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TECHNICAL SUPPORT FOR GEOPRESSURED-GEOTHERMAL WELL ACTIVITIES IN LOUISIANA

FINAL REPORT
for the period
1 January 1992 to 31 December 1993

PROJECT PERSONNEL

C. G. Groat	Program Coordinator
Chacko J. John	Principal Investigator
Bridget Jensen/C. J. John	Microseismic Monitoring
Dianne Lindstedt	Subsidence Monitoring
Chacko J. John	Geological Studies

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Special Programs
Center for Coastal, Energy, and Environmental Resources
Louisiana State University
Room E-302, Howe-Russell Geoscience Complex
Baton Rouge, Louisiana 70803-7509

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DISCLAIMER

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PREFACE

During the search for alternative sources of energy in the mid- to late-'70s, Gulf of Mexico Basin geopressured-geothermal fluids containing dissolved methane emerged as a potentially huge energy source. Among the many unknowns that required study before assessments of the resource's viability could be made was the environmental impact of producing and disposing of tens of thousands of barrels of hot brines each day from a single well, and groups of wells, for 20 to 30 years. Concern rose as to whether the stress release in the producing reservoir would activate growth faults to cause surface displacement and earthquakes. The possible subsidence above depleting reservoirs was of particular concern because the majority of the reservoir systems underlies coastal lowlands where subsidence would exacerbate an already serious land loss problem. The effects on fresh ground water of injecting produced brine into sands at shallow to moderate depths was another environmental concern.

From the beginning of the designed test well program in 1980, production sites were monitored to cull evidence that would confirm or dismiss the environmental concerns. The Department of Energy remained supportive of this critical element of the program, realizing that should the concerns have credence, development of the resource would need to be highly constrained. Seismometer arrays were deployed to detect microseismic events, periodic leveling surveys were run to check subsidence, and ground (and surface) water was monitored—activities complemented by historical studies of surface habitat and elevation changes.

Results in this concluding year of the test well program confirmed those of the previous years, namely that the production and disposal of large volumes of geopressured-geothermal brines have not been accompanied by earthquakes, movement along growth faults, or changes in surface elevation attributable to fluid withdrawal. The rigorous environmental monitoring in this resource production testing program has removed an important barrier to utilization of this thermal and natural-gas resource. In the future, when our energy needs and the economic setting make it prudent to develop geopressured-geothermal energy, the important environmental considerations will have been accounted for by the monitoring program this report brings to conclusion.

—C. G. Groat

MICROEARTHQUAKE MONITORING

by

Chacko J. John

ABSTRACT

The U.S. Department of Energy has operated continuous-recording, microearthquake monitoring networks at geopressured-geothermal test well sites since 1980. These microseismic networks were designed to detect microearthquakes indicative of fault activation and/or subsidence that can potentially result from the deep subsurface withdrawal and underground disposal of large volumes of brine during well testing. Seismic networks were established before the beginning of testing to obtain background levels of seismicity. Monitoring continued during testing and for some time after cessation of flow testing to assess any delayed microseismicity caused by the time dependence of stress migration within the earth. No flow testing has been done at the Hulin well since January 1990, and the Pleasant Bayou well has been shut down since September 1992. Microseismic monitoring continued at the Hulin and Pleasant Bayou sites until 31 December 1992, at which time both operations were shut down and field sites dismantled. During 1992, the networks recorded seismic signals from earthquakes, sonic booms, geophysical blasting, thunderstorms, etc. However, as in previous years, no local microseismic activity attributable to geopressured-geothermal well testing was recorded.

INTRODUCTION

Geopressured-geothermal well testing involves the production of large volumes (> 10,000 bbl per day) of brine from deep subsurface geopressured reservoirs; extraction of the natural gas (mostly methane) at the surface; and finally, the underground disposal of the gas-depleted brine through disposal wells below the freshwater aquifers. Therefore, high-volume, long-term brine production could theoretically change local subsurface stress regimes and might result in ground subsidence and fault activation. The Gulf Coast subsurface is characterized by a large number of growth faults that display various amounts of displacements; however, because this region is generally considered to be aseismic, fault displacements probably occur as a series of small movements, possibly as creep (Stevenson 1985). The principle objective of this DOE-sponsored seismic monitoring program was to study the possibility of small, well-testing-induced, magnitude displacements (characterized by microseismic activity) that occur near faults mapped at the geopressured-geothermal test well sites. Continuous microseismic monitoring networks were in operation during 1992 at the Hulin well site (Vermilion Parish, Louisiana) and the Pleasant Bayou site (Brazoria County, Texas). The location of these two sites, as well as those previously established and discontinued, are shown in figure 1. After short-term flow testing, there was no activity at the Hulin well during the December 1989–January 1990 period. The long-term flow testing of brine production at the Pleasant Bayou site began in May 1988 and ended in September 1992. The well produced 25,290,659 STB of brine, and of 473,110 MCF of separated gas (Eaton Operating Company 1992).

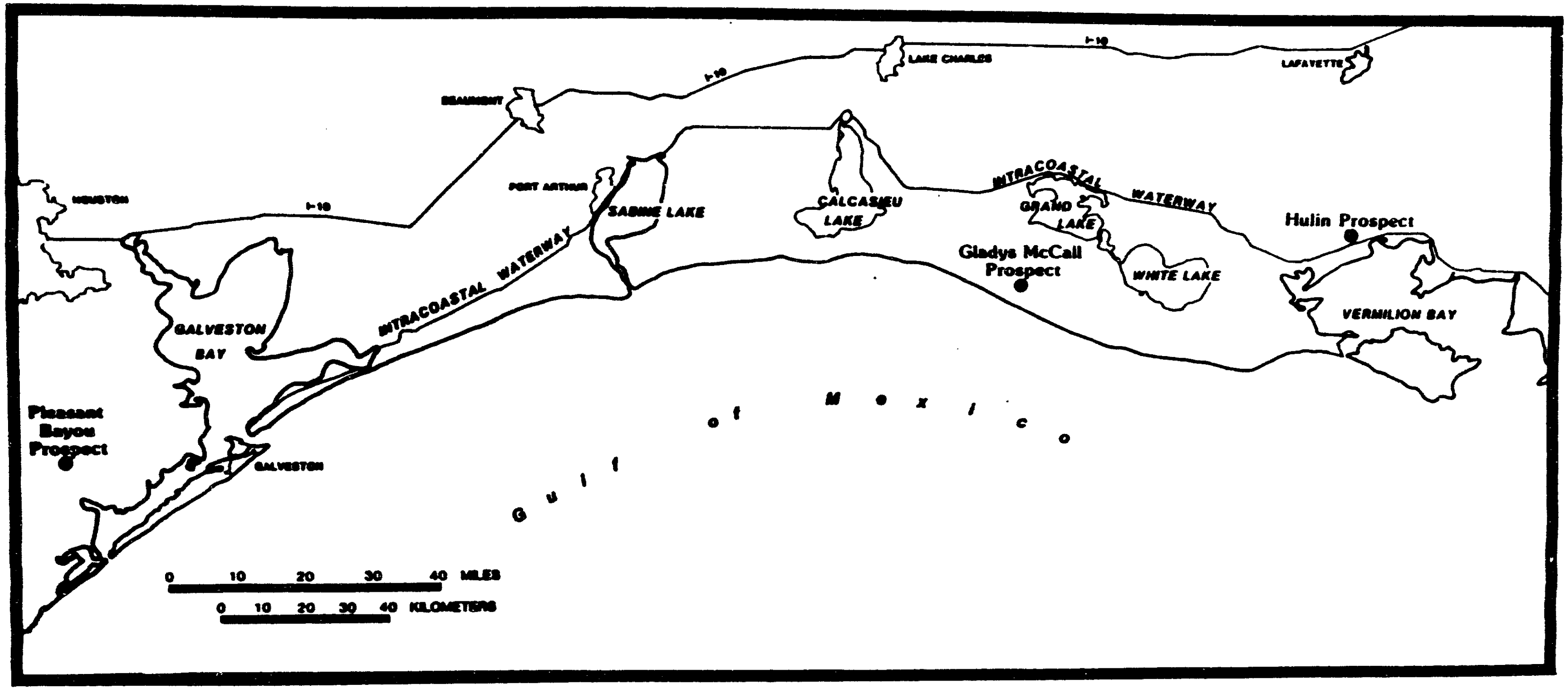


Figure 1. Microearthquake network locations: Louisiana and Texas. Only the Hulin and Pleasant Bayou networks were in operation during 1992 (from Stevenson 1991).

NETWORK INSTRUMENTATION AND DATA ACQUISITION

Previous reports by Stevenson (1991) and Jensen (1992) give detailed descriptions of field stations and instrumentation. These reports provided the information presented here.

The Hulin and Pleasant Bayou microseismic networks each consisted of four seismographic field stations. Locations of each network's field stations are shown in figures 2 and 3, respectively; their coordinates are given in table 1. The Hulin network had been in operation since December 1988, while the Pleasant Bayou network had been in operation since October 1985.

Seismic signals recorded at each field site within the network were transmitted by means of radio telemetry and phone lines to a central recording laboratory located in Baton Rouge, Louisiana. Field data were recorded at the central facility in two formats: (1) direct recording of phone line-transmitted data onto a time-coded, programmable magnetic analog tape recorder; and (2) selective demultiplexing of individual stations' phone signals and daily analysis of the tracings obtained from rotating drum recorders. Any events of seismic interest were selected for more detailed evaluation and tape playback from these paper tracings. These tracings also were scanned daily for any microearthquakes. All such events were processed to obtain hypocenter locations using the HYPOELLIPSE (Lahr 1986) computer algorithm, and magnitude determination was based on event duration. Because no magnitude scale for the Gulf Coast exists, the absolute values of computed magnitudes are probably not valid; however, they are reasonably good indicators of the relative size of events (Stevenson 1991). Magnitudes calculated for microseismic events recorded on both networks show that the events have been small (<1.5) and were unrelated to geopressured-geothermal well testing.

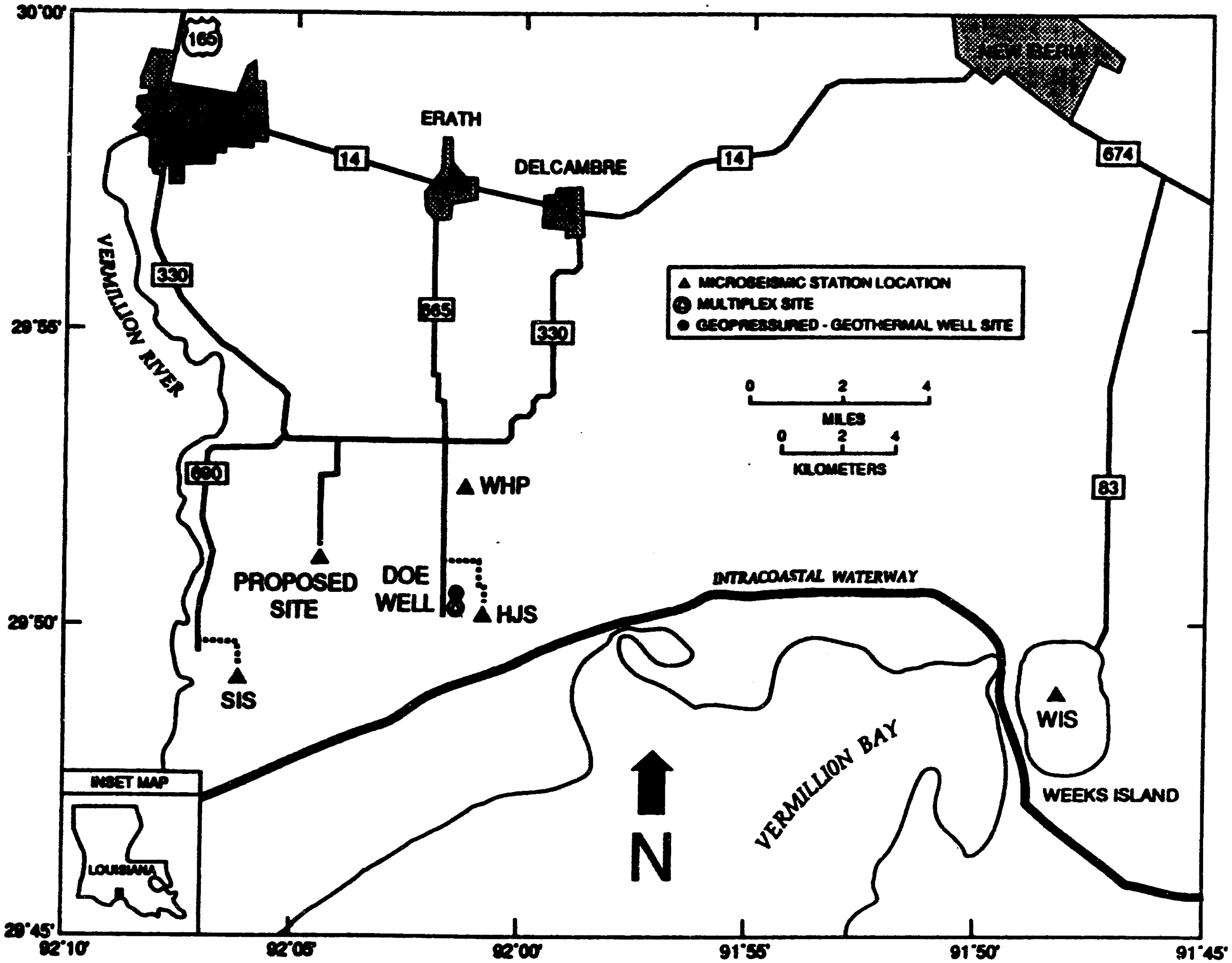
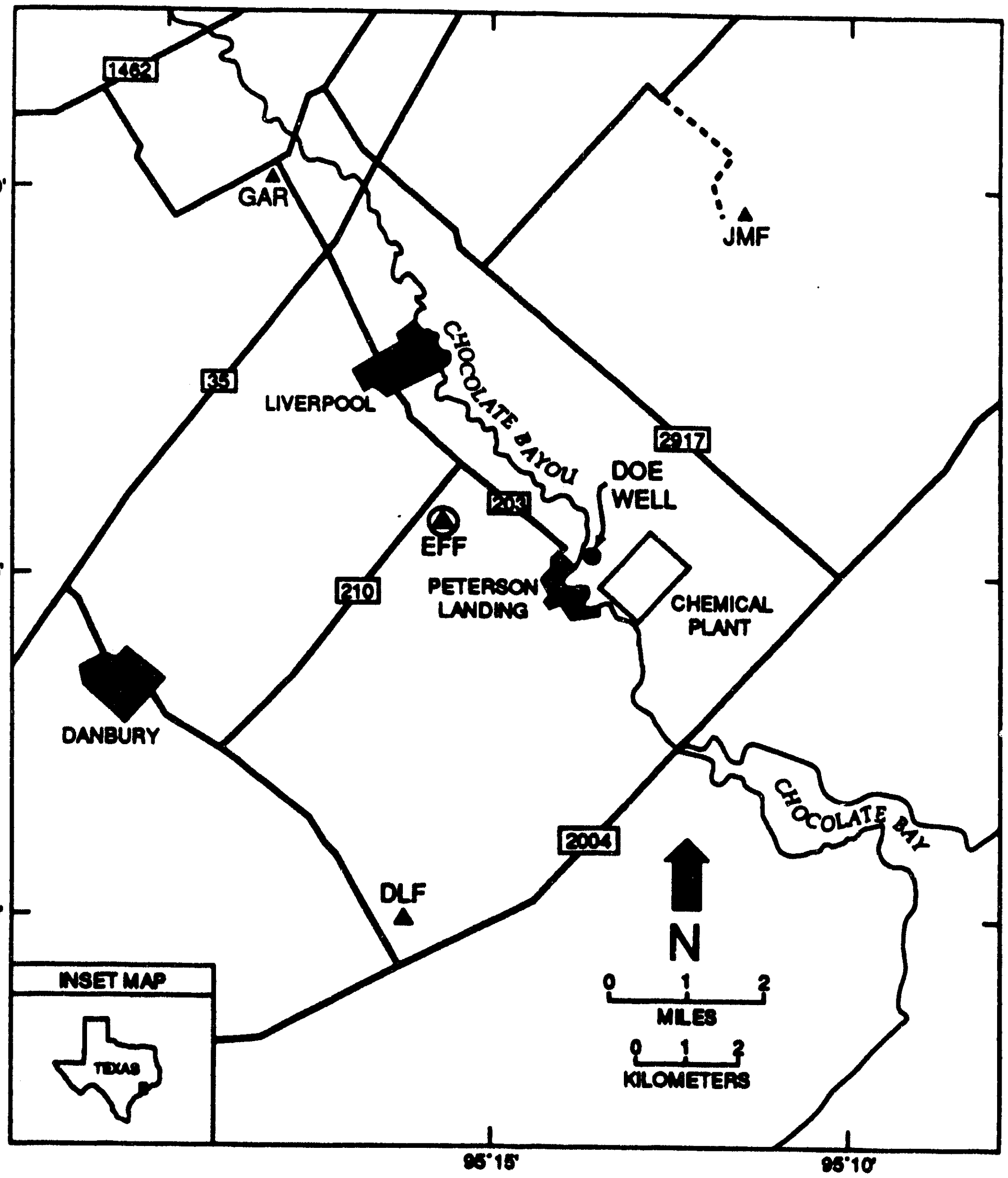


Figure 2. Map showing locations of the microseismic field stations in the vicinity of the Hulin test well site (from Jensen 1992).



▲ MICROSEISMIC STATION LOCATION
▲ MULTIPLEX SITE AND MICROSEISMIC STATION LOCATION
● GEOPRESSURED - GEOTHERMAL WELL SITE

Figure 3. Map of Pleasant Bayou prospect area showing location of the microseismic field station and the test well site (from Jensen 1992).

Table 1. Coordinates of the field stations and well sites for the Hulin, and Pleasant Bayou seismic monitoring networks (Stevenson 1991, Jensen 1992).

Network	Site Name	North Latitude	West Longitude
Hulin			
	Well	29 51'07.4"	92 01'51.0"
	HJS*	29 50'55.6"	92 01'20.1"
	WHP	29 52'20.9"	92 01'40.5"
	SIS	29 49'16.7"	92 06'08.9"
	WIS	29 48'23.4"	92 48'23.2"
Pleasant Bayou			
	Well	29 15'25.5"	92 13'48.4"
	DFL	29 10'29.4"	92 16'10.2"
	EFF*	29 15'53.4"	92 16'10.2"
	GAR	29 20'13.8"	92 18'21.6"
	JMF	29 20'00.0"	92 12'06.0"

* Includes a multiplex site

Field Stations

The microseismic networks at both the Hulin and Pleasant Bayou prospect sites consisted of four vertical component seismometer (geophone) sites, as well as a multiplex site located beside one of the geophone sites. Figures 4 and 5 (respectively) show schematic illustrations of the instrumentation at the geophone multiplex sites. The seismometers were installed in PVC-cased boreholes, typically 20 feet deep and 6 in. wide; in an exception to this 20 ft depth, the Hulin field site (WHP) geophone was installed at 100 ft in a preexisting well. Geophones were sealed in PVC containers to prevent the frequent occurrence of salt water corrosion. Borehole emplacement of seismometers reduced the interfering effects of surface cultural noise. Due to the (much) higher costs for such geophones and the necessity of drilling larger diameter, deeper holes, horizontal (or three component) seismometers were not used in this project. In addition to these impediments to horizontal geophones, using the levelling and horizontal instrument positioning required for accurate earth-motion detection would have caused problems.

