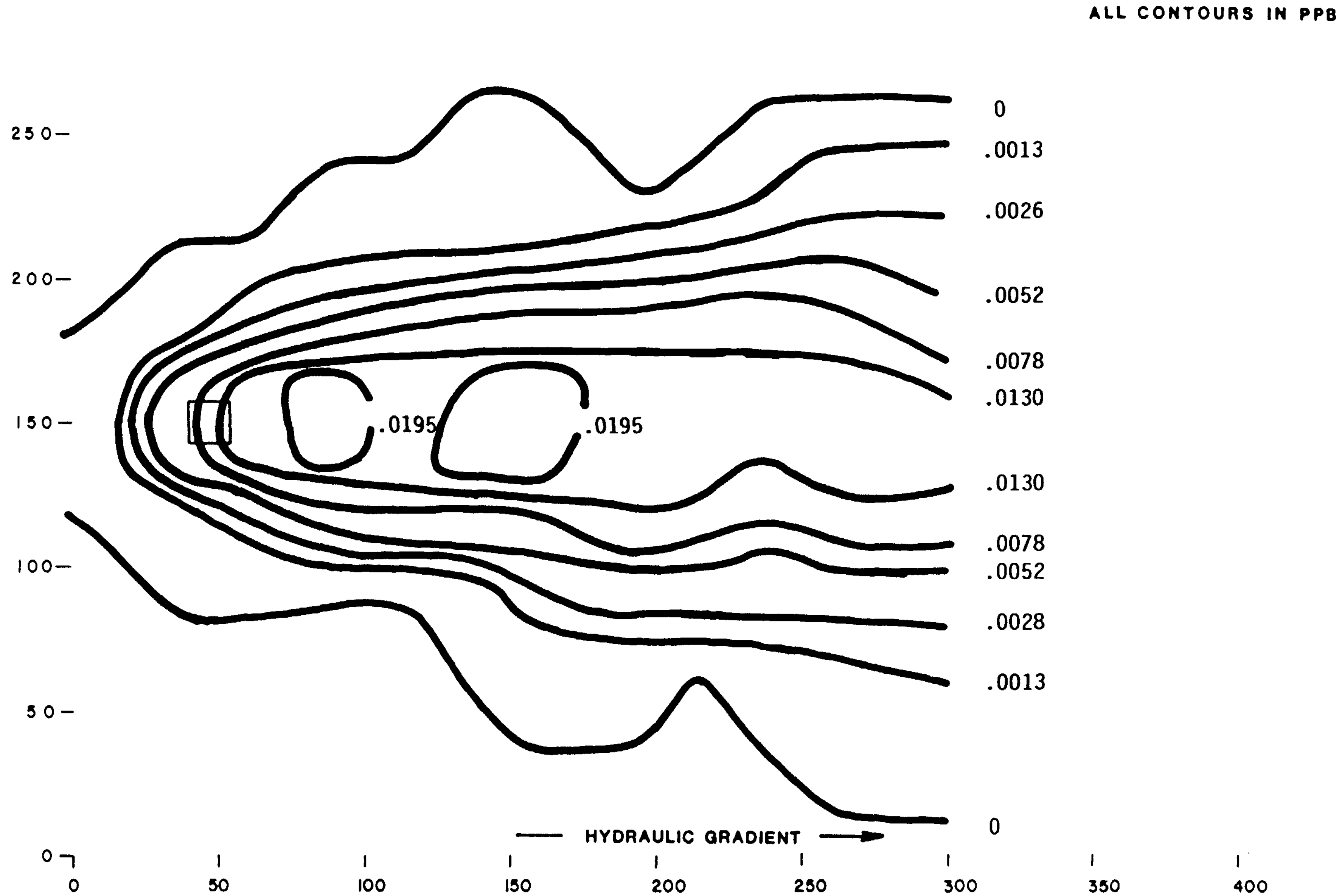
CASE NUMBER IRWIN 1E

Simulation Time (DAYS) - 1110

11 29 N 13 W

SAN JUAN RIVER

dh/dl = 0.01



MODEL INPUT PARAMETERS

Transmissivity (GPD/FT) - 2500
Storage Coefficient - .1
Hydraulic Conductivity (GPD/FT^2) - 100
Porosity - .25
Longitudinal Dispersivity - 5
Transverse Dispersivity - 2

Retardation Coefficient (FT) - 1
Regional X Flow (FT/DAY) - .5
Regional Y Flow (FT/DAY) - 0

SOURCE TERM

Volume Of Produced Water (BBL/DAY) 0.03
Benzene Concentration (PPB) 20

CASE NUMBER HEATH G1

Simulation Time (DAYS) - 1110
SE, SW 8 29 N 9 W
SAN JUAN RIVER
dh/dl = 0.01

Geoscience Consultants, Ltd. is a multidisciplinary firm offering a wide range of geotechnical and engineering services to private and governmental clients. Based in Albuquerque, New Mexico, Geoscience Consultants, Ltd. serves clients throughout the western United States. Principals in the firm have expertise in hydrogeology, hazardous waste management, environmental engineering, permitting, water quality studies, remote sensing, and energy resource evaluation.

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