Mechanical responses to ground motion that affected the seismometer were converted to electrical signals and transmitted (via cable) to a telemetry instrumentation package installed in a protective enclosure approximately five feet above ground level. This telemetry package (figure 4) contained a 12-volt marine battery charged by solar panels mounted alongside the enclosure, a voltage regulator, a transmitter and another box containing an amplifier and voltage controlled oscillator (VCO). The voltage regulator maintained a steady battery charge that also prevented solar panel overcharge. Under continuous cloud cover, the field station was able to operate for approximately one week; it could operate for about four days if the battery was not charged by the solar panel.

The signals from each field station was transmitted to the central (multiplex) network site via frequency modulated signals using a very high frequency (VHF) transmitter. The multiplex site had several antennae and one receiver for each remote field site (figure 5). A 12-volt, solar-charged marine battery, similar to that of the field site, provided electrical power for the multiplex site. The main

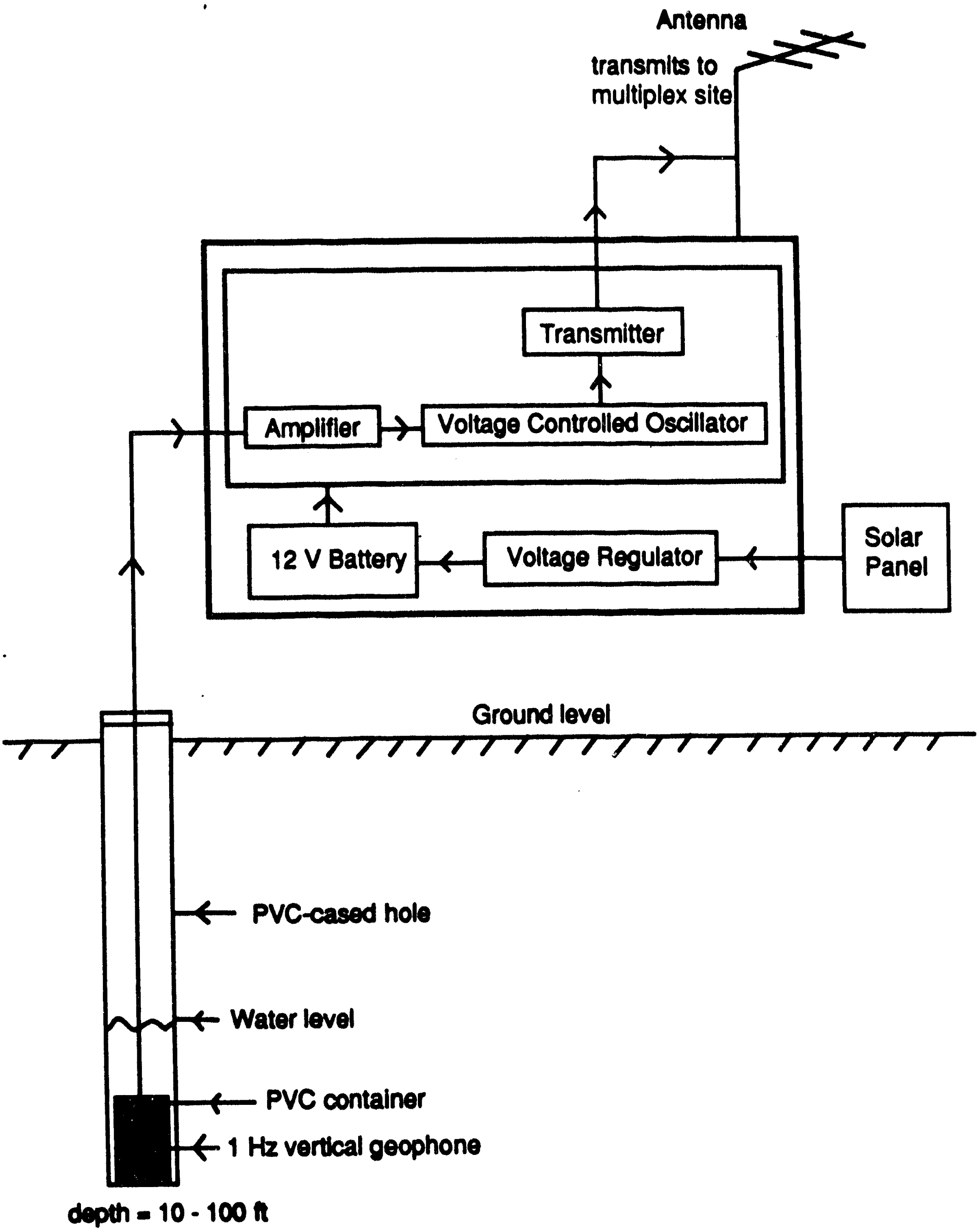


Figure 4. Schematic of seismometer field site (from Jensen 1992).

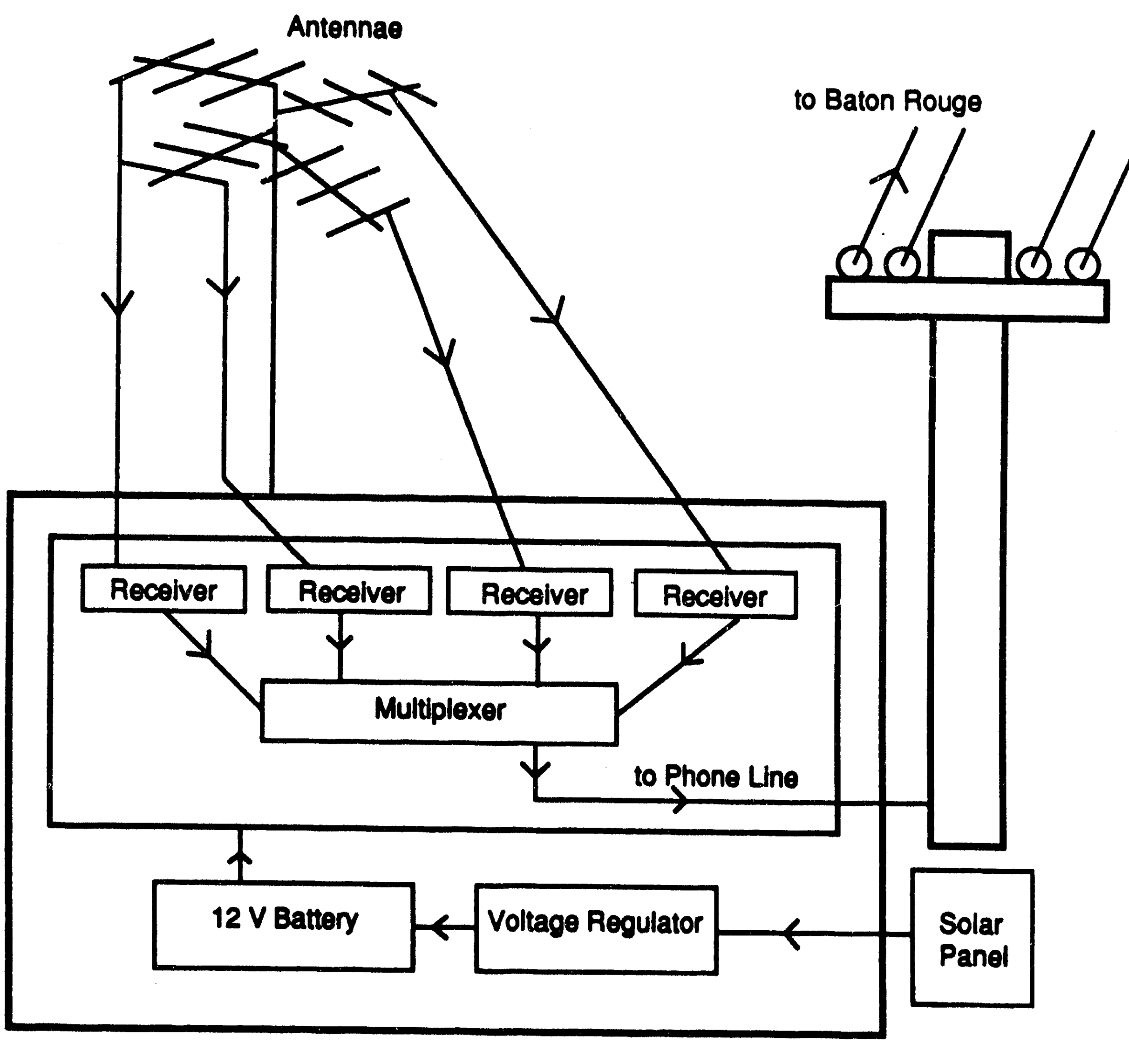


Figure 5. **Schematic of multiplex site (from Jensen 1992).**

function of this set up is to gather all the FM radio signals from the field sites and relay them (through telephone lines with the aid of a multiplexer) to the central recording facility.

Although expensive, this method of data transmission is more economical than long distance transmission via satellite or radio links. The main drawback to this system is that the data cannot by transmitted if the telephone lines are out of service.

Central Recording Facility

A diagrammatic illustration of the central recording facility located in the Howe-Russell Geoscience Complex of Louisiana State University at Baton Rouge is shown in figure 6. Signals transmitted through telephone lines from each multiplex site were received at the central recording facility and recorded using both a half inch analog magnetic tape and also as paper tracings on rotating drum recorders. Both these recording systems were linked to a synchronized timing system (recognized by the National Bureau of Standards) broadcast by radio stations WWV and WWVB (Jensen 1992). A single, half-inch analog magnetic tape was able to continuously record received signals for 48 hours. Each network's multiplexed data were recorded on an assigned track and the time code recorded on another tape track. Discriminators deciphered the signals and relayed them onto the helicorder drums where a heated stylus traced the seismic signal onto heat-sensitive paper. The drum completed one rotation each 15 minutes and each sheet of paper recorded one day's data. Any microearthquakes recorded by the networks were initially identified by daily scrutiny of the paper records. If the specific time window and station of origin is known additional evaluation of relevant events can be obtained through retrieval of this data.

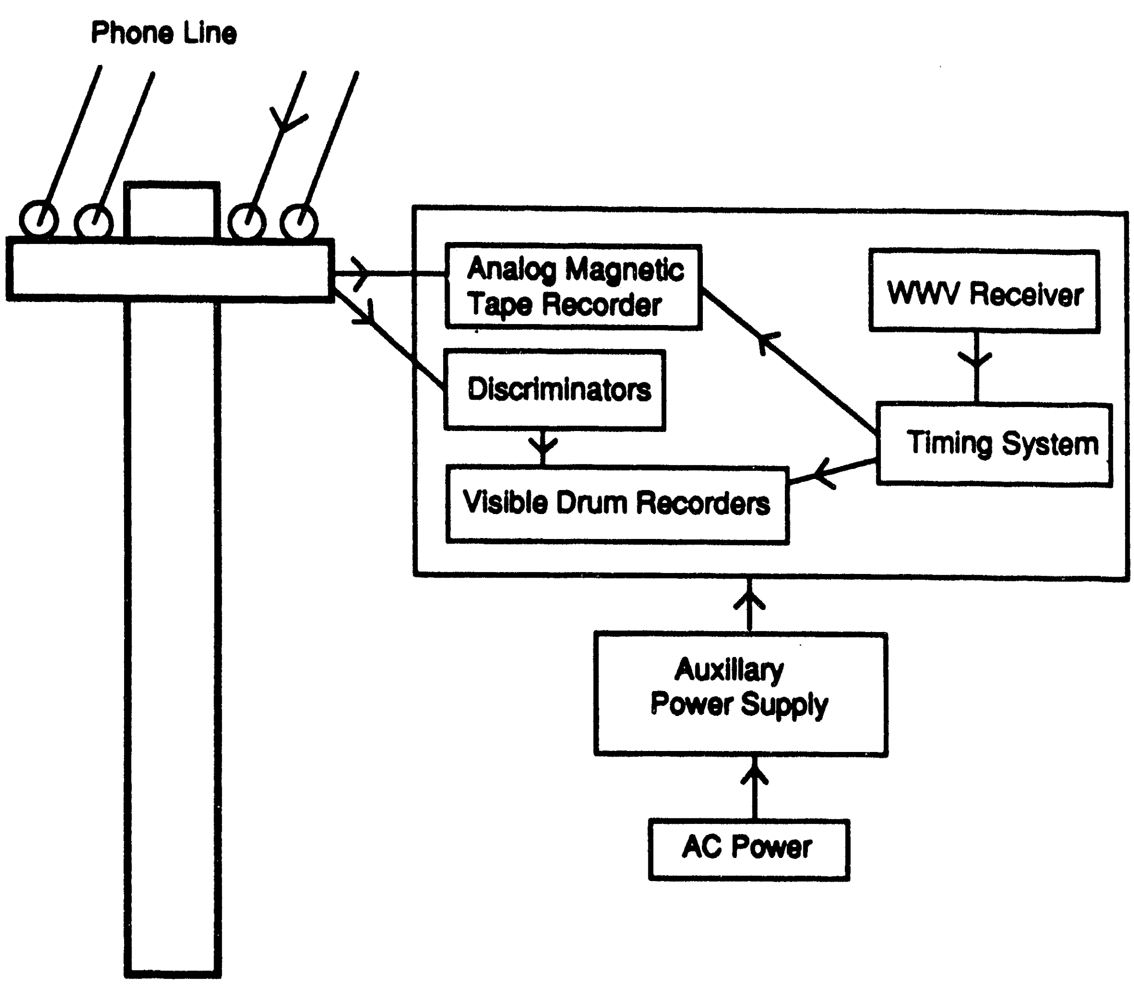


Figure 6. Schematic of central recording facility (from Jensen 1992).

DATA ANALYSIS

Because the microearthquake monitoring networks associated with these geopressured-geothermal test wells were the first (and to date the only) continuous seismic monitoring networks established in the Gulf Coast Region, a learning process during the early stages of the program was necessary to identify the causes of signals received by the networks. Various origins for the ground motion detected by the network seismometers exist. These can be broadly categorized as true seismic events, or as either cultural or natural noise. Although other types of teleseisms were recorded and maintained in the files, they were not evaluated, because the focus of this project was to monitor microearthquakes. All paper records were analyzed daily for microearthquake activity.

Long-term seismic signature monitoring has enabled the accurate identification of background signals due to natural and cultural noises. Because most of these monitoring stations were located near the coast, the instruments recorded many natural noise signals caused by thunder and thunderstorms. Storms punctuated seismic records with continuous noise for a two to three second period (figures 7, 8). Although this type of noise was mostly filtered out for data analysis, it made initial identification of legitimate natural events difficult. Cultural noise includes traffic, sonic booms, geophysical blasting and explosions. Seismic signatures created by passing cars, trucks, or trains showed a gradual increase in vibration amplitude followed by a decrease after the vehicle passed (figure 7). This pattern was easily distinguished from natural events such as earthquakes, which generally show a sharp initial impulse rather than a gradual increase in the vibration amplitude. Figure 8 shows an example of a seismic signature from a chemical explosion. Although only a small amount of blast energy travels is transmitted through the earth, blasting produces seismic signatures similar to small earthquakes (Jensen 1992). Fortunately, blasting can be easily identified because of its regularity, identical blast signatures, and time of occurrence (usually during daylight working hours as shown in figure 9). Distant teleseisms from around the world also were recorded by the networks. Figure 10 shows a seismic record of an earthquake.

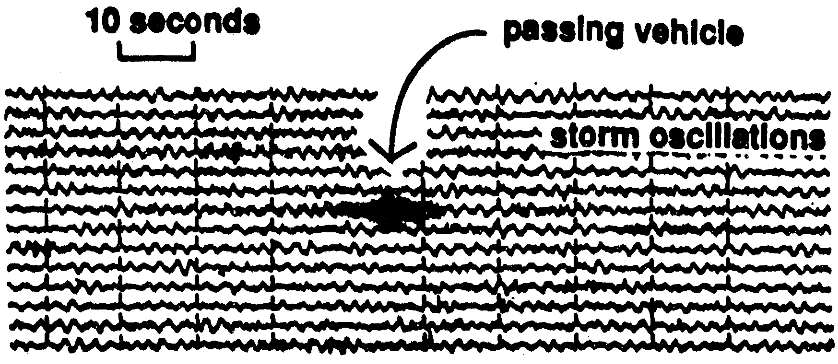
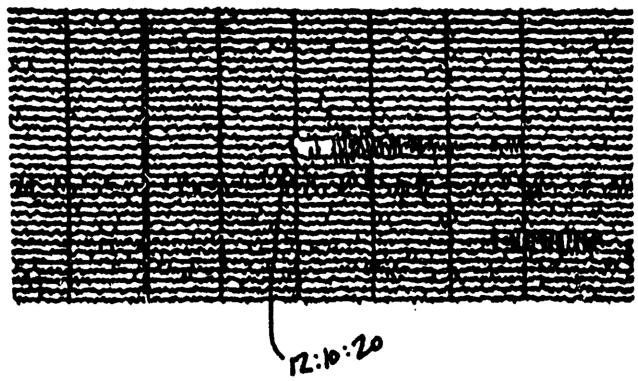
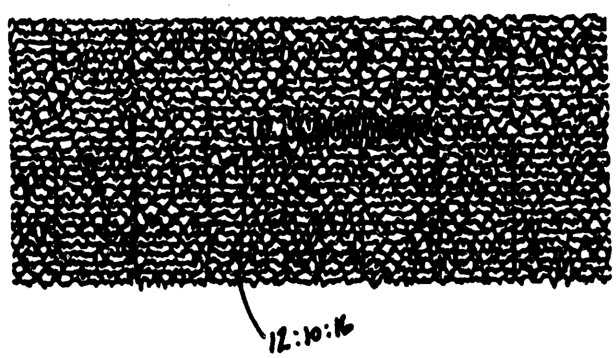


Figure 7. Typical seismic signatures caused by storm and a passing vehicle (from Jensen 1992).



a) station HJS



b) station WHP

Figure 8. Examples of impulsive seismic trace from a plastics plant explosion on 14 December 1991 recorded by Hulin network. White section due to pen moving so fast it did not mark paper. Note slow travel time: 4 seconds between stations only 2.75 km (1.7 mi) apart. Lower record from station WHP shows effects of approaching storm (from Jensen 1992).

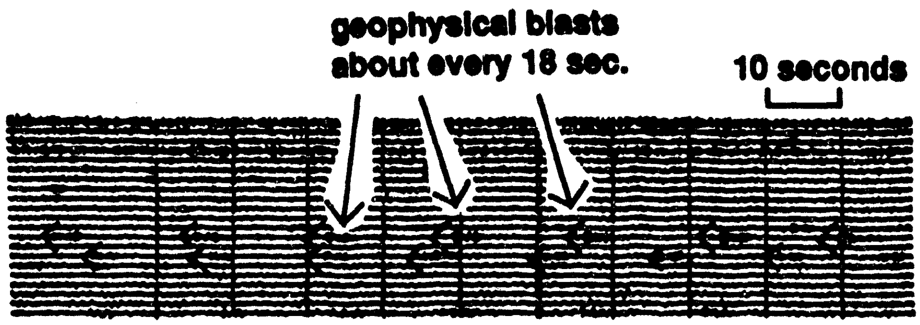


Figure 9. Illustration of the seismic signature from geophysical blasting. Each mark indicates a blast to the right (from Jensen '92).

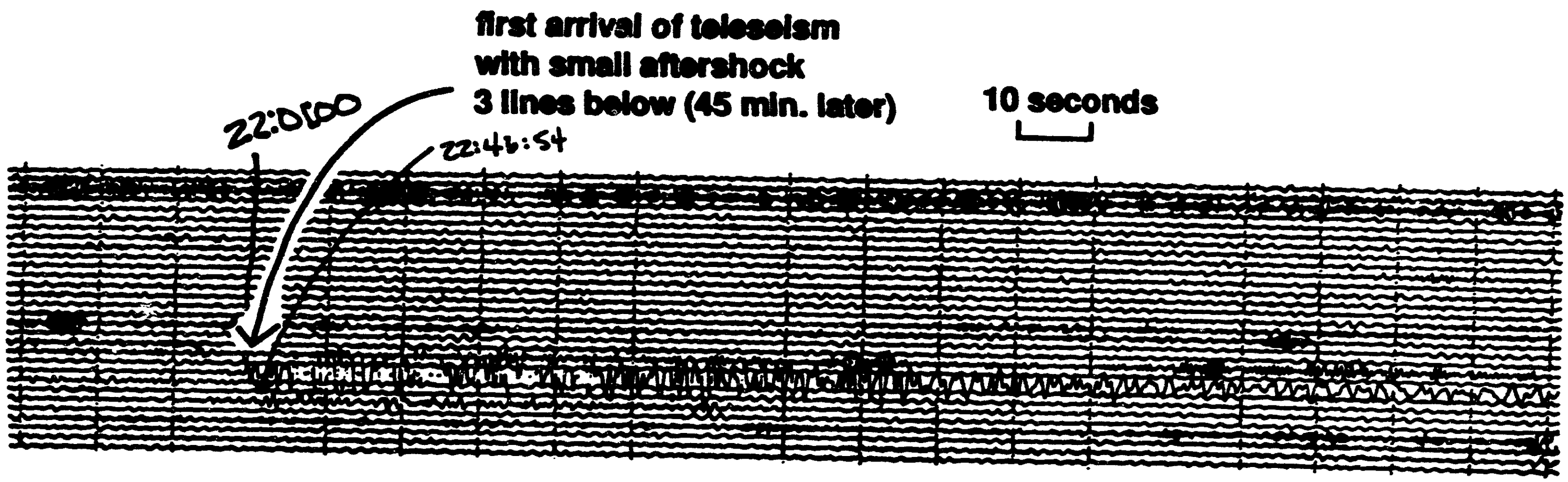


Figure 10. Example of teleseism, a magnitude 7.6 earthquake from Costa Rica on 22 April 1991 (from Jensen 1992).

Apart from the cultural noise signals discussed above, other seismic signals recorded by the networks were classified into two types; as Type I (body wave events) and Type II (surface wave events). Microearthquakes are classified as Type I events. These are characterized by P wave (primary compressional/dilatational) arrival followed by S wave (secondary, shear wave) as well as by surface wave arrival in some cases. Type I seismic events have P wave velocities ranging from 1.5—6.00 km/second (5,000 to 20.000 ft) and certain seismic signals typical of microearthquakes. During 1992—1993, only the Pleasant Bayou site conducted geopressured-geothermal well testing. No local Type I events (microearthquakes) were recorded by the Pleasant Bayou or the Hulin network during this time.

As in previous years, surface wave signals from Type II events (which have impulsive and emergent first arrivals) have continued to be recorded on the networks (figure 11). Except in the case of known explosions, the origins and causes of such Type II events continue to remain unexplained. In the initial years of this project, it was noted that Type II events were similar to the fundamental mode Raleigh waves reported by Ebinero et al. (1983) in their Texas coastal plain study. Because of their similar velocities (35 to 70 km/sec or 1,150 to 2,495 ft) and frequency ranges, at the present time it appears that Type II events are either attributable to leaking energy from microearthquakes within a near-surface, low-velocity layer, or are due to acoustical transmissions (thunder, sonic booms) through the air (Stevenson 1991, Jensen 1992). Further, Stevenson (1991) notes that although the Type II events occur on all days of the week, they most frequently occur during daylight hours, on weekdays rather than weekends, and rarely at night. While these Type II events cannot be attributed to any type of underground earth movements, they probably occur because of some human-induced source. Because they also have occurred when no well testing was being done, these events are unrelated to geopressured-geothermal testing activities.

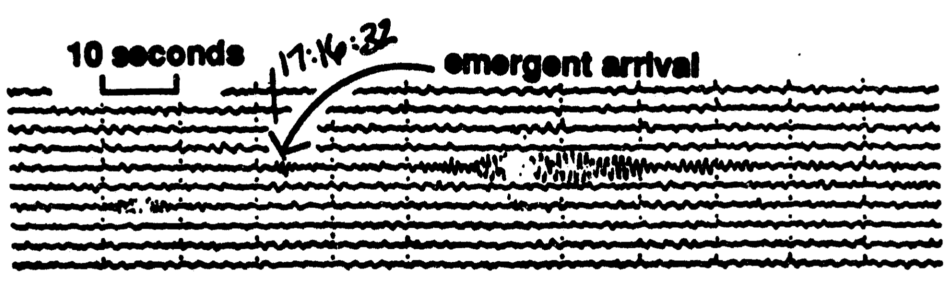


Figure 11. Example of emergent Type II sonic event (from Jensen 1992).

CONCLUSIONS

In 1992, continuous microseismic monitoring continued at the Hulin and Pleasant Bayou geopressure-geothermal prospect sites; although, well testing was conducted only at the Pleasant Bayou site. As in previous years, two main types of seismic signals were recorded by the networks—Type I (body wave) and Type II (surface wave) events. The latter was further classified into emergent and impulsive events. No microearthquake (Type I event) attributable to the geopressured-geothermal well testing at Pleasant Bayou was recorded on the network. However, other Type I events unrelated to well testing (teleseisms) as well as Type II events suspected to be of human-induced atmospheric origin—sonic booms, perhaps—were recorded.

Years of continuous microseismic monitoring has shown no induced microseismicity caused from potential fault activation or ground subsidence resulting from geopressured-geothermal resource testing activities. However, it should be pointed out that (to date) all geopressured-geothermal resource testing at any given time has been limited to only a single test well and single disposal well. Therefore, conclusions reached as a result of this microseismic monitoring data apply only to this situation. Environmental concerns with regard to potential fault activation and ground subsidence cannot be overlooked and must be monitored closely whenever the development of an entire field of geopressured-geothermal wells and disposal wells is being considered.

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SUBSIDENCE MONITORING

by

Dianne Lindstedt

INTRODUCTION

Subsidence monitoring around the Gladys McCall and Pleasant Bayou geopressured-geothermal well sites continued during the reporting period from1 January 1992 to 31 December 1993. The subsidence monitoring portion of the study was designed (within budgetary constraints) to determine subsidence rates around the test well sites and to compare them with regional rates of subsidence in order to assess the effects of subsurface fluid withdrawal. This report presents the most recent results in this ongoing study.

Extraction of large quantities of underground fluids can affect surface elevation if enough fluid has been removed from the area. The resulting compaction in a reservoir can be detected as vertical movement on the surface. Potential fault reactivation and vertical movement through compaction over time are basic types of ground movement associated with subsurface subsidence caused by fluid withdrawal. For example, numerous recent international studies on groundwater and oil and gas extraction sites indicate that surface subsidence can range from 1 mm to 300 mm/yr because of fluid withdrawal (Emery and Aubrey 1991) while previous literature contended that noticeable subsidence above producing fields is the exception rather than the rule (Geertsma 1973).

In southeast Texas surface subsidence due to water withdrawal is well documented (Gabrysch 1984). For example, subsidence due to groundwater withdrawal has been documented in the Houston area since 1906. Subsidence has been as much as 2.3 m from 1943 to 1975, a period when the volume of groundwater withdrawal increased significantly every year.

For fluid withdrawal from oil and gas reservoirs, some studies in Louisiana show a localized influence on subsidence as much as 130 cm above the reservoirs (Suhayda 1988). For example, Turner (1988) reported that water level rises at twice the rate of levels measured on tide gages near the Golden Meadow field.

Although subsurface compaction has been shown to result from fluid removal, other geological and ecological processes in south Louisiana are also at work, complicating our present study. Louisiana's coastal wetlands are being eroded at a rate of about 31 mi^2/yr (Dunbar et al. 1990) primarily because of subsidence, compaction of deltaic sediment, sea level rise, and human activities (Boesch et al. 1983, Dunbar et al. 1990, Britsch and Kemp 1990).

Because the geopressured-geothermal wells in this study are located in areas where land loss rates are already high, local subsidence becomes more critical as rate increases due to additional influences may exacerbate wetland loss in localized areas. Continuous monitoring of bench marks around the well site will enable detection of vertical movement of the surface in the immediate area.

PREVIOUS STUDIES

Tide-gage data indicate that subsidence ranges from 10 to 20 mm/yr in Louisiana (Suhayda 1988, Ramsey and Penland 1989). Other studies show that sediment accumulates about 5 mm/yr (Suhayda 1988) and subsidence rates are lower in the chenier plain (from 6.3 to 6.95 mm/yr) than in the delta plain (from 8.0 to 13.3 mm/yr). With sea level rise about 2.3 mm/yr in the Gulf, subsidence rates are estimated to be from 5.3 to 10.9 mm/yr (Suhayda 1988, Ramsey and Penland 1989). Using tide-gage data with leveling data, Holdahl (1973) determined subsidence rates ranging from 5 to 10 mm/yr in southwestern Louisiana and southeastern Texas. Figure 1 depicts regional subsidence rates for the Gulf Coast area, with southwestern Louisiana and southeastern Texas exhibiting rates from 4 to 5 mm/yr (Holdahl and Morrison 1974). Anomalously high subsidence rates (>5 mm/yr) occur around Houston, Texas, which is north of the Pleasant Bayou site.

Turner (1988) found the highest rates of water level rise where sedimentation rates are the highest and where waterway construction and water management practices were the most intense. Conversely, the lowest rates occurred where the depth to the Pleistocene terrace was the most shallow and where sedimentation rates were the lowest.

Several factors cause subsidence in south Louisiana: compaction of deltaic sediment, river diversion, sediment deprivation, groundwater withdrawal, hydrocarbon extraction and other petroleum-

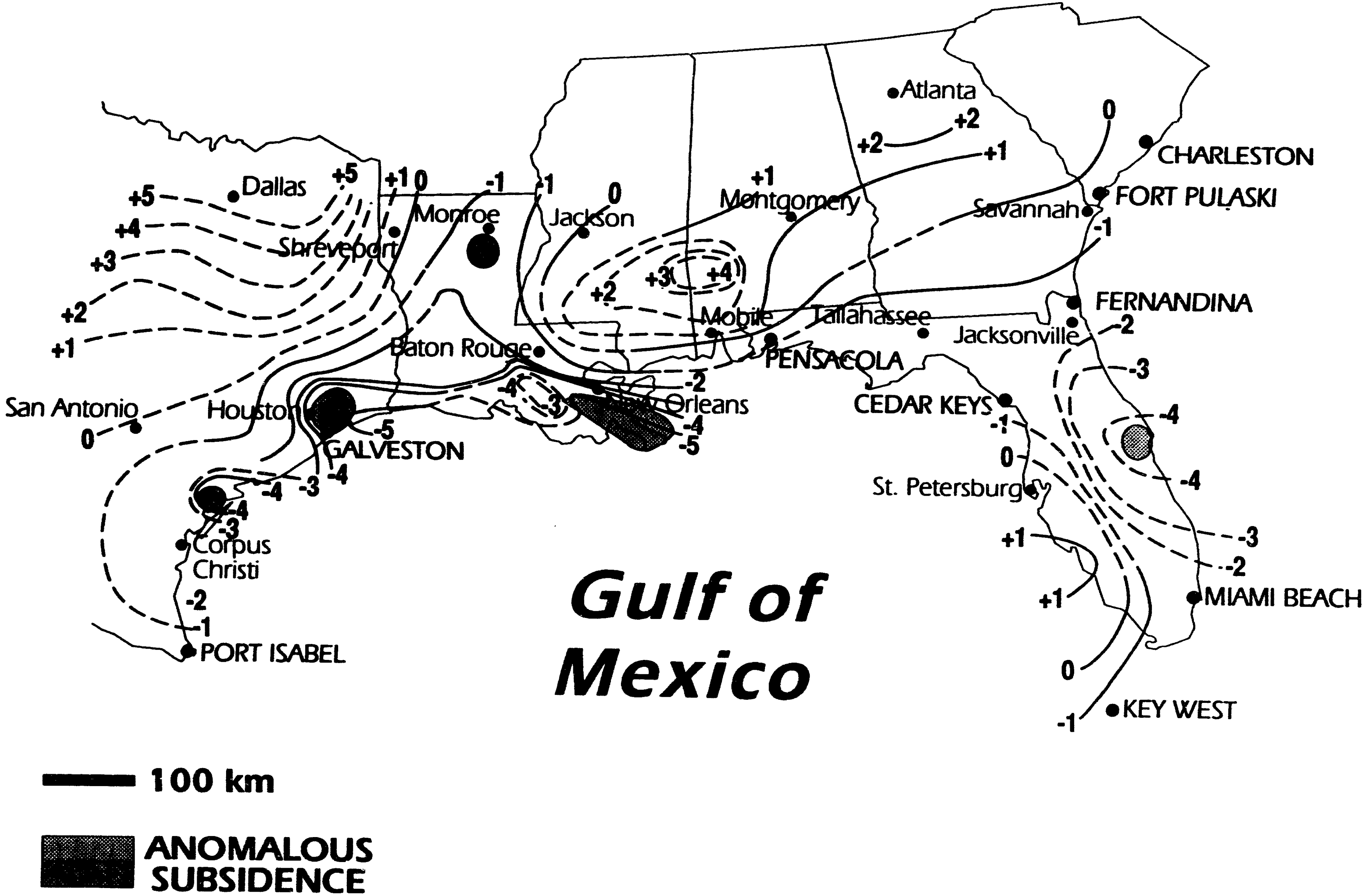

Figure 1. Contour map showing rates of elevation change in mm/yr in the northern Gulf of Mexico (Holdahl and Morrison 1974).

related activities, coastal development, and human impact. The extent to which each factor contributes currently is not quantified, and it may vary among different geographical sections of the state such as river basins or hydrologic units, where geological factors such as faulting, geomorphology, Pleistocene depth, sediment age, and hydrologic setting may vary considerably.

Some documentation of subsidence has been attempted and quantified in south Louisiana. For example, Davis and Rollo (1969) documented subsidence due to groundwater extraction in Baton Rouge. Saucier (1963) calculated an annual subsidence rate of 1.2 mm based on radiocarbon dating in the New Orleans area. Drainage and landfilling there have caused consolidation of drained peat and underlying clays, secondary compression of peat and clay, and oxidation of the drained peat in the New Orleans area. Using data recorded since the 1930s, tide-gage stations at Eugene Island and Bayou Rigaud, Emery and Aubrey (1991) have reported subsidence rates from 9.6 to 10.5 mm/yr. The data also indicate an increase in subsidence rate since the 1960s. Studies in Louisiana have shown that land loss occurs at a rate of 30 to 40 mi^2/yr. (Dunbar et al. 1990, Gagliano 1981). Dunbar et al. (1990) and Britsch and Kemp (1990) acknowledge an increase in land loss rates during the 1970s; however, data that incorporate the early 1980s indicate the rate of loss is decreasing.

Because subsidence and land loss are related and important in Louisiana, the test well sites for this study are located on the more stable chenier plain, where subsidence and related coastal erosion rates are lower than the delta plain. The Hulin site is located in a transition zone of the northwestern edge of the oldest delta lobe (the Maringuoin), where Holocene sediment thickness is about 0–5 ft (Fisk 1948). Pleistocene outcropping begins in this area. In contrast, the Gladys McCall site lies on 15–30 ft of Holocene deposits (Fisk 1948).

The Pleasant Bayou site is also located on recent sediment which is subject to compaction. Regional subsidence in the Houston area has been determined through repeated leveling since 1906. High subsidence rates, approximately 70 to 72 mm/yr, are mostly due to groundwater withdrawal. However, in areas where groundwater levels have risen these rates have decreased by 60–90% (Holdahl et al.

1991). The Holdahl Study also shows that by altering or controlling fluid-withdrawal volume, the rate of subsidence can be controlled. Subsidence in Brazoria County where the test well site is located is far less pronounced than in the Houston area, however the groundwater-withdrawal rates are much lower. Subsidence here is similar to that in Louisiana, where compaction of Holocene sediment occurs.

STUDY SITES

There are three geopressured-geothermal sites in the study: Gladys McCall and Hulin in southwestern Louisiana, and Pleasant Bayou in southeastern Texas.

Gladys McCall

The Gladys McCall test well site is located in the coastal zone near the western edge of the Rockefeller Wildlife Refuge in Cameron Parish, Louisiana (figures 2-5). The Gladys McCall site is located on the relatively stable chenier plain, which was formed indirectly from deposits of the Mississippi River. The Holocene sediments there are thin, approximately 15–30 ft thick (4.5-6 m) (Fisk 1948). Because of its origins, the surface sediment is unstable and subject to compaction.

Historical vegetation maps generated by the Technical Services section of the Coastal Management Division in Louisiana's Department of Natural Resources indicate the area is primarily brackish marsh, which is bounded by a chenier ridge to the north. Some of the marsh north of the site has been converted to agricultural and pastureland. In the area represented in figures 3 and 4 about 45% is brackish marsh and 12% intermediate marsh. Changes in the marsh from 1956 to 1978 showed a 12% loss of marsh during that period (figure 4).

The Gladys McCall test reservoir produced over 27 million barrels of brine during a four-year testing period which ran from September, 1983 through September, 1987. Brine production ranged from about 5,000 to 30,000 bbl per day. Tests indicated that the well can produce approximately 19,000 bbls per day while maintaining constant pressure. During testing of the Gladys McCall well, 676.8 mmcf of gas was produced and a total of 27,318,414 bbls of brine were produced. The well is presently shut in.

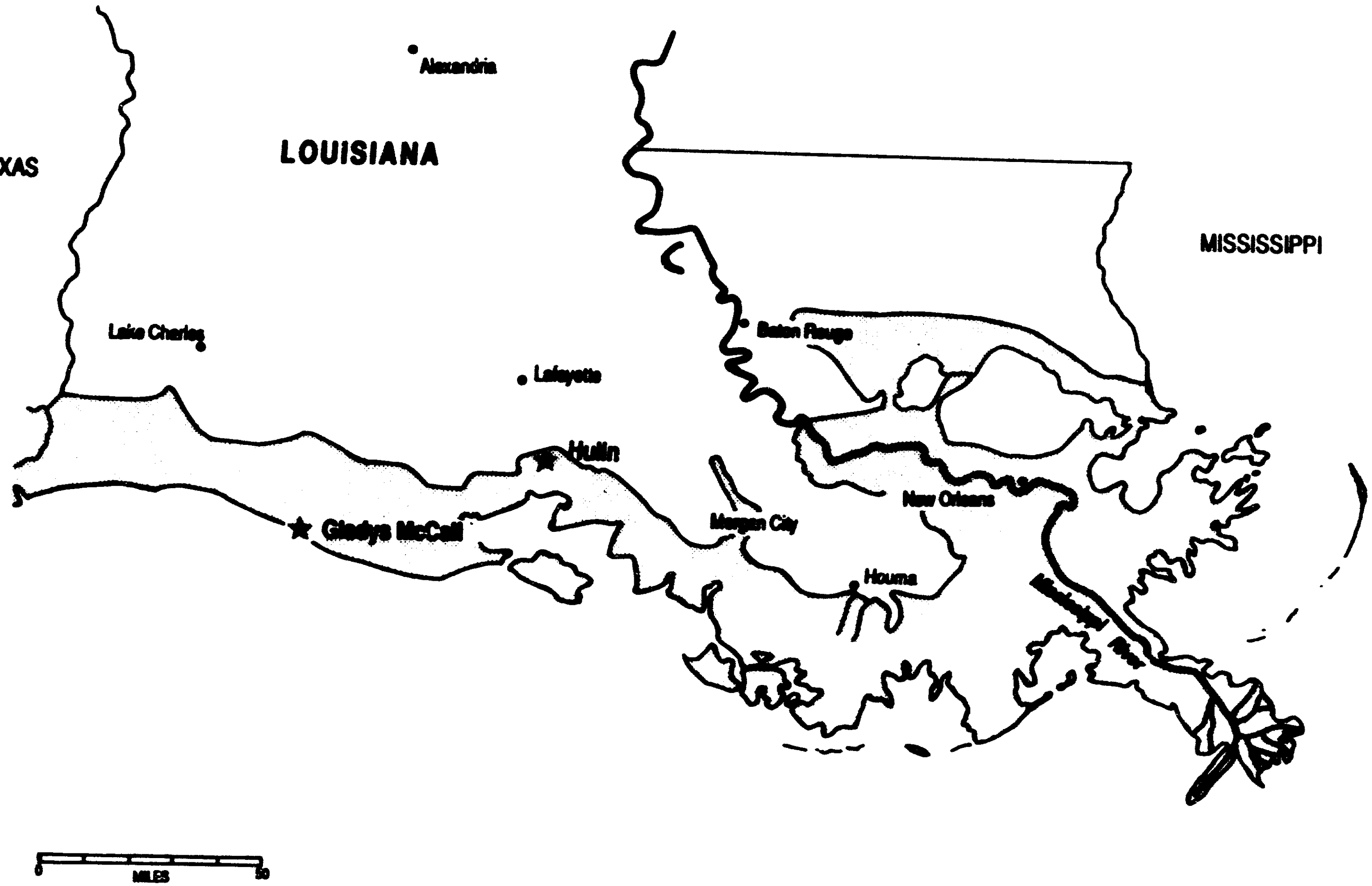

Figure 2. Locations of geopressured-geothermal wells in Louisiana. The shaded area depicts Louisiana's coastal zone boundary.

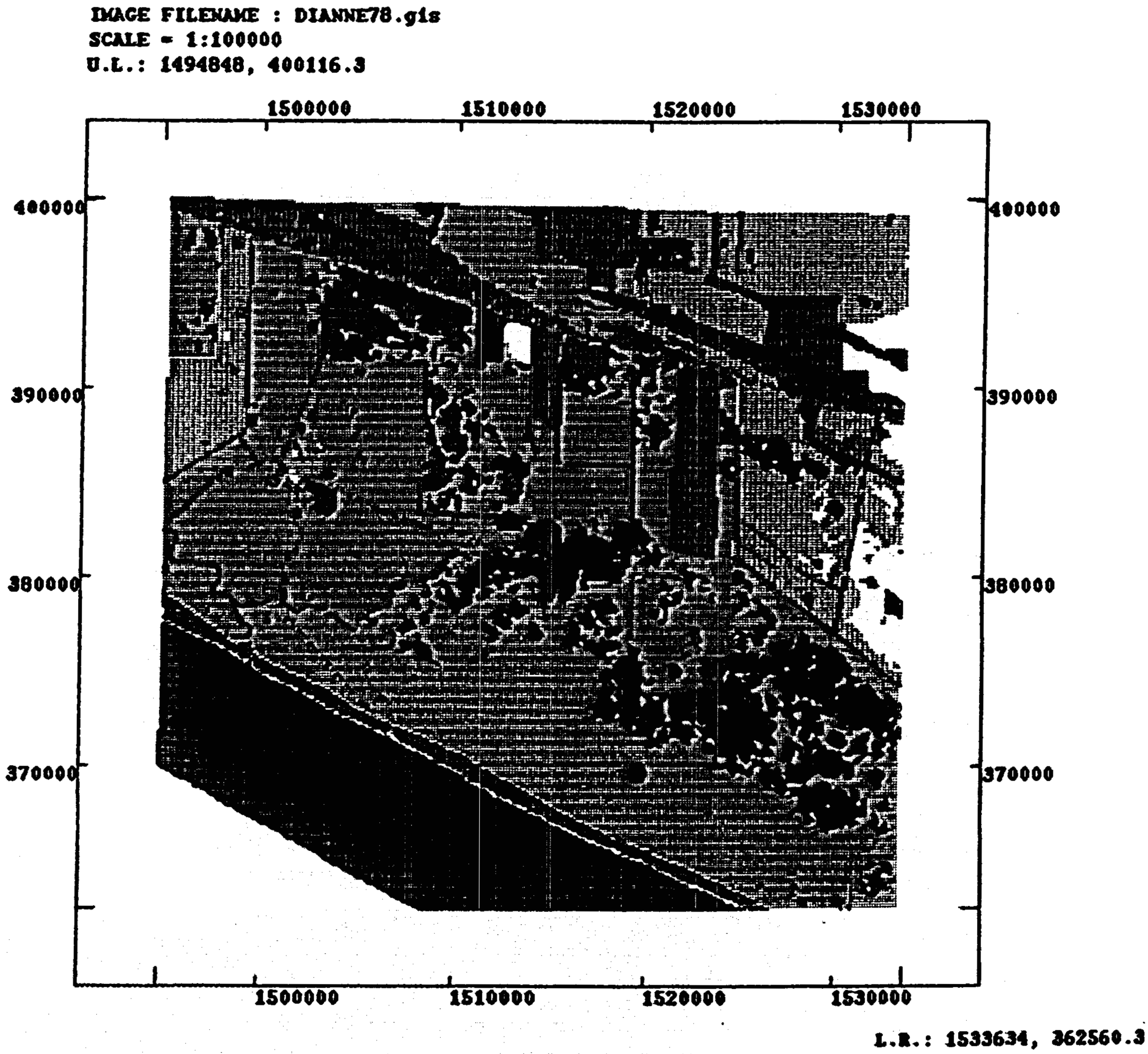

Figure 3. Habitat map of the Gladys McCall site, 1978 (Technical Services Section, Coastal Management Division). Arrow indicates well site.

The variable name is : LA Coastal Zone - 1978 Level 1 Habitat Data

VALUE	CLASS NAME	NO. OF POINTS	%	NO. OF ACRES
1	WATER (Natural)	43223.	20.98	6671.980
2	WATER (Artificial)	11450.	5.56	1767.443
3	FRESH MARSH	1467.	0.71	226.449
4	INTERMEDIATE MARSH	25580.	12.42	3948.575
5	BRACKISH MARSH	92215.	44.76	14234.474
6	SALINE MARSH	3532.	1.71	545.206
7	FOREST	1978.	0.96	305.328
8	SWAMP	0.	0.00	0.000
9	SHRUB/SCRUB	337.	0.16	52.020
10	SHRUB/SCRUB (Spoil)	141.	0.07	21.765
11	AGRICULTURE/PASTURE	17490.	8.49	2699.788
12	DEVELOPED	4317.	2.10	666.380
13	AQUATIC VEGETATION	0.	0.00	0.000
14	INERT	3537.	1.72	545.978
15	BEACH	748.	0.36	115.463
TOTALS:		206015.		31800.846

Points, totals and percentages based on NON-ZERO data values
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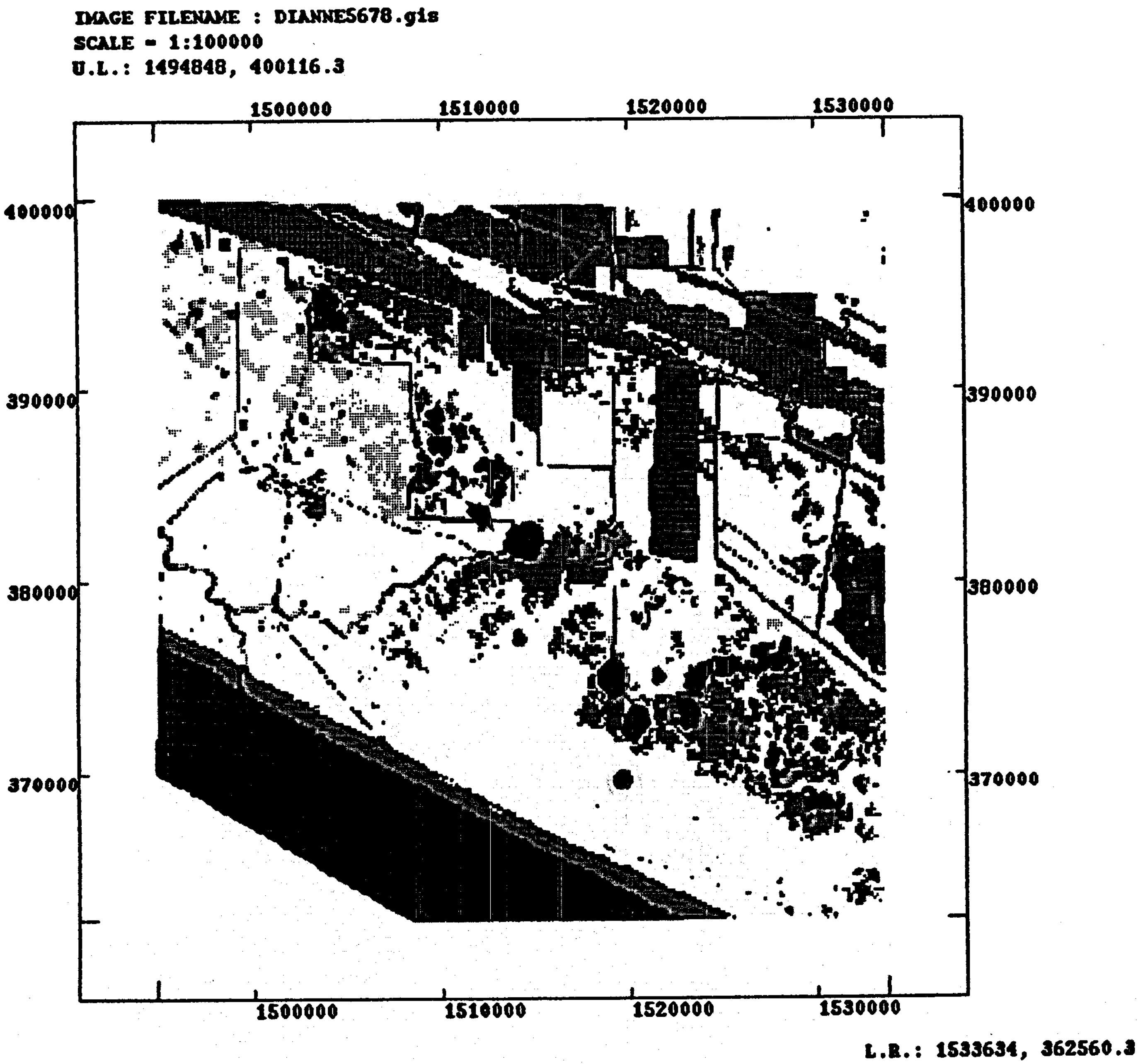

Figure 4. Habitat change map of the Gladys McCall site, 1956 to 1978 (Technical Services Section, Coastal Management Division). Arrow indicates well site.

VALUE	CLASS NAME	NO. OF POINTS	%	NO. OF ACRES
1	1956 Water to 1978 Water	28669.	13.92	4425.398
2	1956 Water to 1978 Marsh	5492.	2.67	847.755
3	1956 Water to 1978 Land	733.	0.36	113.147
4	1956 Marsh to 1978 Water	24719.	12.00	3815.669
5	1956 Marsh to 1978 Marsh	112094.	54.41	17303.031
6	1956 Marsh to 1978 Land	15864.	7.70	2448.796
7	1956 Land to 1978 Water	1285.	0.62	198.355
8	1956 Land to 1978 Marsh	5201.	2.52	802.836
9	1956 Land to 1978 Land	11950.	5.80	1844.624
TOTALS:		206007.		31799.611

Points, totals and percentages based on NON-ZERO data values
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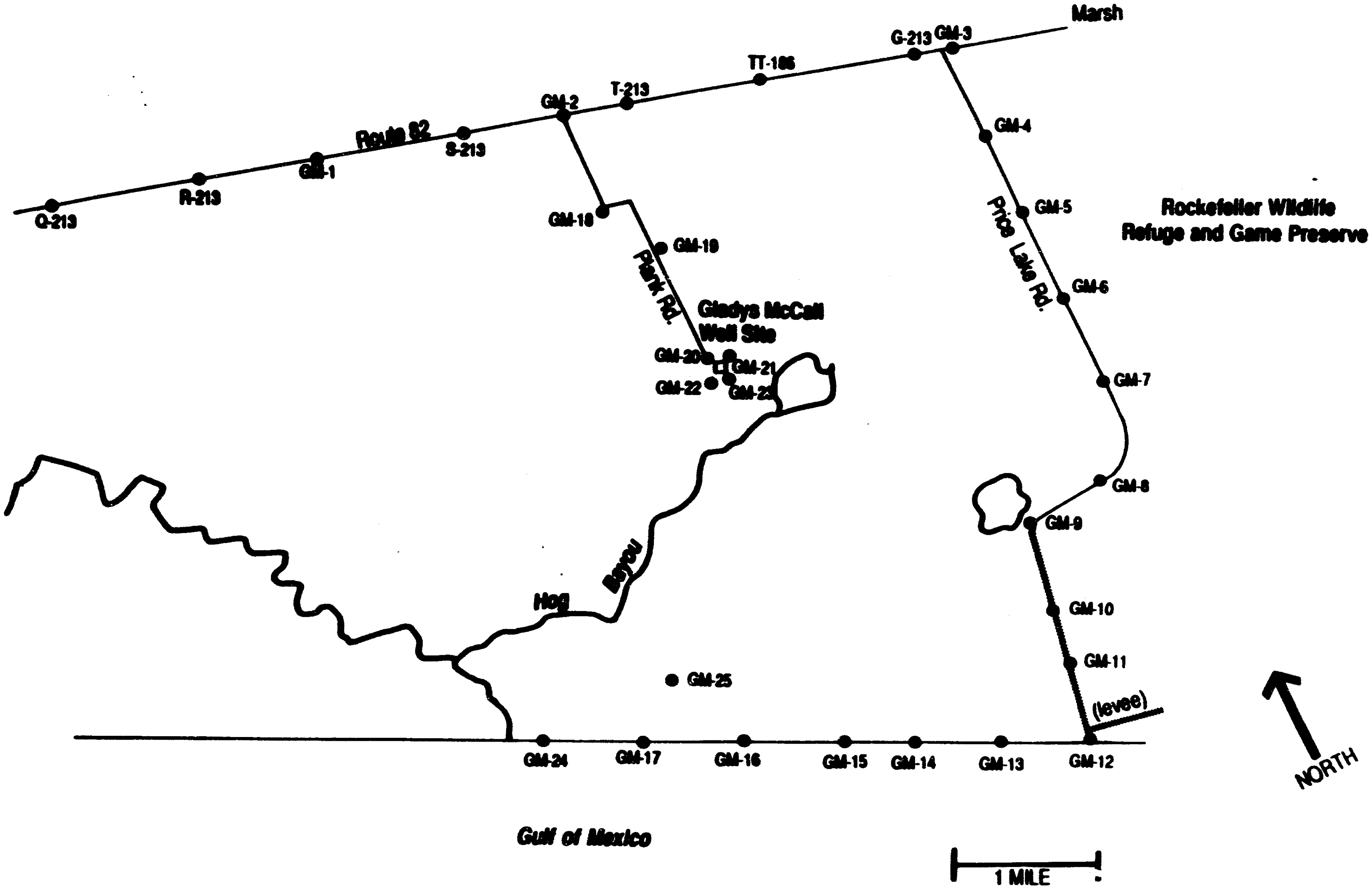

Figure 5. Location of Gladys McCall geopressured-geothermal well with bench mark locations.

Pleasant Bayou

The Pleasant Bayou study area is located in Brazoria County, Texas. Chocolate Bayou merges into Pleasant Bayou just north of the test well site (figure 6). The general area is prairie grasslands. The Pleistocene upland has a mud and sand substrate, much of which is presently used for agriculture or pastureland. Along the rivers are areas of wetland, mostly bottomland hardwoods with fringes of fresh marsh (Fisher et al. 1972).

Drilling at this test well site began in 1984 and brine production occurred from June 1988 to July 1992. A total of 25,290,659 bbl of brine and 473,110 MCF of gas was produced during that period. Brine-flow rates ranged from 12,500 to 25,000 bbl per day. The well is presently shut in.

Hulin

The Hulin test well is located in Vermilion Parish, Louisiana, and is approximately six miles south of Erath, Louisiana (figures 2, 7). The well itself is located just south of the Louisiana coastal zone boundary on a very thin veneer of older Holocene sediment, where surface exposure of Pleistocene prairie can occur in the periphery of the Maringouin delta lobe. This sediment was deposited approximately 7,000 years ago during the formation of the Maringouin delta complex. This sediment is thin (0–5 ft or 0–2 m) (Fisk 1948) compared to the southeastern coastal region in Louisiana, where Holocene sediment is between 100 and 900 ft (30–275 m) thick (Kolb and Van Lopik 1958). The older sediment is relatively more stable than the younger deltaic sediment and should have lower subsidence rates than that on the eastern delta plain mainly because of age (they have had more time to compact) and thickness (they are thinner than the eastern delta-plain sediment).

The well site is bound by a levee and drained agricultural fields and pastureland, with freshwater wetlands within the area. Historical vegetation maps generated by the Technical Services section of the Coastal Management Division in Louisiana's Department of Natural Resources indicate the area was all freshwater marsh during the 1950s. However, between 1956 and 1978 the area was drained and

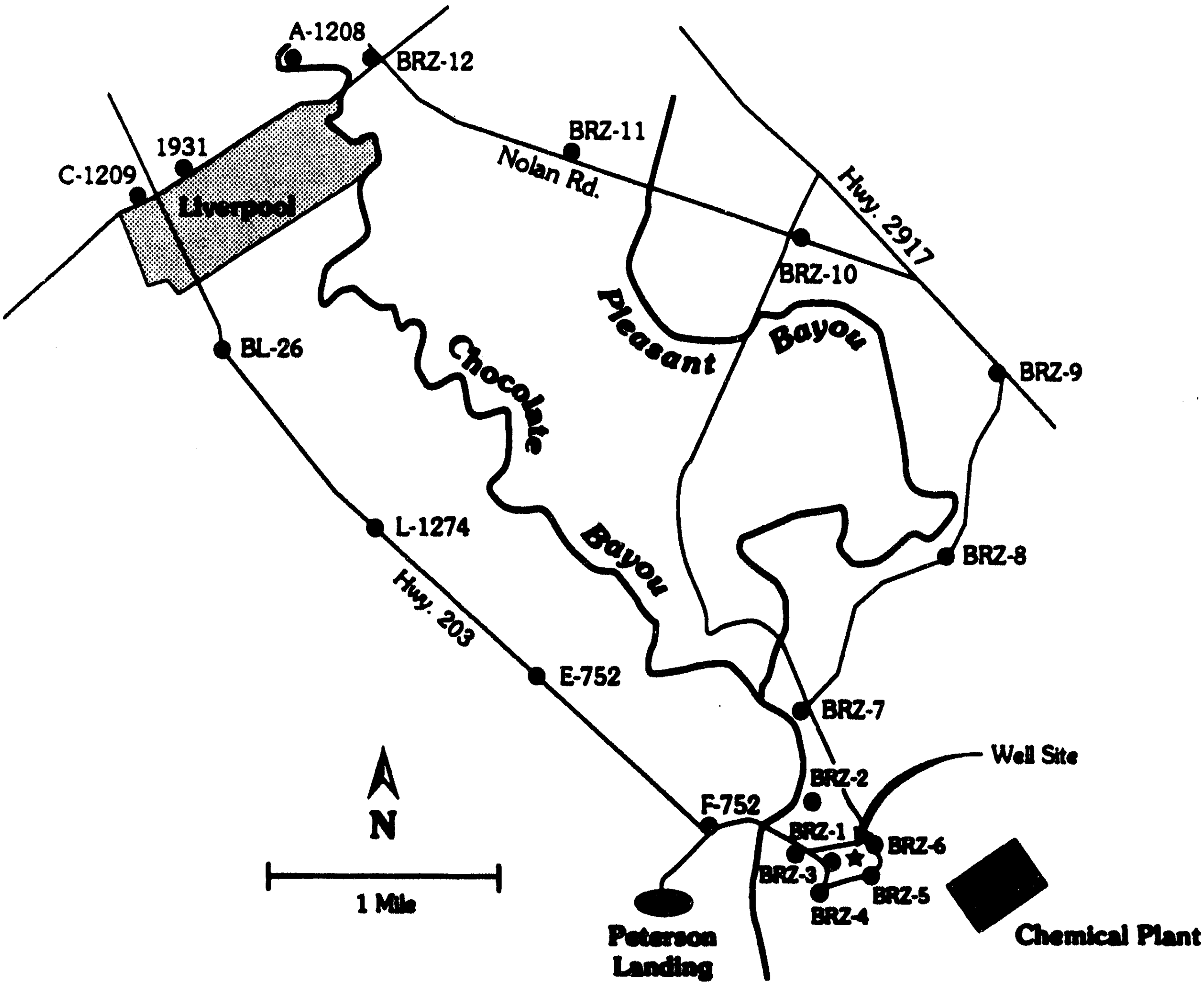

Figure 6. Location of Pleasant Bayou geopressured-geothermal well with bench mark locations.

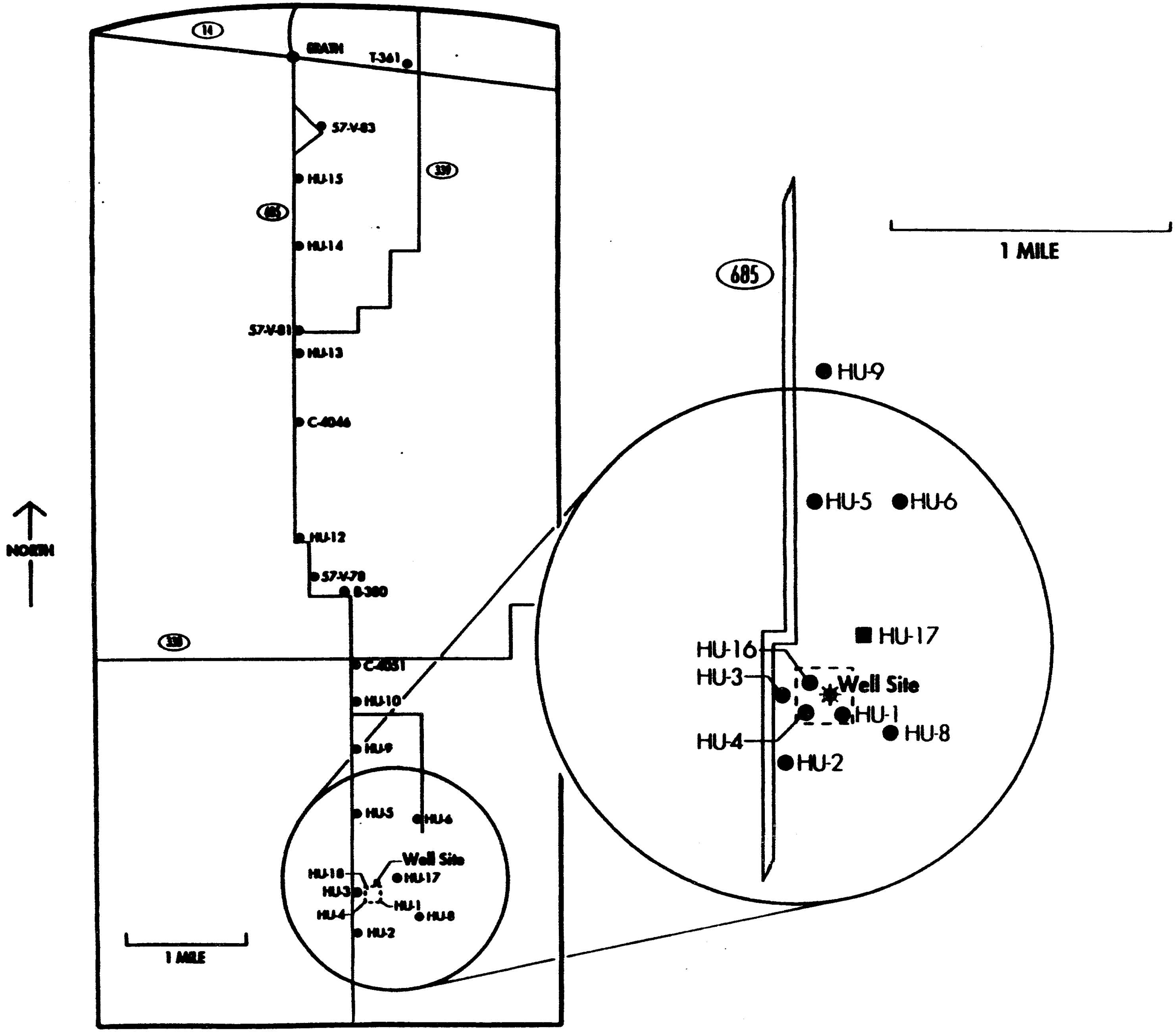

Figure 7. Location of Hulin geopressured-geothermal well with bench mark locations.

converted to agricultural fields and pastureland, and virtually all of the freshwater marsh in the immediate area has been lost to agricultural and pasture development.

While long-term testing of fluid withdrawal at this site has not occurred, a short-term flow test was conducted from December 1989 to January 1990. During this test, 40,163 bbl of brine and 1,246 MCF of gas were produced (Eaton Operating Co. 1990). The well is presently shut in.

METHODS

For each study site in the project, First-Order leveling networks were established and tied into the National Geodetic Survey (NGS) lines using Class B monuments that were installed approximately 1 km apart near the Pleasant Bayou, Gladys McCall, and Hulin prospects. Class B refers to the NGS classification for monument quality. These bench marks consist of capped steel rods driven to 100 ft deep or to refusal.

Approximately every two years surveys have been conducted to monitor the test sites. To determine local motion, a bench mark outside of the prospect area is held fixed during two or more surveys. Because there are no "stable" bench marks in the Gulf Coast Region, elevations are referenced to a NGS adjusted elevation of a deep rod mark in the network, which is referred to as the base bench mark in this study. Analysis on the bench-mark elevations with repeated surveys in the network indicates movement relative to this fixed point. It is assumed that regional subsidence due to crustal movement is affecting each network somewhat uniformally since they are relatively small areas; therefore, crustal movement is affecting each base bench mark and the network equally within the site, and any elevation changes in the network are presumably due to local activity.

After installation, the bench marks were allowed one year for stabilization and then were leveled again. The first leveling survey (1981 for Gladys McCall, 1984 for Pleasant Bayou, and 1989 for Hulin) served as the baseline data for subsequent years of leveling at each site for the duration of the project. For each site, differences in elevation were calculated by subtracting the present year elevations (1992) from the baseline year elevations and from the previously surveyed elevations (1990), with one base bench mark held constant from the leveling. Any change in elevation is reflected as a positive (increase in elevation) or a negative (decrease in elevation) number. A negative value indicates an area where subsidence is occurring *relative* to the base bench mark, and a positive value indicates uplift *relative* to the base bench mark. Annual subsidence rates have been calculated by dividing the difference in elevation by the time interval between leveling.

For this study period, First-Order leveling was performed at two sites using procedures and equipment identical to that used by NGS for First-Order Class I leveling. The leveling began at bench mark C-1209 at Pleasant Bayou and GM-1 at Gladys McCall.

Gladys McCall

A bench-mark monitoring network was established at this well site in September 1981 before testing began. Nine monuments consisting of stainless steel rods with aluminum caps were installed along Highway 82 and around the wellhead. Eight monuments were installed perpendicular to Highway 82 along Price Lake Road and the adjoining levee down to the shoreline. Early in the program seven monuments were installed parallel to the shoreline to monitor shoreline erosion as well as subsidence (figure 5). However, all of these monuments have been destroyed during the course of the study. All monuments were installed according to National Geodetic Survey specifications for First-Order leveling surveys and tied into the NGS network.

In July, 1992 releveling of the geodetic network around the Gladys McCall site consisted of 17.7 km (11 miles) of level line. All leveling adhered to NGS procedures and specifications of First-Order Class I leveling. Leveling began at GM-1 (figure 5). During this survey bench marks GM-4 and GM-7 were searched for but not recovered. The caps for bench marks GM-6 and GM-8 were missing.

Differences in elevation were calculated by subtracting the present year elevations from the baseline (1981) elevations and from the previously surveyed elevations (1990), with bench mark GM-1 held constant from the leveling. Any change in elevation is *relative* to GM-1, the base bench mark.

Pleasant Bayou

Twelve Class B monuments were established at the Pleasant Bayou site June 1984 (figure 6). These monuments were also installed according to NGS specifications for First-Order leveling surveys and tied into the NGS network on lines #101 and #105.

For this reporting period two releveling surveys were conducted in August and September 1992 19.41 km (12 miles) of double-run First-Order levels and 2.01 km (1.25 miles) of single-run First-Order levels were surveyed. For 1993, 19.9 km (12.4 miles) of double-run First-Order levels and 2.0 km (1.2 miles) of single-run First-Order levels were were surveyed during the first week of October. All leveling adhered to NGS procedures and specifications for First-Order, Class I leveling.

During the reconnaissance phase of the 1992 survey, along NGS level line #105 bench mark L-1274 was found. This bench mark was previously reported destroyed in 1985. Bench mark BRZ-5 was confirmed as destroyed reportedly by bulldozer activity. The United States Coast and Geodetic Survey (USCGS) bench mark BL-26 appeared to have been disturbed since the concrete monument was leaning to one side. All other bench marks were recovered.

Differences in elevation were observed to a tenth of a millimeter. For both surveys the leveling began at NGS level line #101 bench mark L-1931 and made a complete loop around the project area. Elevations of project bench marks are referenced to the 1979 NGS adjusted elevation of the deep rod mark of C-1209 in Liverpool.

Differences in elevation were calculated by subtracting the recent year (1992 and 1993) elevations from the baseline (1984) elevations and from the previously surveyed elevations (1990, 1992), with bench mark C-1209 held constant from the leveling. Any change in elevation is *relative* to C-1209, the base bench mark.

Hulin

A network of Class B bench marks was established around each test site to monitor subsidence in the Hulin area (figure 7). The bench marks were set approximately one km apart, and concentrated around the wellhead. This enables detection of relative vertical movement around the well site and at specified intervals from the site.

In 1988, 17 Class B monuments were established between the NGS line (T-361) along Highway 14 in Erath and the Hulin well site (figure 7). The orientation and number of bench marks were limited by cost and distance from NGS bench marks, which were used to begin the line. All bench marks with the prefix HU were installed for this project, while all others are either federal or state agency bench marks. This site was not releveled during this reporting period.

RESULTS

Gladys McCall

Elevation changes for the current reporting period and for the duration of the study are presented in figures 8–10 and tables 1–4 for the Gladys McCall site. The original elevations from each survey are presented in table 5. The surveying team report is presented in Appendix A. The most recent leveling indicates that little or no subsidence has occurred in the area for the last two years, and in fact a slight uplift is occurring near the well site (figure 8). The greatest increase in elevation has occurred at the well itself (19.8 mm) and in the surrounding area from 8.8 to 10.9 mm (table 1, figure 8). The annual change in elevation ranges from 4.4 to 5.45 mm/yr around the well and 9.9 mm/yr at the well. These rates seem to be relatively consistent within 7,000 feet of the well. At bench marks more that 10,000 feet from the well, the results are more variable, with some areas showing minimal subsidence or minimal uplifting.

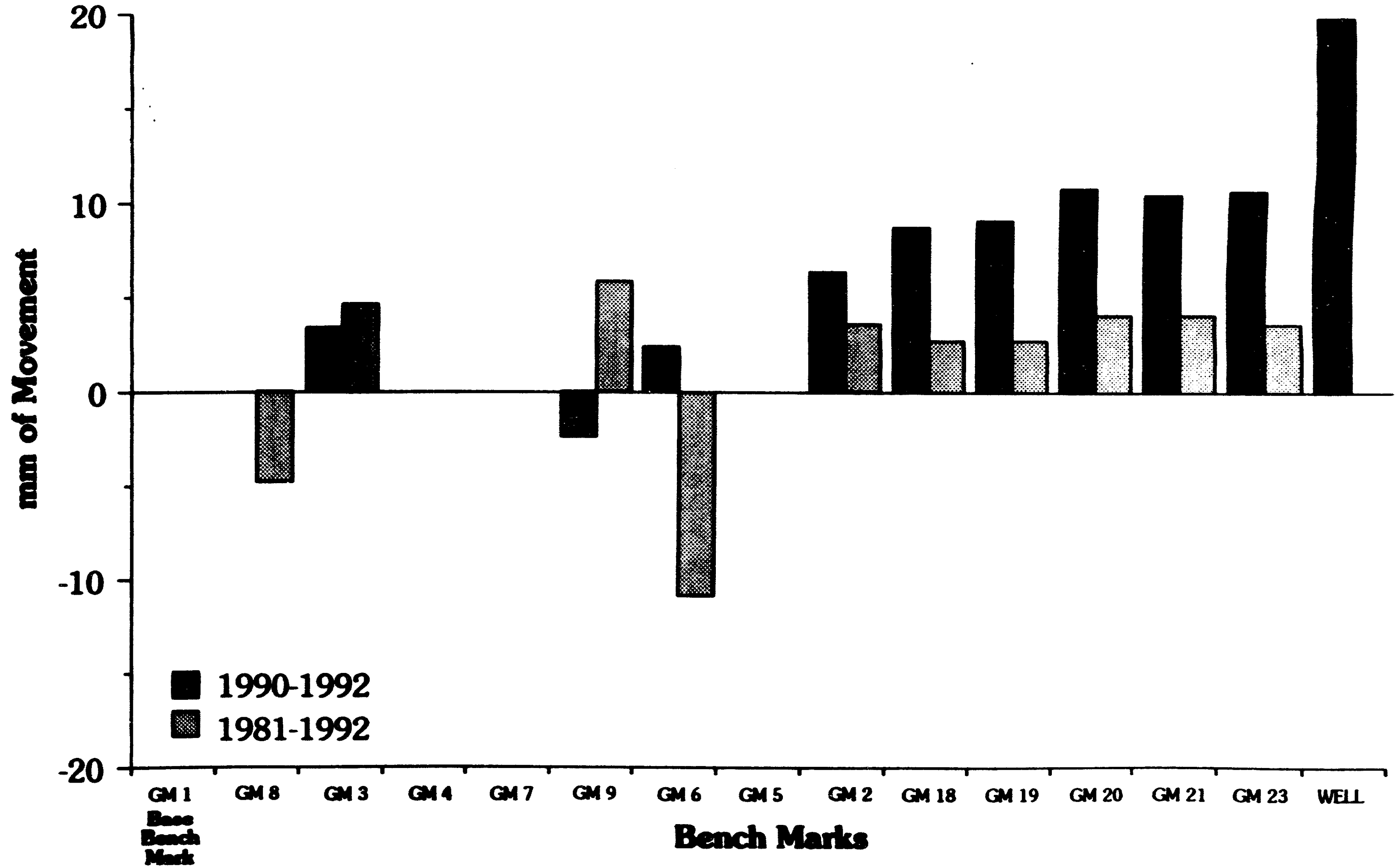

Figure 8. Elevation changes of bench marks for 1990–1992 and throughout the whole study (1981–1992) at the Gladys McCall site relative to GM-1 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. Bench marks GM-4, GM-5, and GM-7 have no data for these reporting periods.

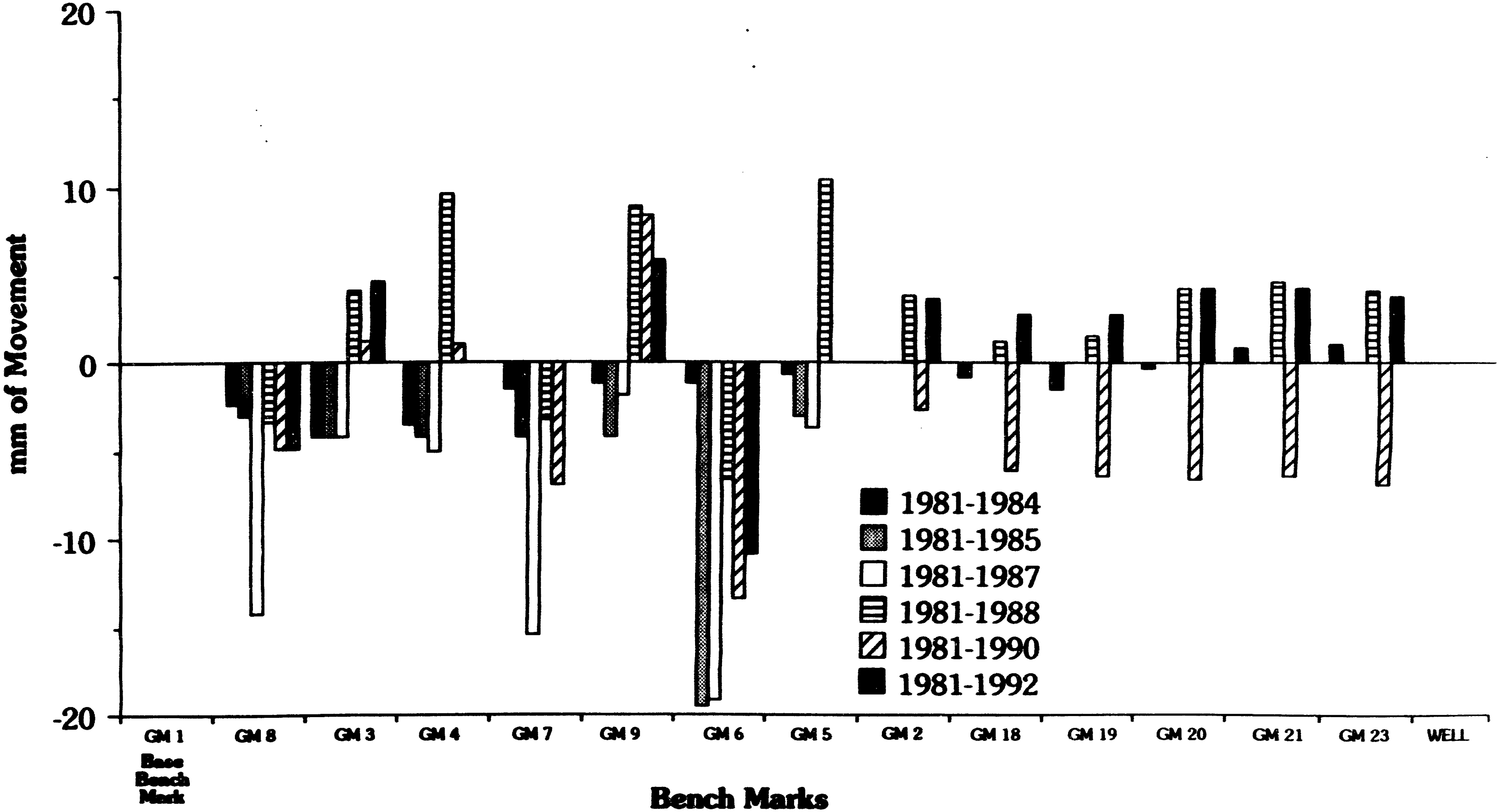

Figure 9. Elevation changes of bench marks from 1981 for all reporting periods at the Gladys McCall site relative to GM-1 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. There is no data available for GM-2 in 1984, 1985, and 1987, for GM-4 in 1992, for GM-5 in 1990 and 1992, *GM-7 in 1992, GM-18, GM-19, GM-20, GM-21, GM-23* for 1985 and 1987, and the wellhead in 1981, 1985, and 1987.

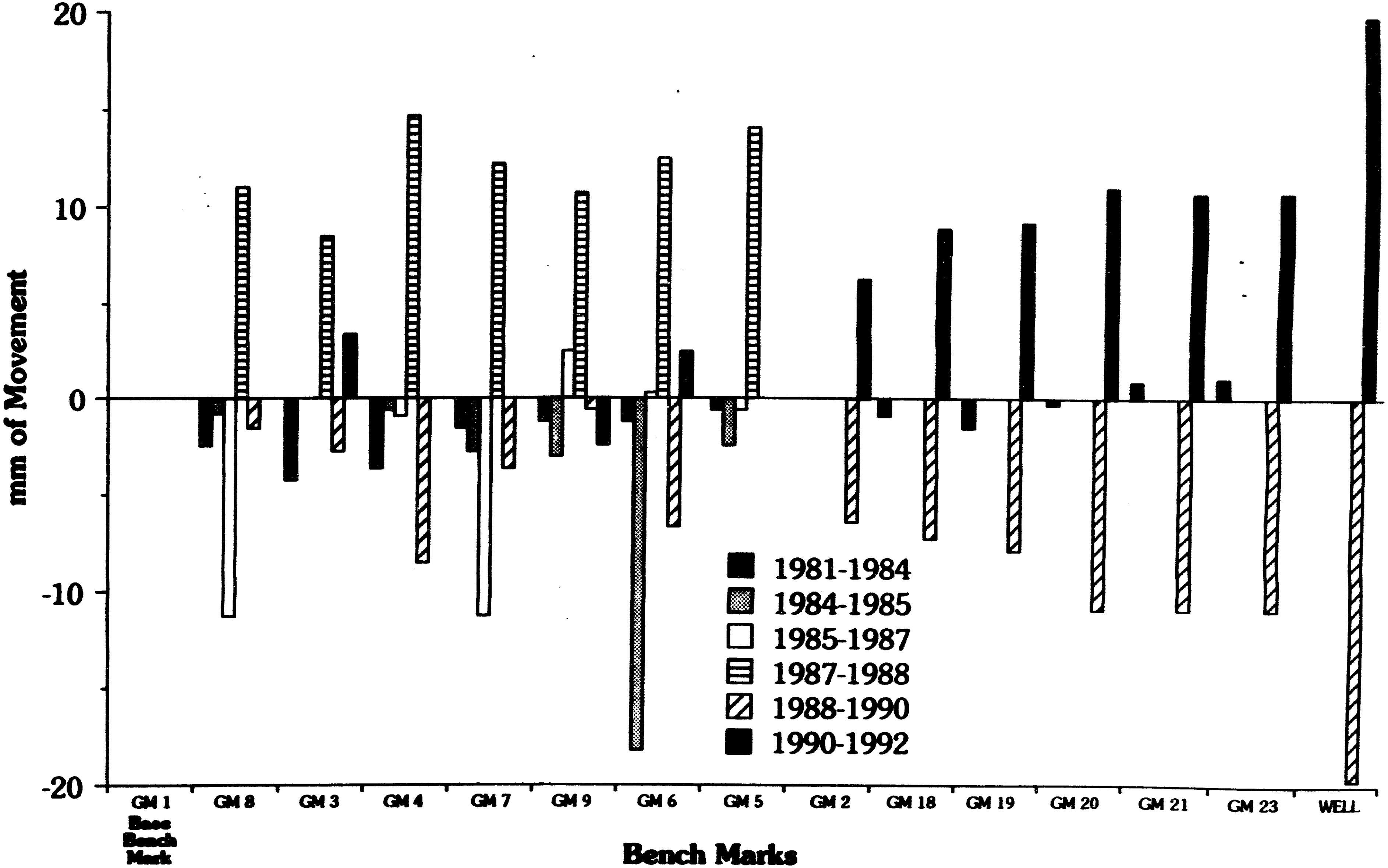

Figure 10. Elevation changes of bench marks for each two-year interval for the duration of the study at the Gladys McCall site relative to GM-1 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. There is no data available for GM-2 in 1984, 1985, and 1987, for GM-4 in 1992, for GM-5 in 1990 and 1992, GM-7 in 1992, GM-18, GM-19, GM-20, GM-21, GM-23 for 1985 and 1987, and the wellhead in 1981, 1985, and 1987.

Table 1. Elevation (in meters) of bench marks and difference in elevation (in mm) in the Gladys McCall area for 1990 and 1992.

Station	Distance (ft)	1990 (m)	1992 (m)	Difference (mm)	Difference (mm\yr)
GM-1*	16,000	2.5972	2.5972	0.0	0.0
GM-2	10,200	1.9285	1.9348	6.3	3.25
GM-3	13,300	1.1195	1.1229	3.4	1.7
GM-4	13,300	1.1723	--	—	—
GM-5	11,400	—	—	—	—
GM-6	11,800	0.9348	0.9373	2.5	1.25
GM-7	12,600	0.5282	—	—	—
GM-8	14,200	0.4072	0.4072	0.0	0.0
GM-9	12,000	0.7602	0.7577	-2.5	-1.25
GM-18	6,600	1.1677	1.1765	8.8	4.4
GM-19	4,100	0.6419	0.651	9.1	4.51
GM-20	275	0.755	0.7659	10.9	5.45
GM-21	250	1.0083	1.0189	10.6	5.3
GM-23	200	0.3828	0.3935	10.7	5.35
Wellhead	0	0.63	0.6498	19.8	9.9

*Held constant

Table 2. Elevation (in meters) of bench marks and difference in elevation (in mm) in the Gladys McCall area for 1981 and 1992.

Station	Distance (ft)	1981 (m)	1992 (m)	Difference (mm)	Difference (mm\yr)
GM-1*	16,000	2.5972	2.5972	0.0	0.0
GM-2	10,200	1.9312	1.9348	3.6	1.8
GM-3	13,300	1.1183	1.1229	4.6	2.3
GM-4	13,300	1.1713	—	—	—
GM-5	11,400	0.8489	—	—	—
GM-6	11,800	0.9482	0.9373	-10.9	-5.45
GM-7	12,600	0.5352	—	—	—
GM-8	14,200	0.4121	0.4072	-4.9	-2.45
GM-9	12,000	0.7519	0.7577	5.8	2.9
GM-18	6,600	1.1738	1.1765	2.7	1.35
GM-19	4,100	0.6483	0.651	2.7	1.35
GM-20	275	0.7617	0.7659	4.2	2.1
GM-21	250	1.0147	1.0189	4.2	2.1
GM-23	200	0.3898	0.3935	3.7	1.85
Wellhead	0	—	0.6498	—	—

* Held constant

Table 3. Elevation differences (in mm) of bench marks in the Gladys McCall area for each releveling from the first year (1981).

Station	81/84 (mm)	81/85 (mm)	81/87 (mm)	81/88 (mm)	81/90 (mm)	81/92 (mm)
GM-1*	0.0	0.0	0.0	0.0	0.0	0.0
GM-2	0.0	—	—	3.7	-2.7	3.6
GM-3	-4.3	-4.3	-4.3	4	1.2	4.6
GM-4	-3.6	-4.2	-5.1	9.5	1	—
GM-5	-0.6	-3.1	-3.7	10.3	—	—
GM-6	-1.2	-19.5	-19.2	-6.7	-13.4	-10.9
GM-7	-1.5	-4.2	-15.5	-3.3	-7	—
GM-8	-2.4	-3.1	-14.3	-3.4	-4.9	-4.9
GM-9	-1.2	-4.2	-1.8	8.9	8.3	5.8
GM-18	-0.9	—	—	1.2	-6.1	2.7
GM-19	-1.5	—	—	1.5	-6.4	2.7
GM-20	-0.3	—	—	4.3	-6.7	4.2
GM-21	0.9	—	—	4.6	-6.4	4.2
GM-23	1	—	—	4	-7	3.7
Wellhead	—	—	—	—	—	—

*Held constant

Table 4. Elevation differences (in mm) of bench marks in the Gladys McCall area for each two-year leveling period.

Station	81/84 (mm)	84/85 (mm)	85/87 (mm)	87/88 (mm)	88/90 (mm)	90/92 (mm)
GM-1*	0.0	0.0	0.0	0.0	0.0	0.0
GM-2	0.0	—	—	—	-6.4	6.3
GM-3	-4.3	0.0	0.0	8.3	-2.8	3.4
GM-4	-3.6	-0.6	-0.9	14.6	-8.5	—
GM-5	-0.6	-2.5	-0.6	14	—	—
GM-6	-1.2	-18.3	0.3	12.5	-6.7	2.5
GM-7	-1.5	-2.7	-11.3	12.2	-3.7	—
GM-8	-2.4	-0.7	-11.2	10.91	-1.5	0.0
GM-9	-1.2	-3.0	2.4	10.7	-0.6	-2.5
GM-18	-0.9	—	—	—	-7.3	8.8
GM-19	-1.5	—	—	—	-7.9	9.1
GM-20	-0.3	—	—	—	-11.0	10.9
GM-21	0.9	—	—	—	-11.0	10.6
GM-23	1	—	—	—	-11.0	10.7
Wellhead	—	—	—	—	-19.8	19.8

* Held constant

Table 5. Elevation (in meters) of bench marks in the Gladys McCall area from 1981 to 1992.

Station	1981 (m)	1984 (m)	1985 (m)	1987 (m)	1988 (m)	1990 (m)	1992 (m)
GM-1*	2.5972	—	—	—	2.5972	2.5972	2.5972
GM-2	1.9312	1.9312	—	—	1.9349	1.9285	1.9348
GM-3	1.1183	1.1140	1.1140	1.1140	1.1223	1.1195	1.1229
GM-4	1.1713	1.1677	1.1671	1.1662	1.1808	1.1723	—
GM-5	0.8489	0.8483	0.8458	0.8452	0.8592	—	—
GM-6	0.9482	0.9470	0.9287	0.9290	0.9415	0.9348	0.9373
GM-7	0.5352	0.5337	0.5310	0.5197	0.5319	0.5282	—
GM-8	0.4121	0.4097	0.4090	0.3978	0.4087	0.4072	0.4072
GM-9	0.7519	0.7507	0.7477	0.7501	0.7608	0.7602	0.7577
GM-18	1.1738	1.1729	—	—	1.175	1.1677	1.1765
GM-19	0.6483	0.6468	—	—	0.6498	0.6419	0.651
GM-20	0.7617	0.7614	—	—	0.766	0.7550	0.7659
GM-21	1.0147	—	—	—	1.0193	1.0083	1.0189
GM-23	0.3898	0.3908	—	—	0.3938	0.3828	0.3935
Wellhead	—	0.6956	—	—	0.6498	0.6300	0.6498

*Held constant

There were no significant correlations between elevation change and distance from the well for the reporting period.

Figure 9 presents the elevation changes for each reporting period with respect to the first year (1981). This figure shows how variable the cumulative elevation change is with each leveling survey. It is assumed that if the area were relatively stable the patterns of elevation change would be similar. During the study period, the fluid withdrawal associated with well testing occurred between 1983 and 1987 did not seem to affect the pattern of elevation change near the well site. For the bench marks furthest from the well, elevation changes seem to be slightly more consistent (either always subsiding or always uplifting) than those around the well where it appears that uplifting occurred during the 1981/1988 and 1981/1992 intervals whereas subsidence occurred in the 1981/1990 interval (table 3).

Over the duration of the project elevation changes were recorded for each two-year period (figure 10, table 4). These data indicate an increase in elevation ranging from 8.8 to 19.8 mm between 1990 and 1992 at bench marks close to the well site. This pattern is completely opposite to what occurred in the previous two-year period. Elevation increases ranging from 2.5 to 3.4 mm occurred further from the well site with only one subsiding bench mark (GM-9). During the 1988 to 1990 period it appears that all bench marks subsided to some degree (from -1 to -19.8 mm) (figure 10, table 4). The bench marks close to the well site generally subsided the most (from -6 to -19.8 mm). Another feature indicated in figure 10 is the apparent uplifting occurring at the bench marks furthest from the well during the 1987 to 1988 period. Data for this period were unavailable for the bench mark closest to the well.

During the last reporting period the surveyors also took gross measurements of the bench marks relative to natural ground because there was a noticeable change from when they were installed. Basically, during installation the bench marks were driven to ground level or slightly below the natural surface. Change in elevation of the bench mark relative to the ground ranged from 0 to -1.35 feet (table 6). This elevation change is indicative of surface subsidence, probably due to compaction of surface sediments. All of the measurements were taken at the bench marks close to the well site. Observations by the surveyors indicated that little change occurred at the bench marks further from the well site (Cox 1993).

Pleasant Bayou

Elevation changes for the 1990–1992 and 1992–1993 reporting periods and for the duration of the study are presented in figures 11–14 and tables 7–13 for the Pleasant Bayou site. The original elevations from each survey are presented in table 13. The surveying team report for 1992 is presented in Appendix B and Appendix C for 1993. The leveling indicates that little or no subsidence has occurred at the benchmarks within 4,000 feet from the well from 1990 to 1992, and in fact a slight uplift is occurring near there. Increases in elevation in the surrounding area ranged from 1.55 to 3.35 mm (table 7, figure 11). The annual change in elevation within the vicinity of the well site ranges from 0.78 to 1.67 mm/yr, except for BRZ-2 where a decrease in elevation of -0.4 has occurred in the last two years. At bench

Table 6. Heights of bench marks with respect to natural ground in the Gladys McCall site in 1992 (heights were zero or less than zero when installed).

Station	Height in 1981 (ft)	Height in 1992 (ft)
GM-1	0.0	—
GM-2	0.0	—
GM-3	0.0	—
GM-4	0.0	—
GM-5	0.0	—
GM-6	0.0	0.0
GM-7	—	—
GM-8	0.0	0.2
GM-9	0.0	0.0
GM-18	0.0	0.0
GM-19	0.0	0.4
GM-20	-0.3	1.05
GM-21	0.0	0.871
GM-23	0.0	0.6
Wellhead		

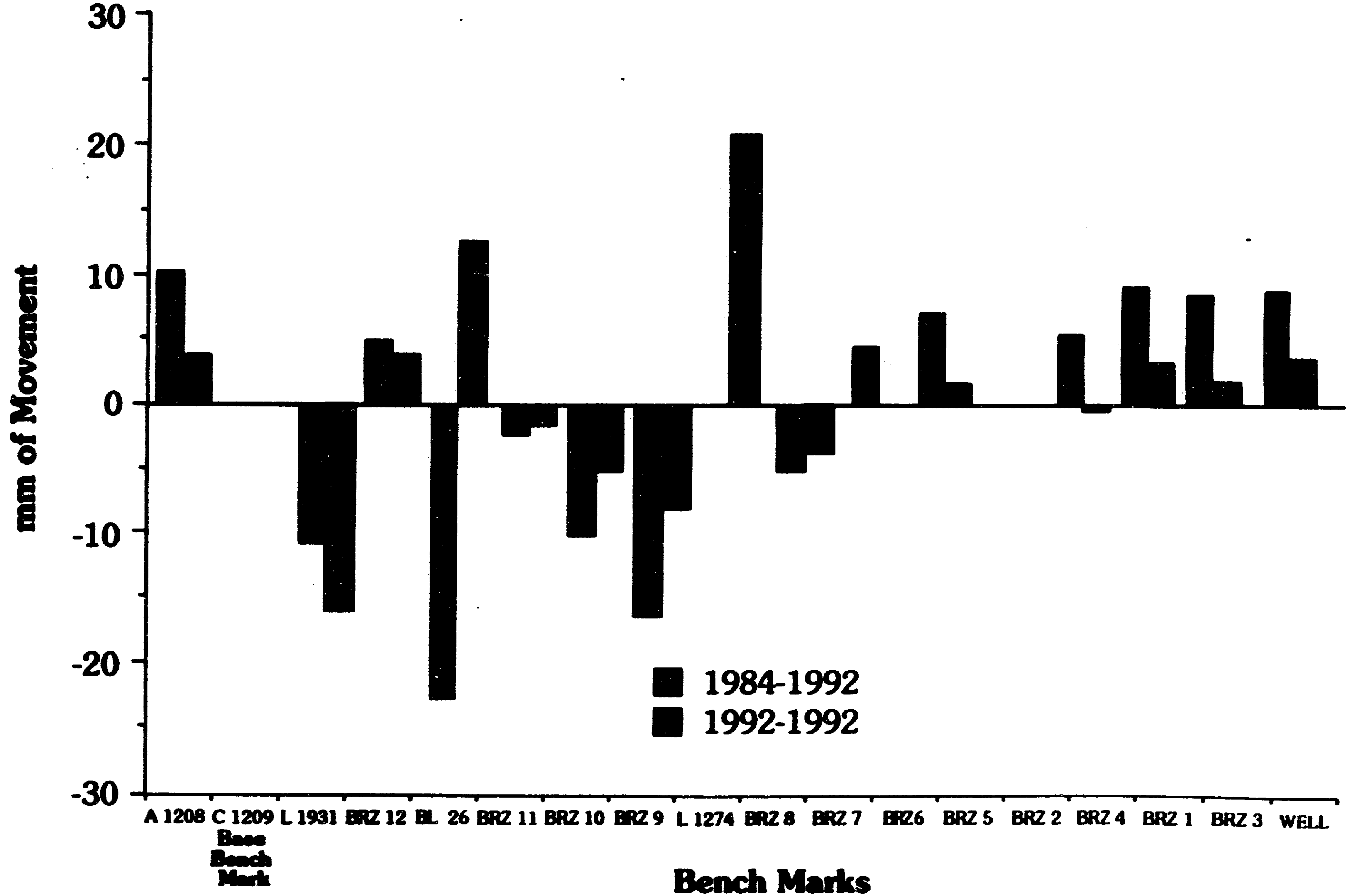

Figure 11. Elevation changes of bench marks for the recent reporting period (1990–1992) and throughout the whole study (1984–1992) at the Pleasant Bayou site relative to C-1209 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. There are no data available for BRZ-5 in 1990 and 1992.

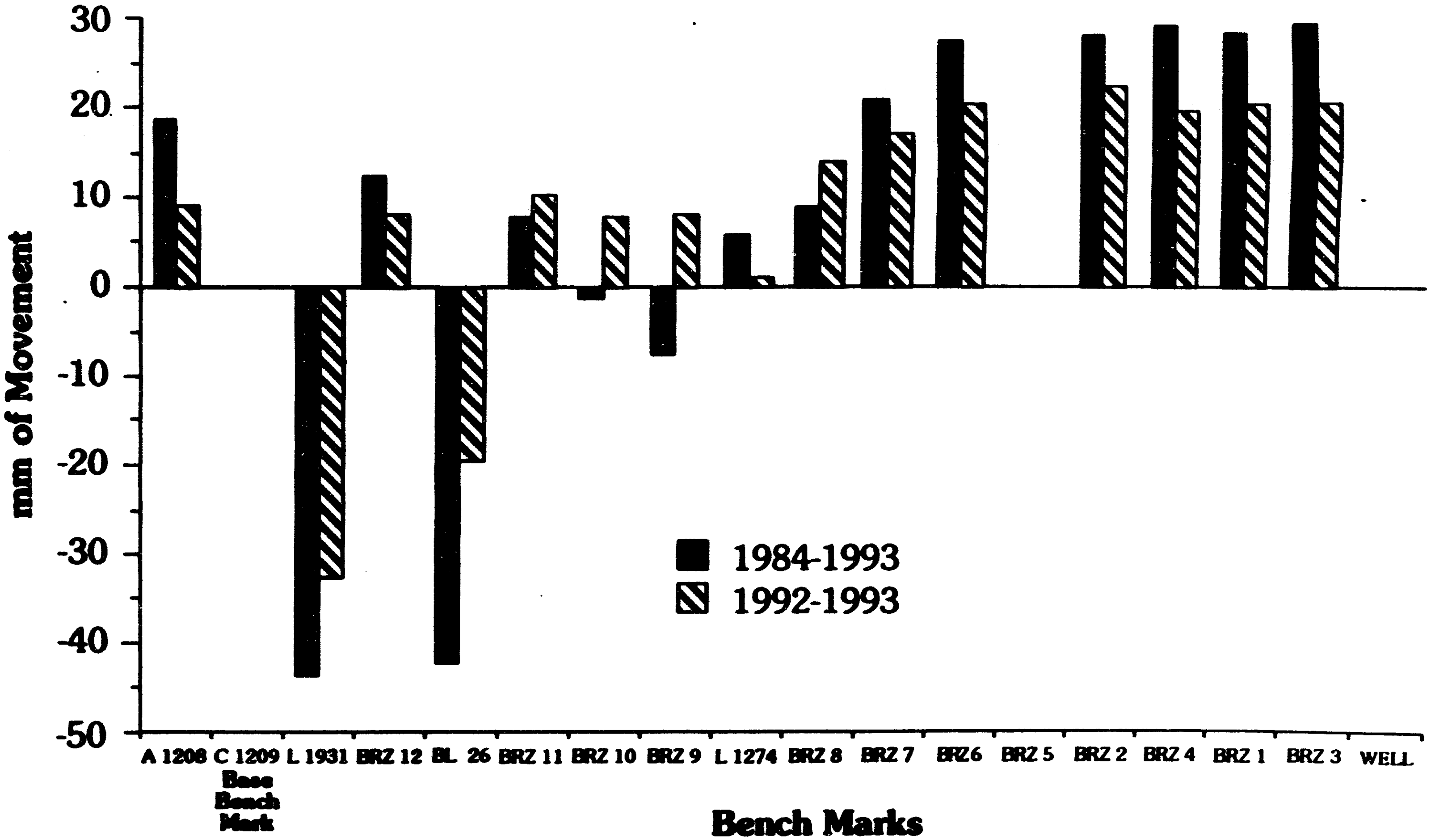

Figure 12. Elevation changes of bench marks for the recent reporting period (1992–1993) and throughout the whole study (1984–1993) at the Pleasant Bayou site relative to C-1209 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. There are no data available for BRZ-5 in 1990 and 1993.

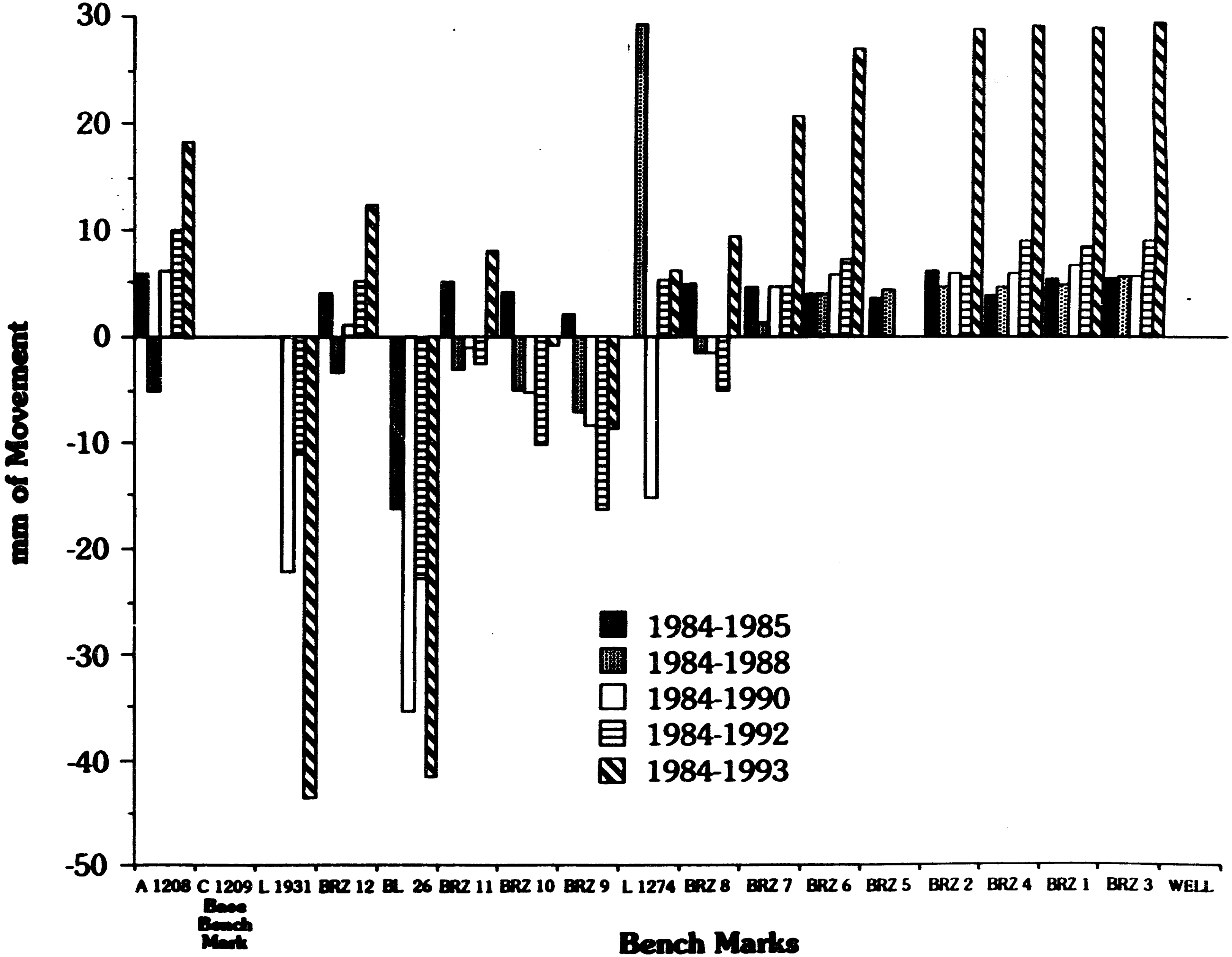

Figure 13. **Elevation changes of bench marks from 1984 for all reporting periods at the Pleasant Bayou site relative to C-1209 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. There are no data available for BRZ-5 in 1990, 1992, and 1993.**

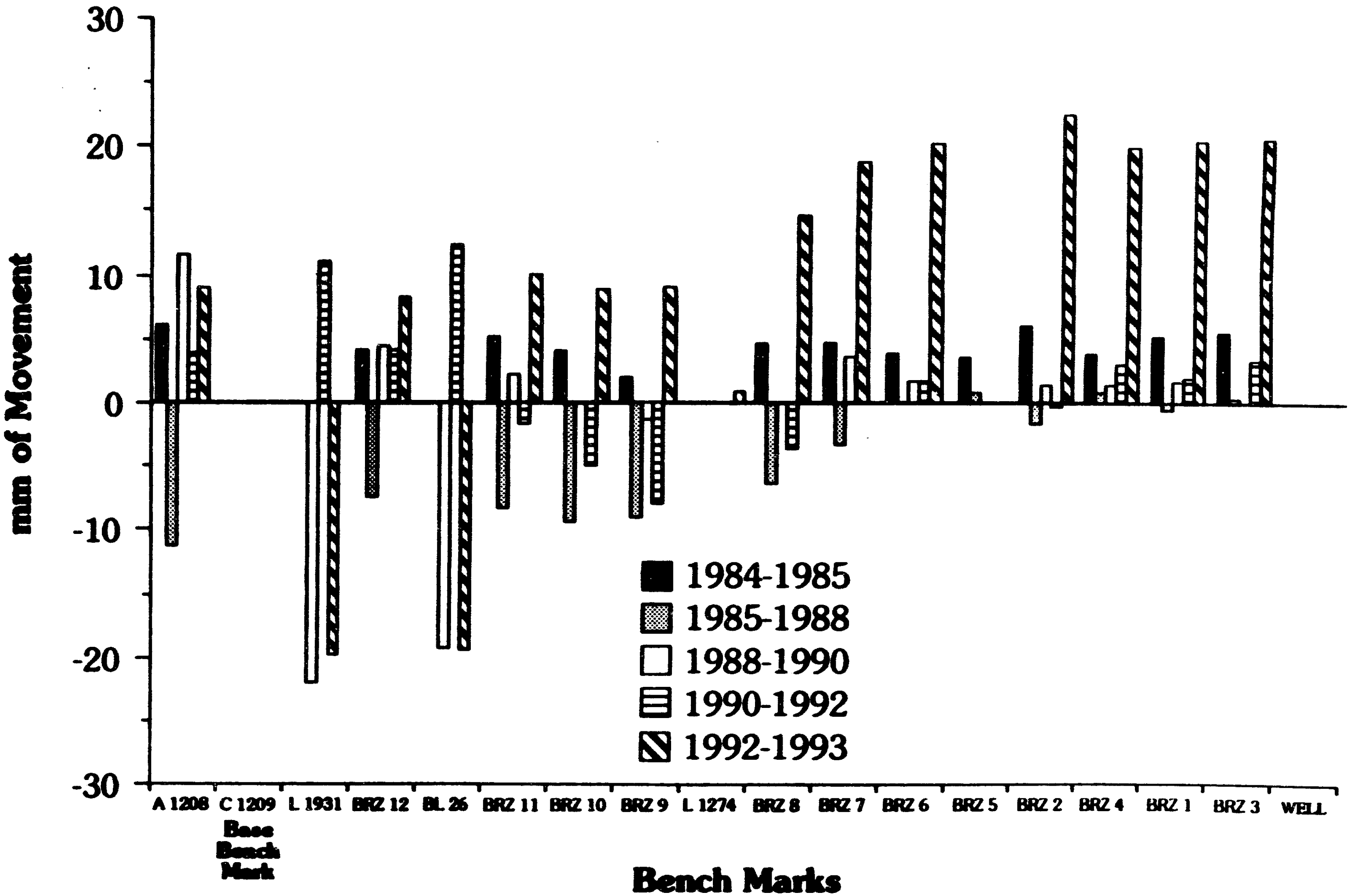

Figure 14. Elevation changes of bench marks for each leveling interval for the duration of the study at the Pleasant Bayou site relative to C-1209 (held constant). The direction of movement is indicated by positive (uplift) and negative (subsidence) values. Bench marks are arranged in decreasing distance from the well. There is no data available for BRZ-5 in 1990, 1992, and 1993 and for L-1274 and L-1931 in 1985.

Table 7. Elevation (in meters) and difference in elevation (in mm) of bench marks in the Pleasant Bayou area for 1990 and 1992.

Station	Distance (ft)	1990 (m)	1992 (m)	Difference (mm)	Difference (mm\yr)
C 1209*	21,360	5.86175	5.86175	0.0	0.0
BL 26	18,000	4.63675	4.64925	12.5	6.25
L 1274	12,240	4.7689	4.7897	20.8	10.4
F 752	3,600	5.37835	5.38025	1.9	0.95
BRZ 1	123	0.9199	0.92185	1.95	0.98
BRZ 2	1,107	2.1905	2.1901	-0.4	-0.2
BRZ 3	8	3.9457	3.94905	3.35	1.67
BRZ 4	828	4.4534	4.45645	3.05	1.53
BRZ 5	600	destroyed	—	—	—
BRZ 6	1,768	4.2884	4.28995	1.55	0.78
BRZ 7	3,360	4.91245	4.91235	-0.1	-0.05
BRZ 8	7,840	5.2175	5.21395	-3.55	-1.78
BRZ 9	12,560	4.91255	4.9046	-7.95	-3.98
BRZ 10	14,480	5.7038	5.69885	-4.95	-2.48
BRZ 11	17,200	6.22895	6.2274	-1.55	-0.78
BRZ 12	19,875	4.96235	4.9664	4.05	2.03
A 1208	22,000	8.44765	8.45145	3.8	1.9
L-1931	21,200	5.6597	5.67075	11.05	5.53
		5.67345	5.65725	-16.2	-8.1

*Held constant

Table 8. Elevation (in meters) and difference in elevation (in mm) of bench marks in the Pleasant Bayou area for 1992 and 1993.

Station	Distance (ft)	1992 (m)	1993 (m)	Difference (mm)	Difference (mm\yr)
C 1209*	21,360	5.86175	5.86175	0.0	0.0
BL 26	18,000	4.64925	4.62960	-19.25	-19.25
L 1274	12,240	4.78970	4.79095	1.25	1.25
F 752	3,600	5.38025	5.37538	-4.87	-4.87
BRZ 1	123	0.92185	0.94220	20.35	20.35
BRZ 2	1,107	2.19010	2.21280	22.70	22.70
BRZ 3	8	3.94905	3.96970	20.65	20.65
BRZ 4	828	4.45645	4.47640	19.95	19.95
BRZ 5	600		—	—	—
BRZ 6	1,768	4.28995	4.31020	20.25	20.25
BRZ 7	3,360	4.91235	4.92958	17.23	17.23
BRZ 8	7,840	5.21395	5.22818	14.23	14.23
BRZ 9	12,560	4.90460	4.91348	8.88	8.88
BRZ 10	14,480	5.69885	5.70766	8.81	8.81
BRZ 11	17,200	6.22740	6.23766	10.26	10.26
BRZ 12	19,875	4.96640	4.97421	7.81	7.81
A 1208	22,000	8.45145	8.46021	8.76	8.76
L-1931	21,200	5.67075	5.63787	-32.88	-32.88
		5.65725	5.64991	-7.34	-7.34

*Held constant

Table 9. Elevation (in meters) and difference in elevation (in mm) of bench marks for the Pleasant Bayou area for 1984 and 1992. For bench mark L-1931, 1988 is the base year.

Station	Distance (ft)	1984 (m)	1992 (m)	Difference (mm)	Difference (mm\yr)
C 1209*	21,360	5.86175	5.86175	0.0	0.0
BL 26	18,000	4.67203	4.64925	-22.78	-2.85
L 1274	12,240	4.78423	4.7897	—	—
F 752	3,600	5.3931	5.38025	-12.85	-1.61
BRZ 1	123	0.91328	0.92185	8.57	1.07
BRZ 2	1,107	2.1845	2.1901	5.6	0.7
BRZ 3	8	3.94013	3.94905	8.92	1.12
BRZ 4	828	4.44738	4.45645	9.07	1.13
BRZ 5	600	4.09438	destroyed	—	—
BRZ 6	1,768	4.28288	4.28995	7.07	0.88
BRZ 7	3,360	4.90775	4.91235	4.6	0.58
BRZ 8	7,840	5.21915	5.21395	-5.2	-0.65
BRZ 9	12,560	4.921	4.9046	-16.4	-2.05
BRZ 10	14,480	5.70915	5.69885	-10.3	-1.29
BRZ 11	17,200	6.22985	6.2274	-2.45	-0.30625
BRZ 12	19,875	4.96135	4.9664	5.05	0.63
A 1208	22,000	8.44137	8.45145	10.08	1.26
L-1931	21,200	5.68175	5.67075	-11.00	-2.75
		5.67538	5.65725	-18.1	-4.53

*Held constant

Table 10. Elevation (in meters) and difference in elevation (in mm) of bench marks for the Pleasant Bayou area for 1984 and 1993. For bench mark L-1931, 1988 is the base year.

Station	Distance (ft)	1984 (m)	1993 (m)	Difference (mm)	Difference (mm\yr)
C 1209*	21,360	5.86175	5.86175	0.0	0.0
BL 26	18,000	4.67203	4.62960	-42.43	-4.71
L 1274	12,240	4.78423	4.79095	6.72	0.75
F 752	3,600	5.39310	5.37538	-17.72	-1.97
BRZ 1	123	0.91328	0.94220	28.92	3.21
BRZ 2	1,107	2.18450	2.21280	28.3	3.14
BRZ 3	8	3.94013	3.96970	29.57	3.29
BRZ 4	828	4.44738	4.47640	29.02	3.22
BRZ 5	600	4.09438	destroyed	—	—
BRZ 6	1,768	4.28288	4.31020	27.32	3.04
BRZ 7	3,360	4.90775	4.92958	21.83	2.43
BRZ 8	7,840	5.21915	5.22818	9.03	1.00
BRZ 9	12,560	4.92100	4.91348	-7.52	-0.84
BRZ 10	14,480	5.70915	5.70766	-1.49	-0.17
BRZ 11	17,200	6.22985	6.23766	7.81	0.87
BRZ 12	19,875	4.96135	4.97421	12.86	1.43
A 1208	22,000	8.44137	8.46021	18.84	2.09
L-1931	21,200	5.68175	5.63787	-43.88	-8.78
		5.67538	5.64991	-25.4	-5.08

*Held constant

Table 11. Elevation differences (in mm) of bench marks in the Pleasant Bayou area for each releveling from the first year (1984). For bench mark L-1931, 1988 is the base year.

Station	84/85	84/88	84/90	84/92	84/93
C 1209*	—	0.0	0.0	0.0	0.0
BL 26	—	-16.08	- 35.28	-22.78	-42.43
L 1274	—	33.54	-15.33	5.47	6.72
F 752	1.58	5.48	-14.75	-12.85	-17.72
BRZ 1	5.32	4.85	6.62	8.57	28.92
BRZ 2	6.18	4.63	6.00	5.60	28.30
BRZ 3	5.37	5.65	5.57	8.92	29.57
BRZ 4	3.77	4.55	6.02	9.07	29.02
BRZ 5	3.47	4.25	—	—	—
BRZ 6	3.87	3.85	5.52	7.07	27.31
BRZ 7	4.58	1.18	4.70	4.60	21.83
BRZ 8	4.81	-1.57	-1.65	-5.20	9.03
BRZ 9	2.01	-7.17	-8.45	-16.00	-7.52
BRZ 10	4.06	-5.22	-5.35	-10.30	-1.49
BRZ 11	5.21	-3.02	-0.90	-2.45	7.81
BRZ 12	4.13	-3.42	1.00	5.05	12.86
A 1208	5.99	-5.21	6.28	10.08	18.81
L-1931	—	—	-22.05	-11.00	-43.88
		—	-1.93	-18.1	25.47

*Held constant

Table 12. Elevation differences (in mm) of bench marks in the Pleasant Bayou area for each leveling period.

Station	84/85 (mm)	85/88 (mm)	88/90 (mm)	90/92 (mm)	92/93 (mm)
C 1209*	—	—	0.0	0.0	0.0
BL 26	—	—	-19.20	12.50	-19.65
L 1274	—	—	—	20.80	1.25
F 752	—	—	-4.78	13.65	-4.87
BRZ 1	5.32	-0.47	1.77	1.95	20.35
BRZ 2	6.18	-1.55	1.37	-0.40	22.70
BRZ 3	5.37	0.28	-0.08	3.35	20.65
BRZ 4	3.77	0.78	1.47	3.05	19.95
BRZ 5	3.47	0.78	—	—	—
BRZ 6	3.87	-0.02	1.67	1.55	20.25
BRZ 7	4.58	-3.4	3.52	-0.10	17.23
BRZ 8	4.81	-6.38	-0.08	-3.55	14.23
BRZ 9	2.01	-9.18	-1.28	-7.95	8.88
BRZ 10	4.06	-9.28	-0.13	-4.95	8.81
BRZ 11	5.21	-8.23	2.12	-1.55	10.26
BRZ 12	4.13	-7.55	4.42	4.05	7.81
A 1208	5.99	-11.2	11.49	3.80	8.76
L-1931	—	—	-1.93	-16.20	-32.88
	—	—	-22.05	11.05	-7.34

*Held constant

Table 13. Elevation (in meters) of bench marks in the Pleasant Bayou area from 1984 to 1993.

Station	1984 (m)	1985 (m)	1988 (m)	1990 (m)	1992 (m)	1993 (m)
C 1209*	5.86175	—	5.86175	5.86175	5.86175	5.86175
BL 26	4.67203	—	4.65595	4.63675	4.64925	4.62960
L 1274	4.78423	—	5.11963	4.76890	4.78970	4.79095
F 752	5.39310	5.39468	5.39858	5.37835	5.38025	5.37538
BRZ 1	0.91328	0.91860	0.91813	0.91990	0.92185	0.94220
BRZ 2	2.18450	2.19068	2.18913	2.19050	2.19010	2.21280
BRZ 3	3.94013	3.94550	3.94578	3.94570	3.94905	3.96970
BRZ 4	4.44738	4.45115	4.45193	4.45340	4.45645	4.47640
BRZ 5	4.09438	4.09785	4.09863	destroyed	—	—
BRZ 6	4.28288	4.28675	4.28673	4.28840	4.28995	4.31020
BRZ 7	4.90775	4.91233	4.90893	4.91245	4.91235	4.92958
BRZ 8	5.21915	5.22396	5.21758	5.21750	5.21395	5.22818
BRZ 9	4.92100	4.92301	4.91383	4.91255	4.90460	4.91348
BRZ 10	5.70915	5.71321	5.70393	5.70380	5.69885	5.70766
BRZ 11	6.22985	6.23506	6.22683	6.22895	6.22740	6.23766
BRZ 12	4.96135	4.96548	4.95793	4.96235	4.96640	4.97421
A 1208	8.44137	8.44736	8.43616	8.44765	8.45145	8.46021
L-1931	5.77430	—	5.68175	5.65970	5.67075	5.63787
L-1931	5.76962	—	5.67538	5.67345	5.65725	5.64991

*Held constant

marks more than 4,000 feet from the well, the results are variable (figure 11) but mostly exhibit a decrease in elevation, especially at L-1931 where subsidence of -16.2 mm in the two-year period occurred. Subsidence at the other bench marks ranged from -0.1 to -7.95 mm. At three bench marks elevation appeared to be rising between 3.8 and 11.05 mm for the two-year period. There was no significant correlation between elevation change and distance from the well.

The 1993 leveling indicates an overall uplift since the 1992 survey. The elevation increase ranged from 7.81 to 22.7 mm, which varies from 1992 when more than half of the bench marks were subsiding. The only recorded subsidence for this period was at three bench marks (table 8). Two of these bench marks (BL26 and L1931) are more than 18,000 feet from the well and the bench marks nearest C1209, which was held constant.

Figure 13 and table 11 present the elevation changes for each reporting period with respect to the first year (1984). This figure shows how variable the cumulative elevation change can be with each leveling survey. For bench marks which are near the well site, beginning with BRZ-7 and ending with the well site on figure 13, elevation change appears to be consistently positive (uplifting). Most bench marks furthest from the well site appear to be subsiding, with the greatest subsidence occurring at L-1931 and BL-26.

Over the duration of the project elevation changes were recorded for each leveling period (figure 14, table 12). These results show a general increase in elevation at bench marks close to the well especially during the 1984 to 1985 period and the 1992 to 1993 period. From 1985 to 1988 a minimal increase in elevation occurred near the well site and some subsidence (< -2 mm) as well. During two periods, 1985 to 1988 and 1988 to 1990, subsidence ranging from -6 to -11 mm occurred further from the well site. An increase in elevation occurred between 1990 to 1992 and 1984 to 1985 at four bench marks.

Hulin

There was no leveling survey conducted for this area during the study period, and no new data are presented for this test well site.

DISCUSSION

Data from previous reports indicate that loading occurs at the sites during site preparation and drilling, and then rebound occurs following completion of the well. Regional subsidence ranges from 1 to 5 mm/yr in Louisiana coastal zone and 4 mm/yr in the Texas coastal area, and little or no increase in subsidence due to fluid withdrawal has been evident (Ramsey 1989, Stevenson 1991). Stevenson also reported a slight uplift at the well site when comparing bench marks close to the site to outlying bench marks. This report shows similar results. Besides fluid withdrawal there are several reasons that could be presented to explain the reported elevation changes in the study area. The changes may be due to instrument error, human error, short- or long-term natural processes, or human-induced effects.

One important long-term aspect of subsidence in the area is the effect of regional crustal subsidence on local subsidence rates. The data on regional crustal subsidence were last reported by Holdahl and Morrison (1974). When comparing regional subsidence rates with the rates of this study, it appears that some local subsidence rates are higher than regional rates. Regional subsidence in the Gladys McCall area is about 1.5 to 3 mm/yr (Holdahl and Morrison 1974), and 4 mm/yr for the Pleasant Bayou site. However, with sea level rise added to regional subsidence, the local rates are only slightly higher than the expected 1 to 3 mm/yr.

For the Gladys McCall site, although elevation changes are variable for each two-year period for the first eight years, there appears to be an overall elevation drop concentrated near the site between 1988 and 1990, followed by a rebound. This is probably not related to testing since the elevation drop occurred after testing was stopped. It could be a localized reaction to an unrelated event. These changes in elevation, ranging from 4 to 10 mm/yr, are small but remain larger than the rate of regional subsidence which is no greater than 5 mm/yr.

The data from the Pleasant Bayou site are difficult to interpret because past reports have indicated uplift in an area where natural subsidence of 1 to 3.5 mm/yr is expected. However, our data have been showing an increase in elevation, or a slight uplift, instead of subsidence near the well site. Vernon F. Meyers addressed this problem and presented some interesting observations concerning the bench marks in this study area in their most recent report. They conclude that due to the rapid subsiding rate of the deep-rod bench mark C-1209, the mark used as a reference point in the surveys, the bench marks surrounding the well site (BRZ-1 through 6) *appear* to have risen about 1 mm/yr since 1984, when in fact they have subsided but at a slower rate. A complete explanation is found in Appendix B.

CONCLUSION

Geopressured-geothermal reservoir sites have been monitored since 1981 at Gladys McCall, and since 1984 at Pleasant Bayou. It is uncertain whether the elevation changes are due to geopressured-geothermal well testing activities, or whether they are a reflection of the local rate of subsidence due to natural processes or other local or human-induced activities. With the present data, it is difficult to extrapolate the reasons for the variables that control the observed elevation changes.

The previous studies have indicated that loading occurs at the sites during site preparation and drilling, and rebound occurs following completion of the well. The present study has demonstrated variable, but small elevation changes. However, there is no conclusive evidence indicating that regional and local subsidence rates have been significantly altered due to fluid withdrawal during geopressured-geothermal well testing.

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HULIN PROSPECT GEOLOGY INCORPORATING DATA FROM THE BRITISH GAS EXPLORATION WELL

by

Chacko J. John

GEOLOGICAL NOTE

As was discussed in detail in an earlier pre-drilling report (John 1991) for the British Gas exploration well, this well was drilled to a total depth of 21,197 ft and is located approximately 4,000 ft. NNE of the DOE/Superior Hulin well (figure 1). Data from this well, obtained through the courtesy of Eaton Operating Company, Houston, included a paleontological analysis (appendix D) velocity survey summary (appendix E), induction-sonic electric log, diameter log, and a paper copy of a seismic line approximately 2 1/4 line mile length (PI-502). As reported in the quarterly report for the last quarter of 1991, this line is similar to line TL-4 (figure 1), which was purchased earlier and used for making the Hulin seismic structure map and hence did not change any interpretations presented in the 1991 report.

Figure 2 shows a stratigraphic comparison of the genetic sand section found in the British Gas well, which is equivalent to that tested in the DOE/Superior Hulin well. The British Gas well section is approximately 250 ft structurally lower than its position in the Hulin well. Though the gross thickness of the main sand section in both the wells is about the same, the top portion of the British Gas well sand is thicker than in the Hulin well and represents the thicker sands towards the central part of the depositing channel. Further, the sand section in the British Gas well appears shalier with better defined shale breaks than that seen in the DOE/Superior Hulin well. However, this may be because of the better resolution obtained through use of improved logging tools in 1991 at the British Gas well, compared to those used in 1978 to log the DOE/Superior Hulin well. Paleontologic data indicate that the age of sand sections in the two wells are of Lower Middle to Lower Miocene based on the occurrence of DISCORBIS BOLIVARENSIS, a characteristic microfossil used for local correlations in this area; in addition, the sands were deposited in the inner neritic paleoenvironment, characteristic of (delta-fringe) shelf environments.

As stated in the 1991 report, regional studies indicate that the geopressured-geothermal sand section tested in the DOE/Superior Hulin well represents dip-elongated canyon sandstone facies. Further, the sand section also could represent an unstable shelf delta wherein the sands were deposited on a subsiding shelf; this would account for the great thickness of the genetic sand section. The DOE/Superior Hulin and the British Gas wells were drilled on the basis of this depositional environmental model. Paleoenvironmental analysis obtained from the British Gas well indicates this model is the more likely depositional environment for the geopressured-geothermal equivalent sand sections seen in the two wells.

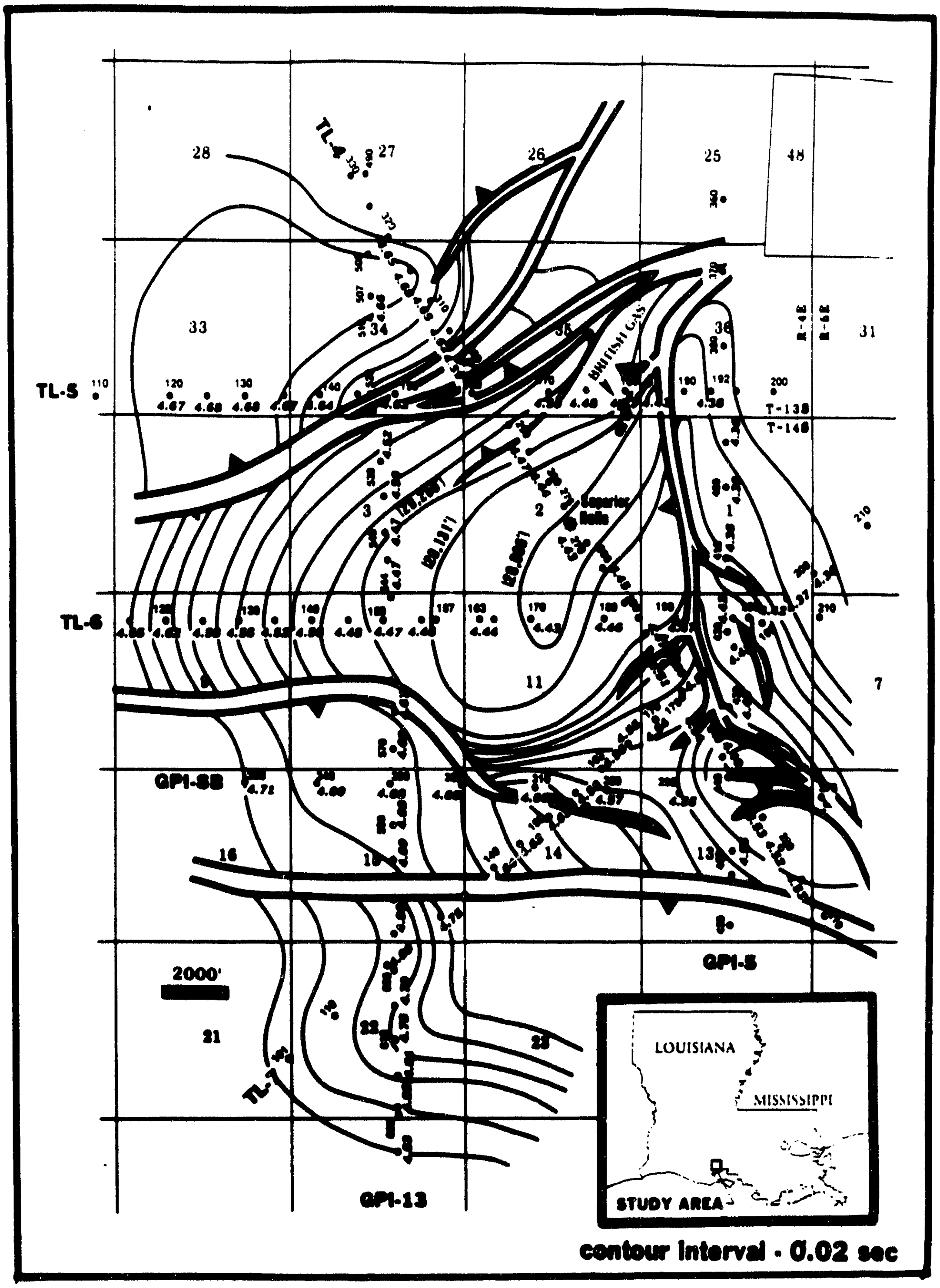


Figure 1. **Seismic structure map of the Hulin prospect contoured at the top of the geopressured geothermal sand section tested in the DOE/Superior Hulin well (modified from map by Don Stevenson [John 1991]). Velocity survey for the Hulin Well is presented in appendix F.**

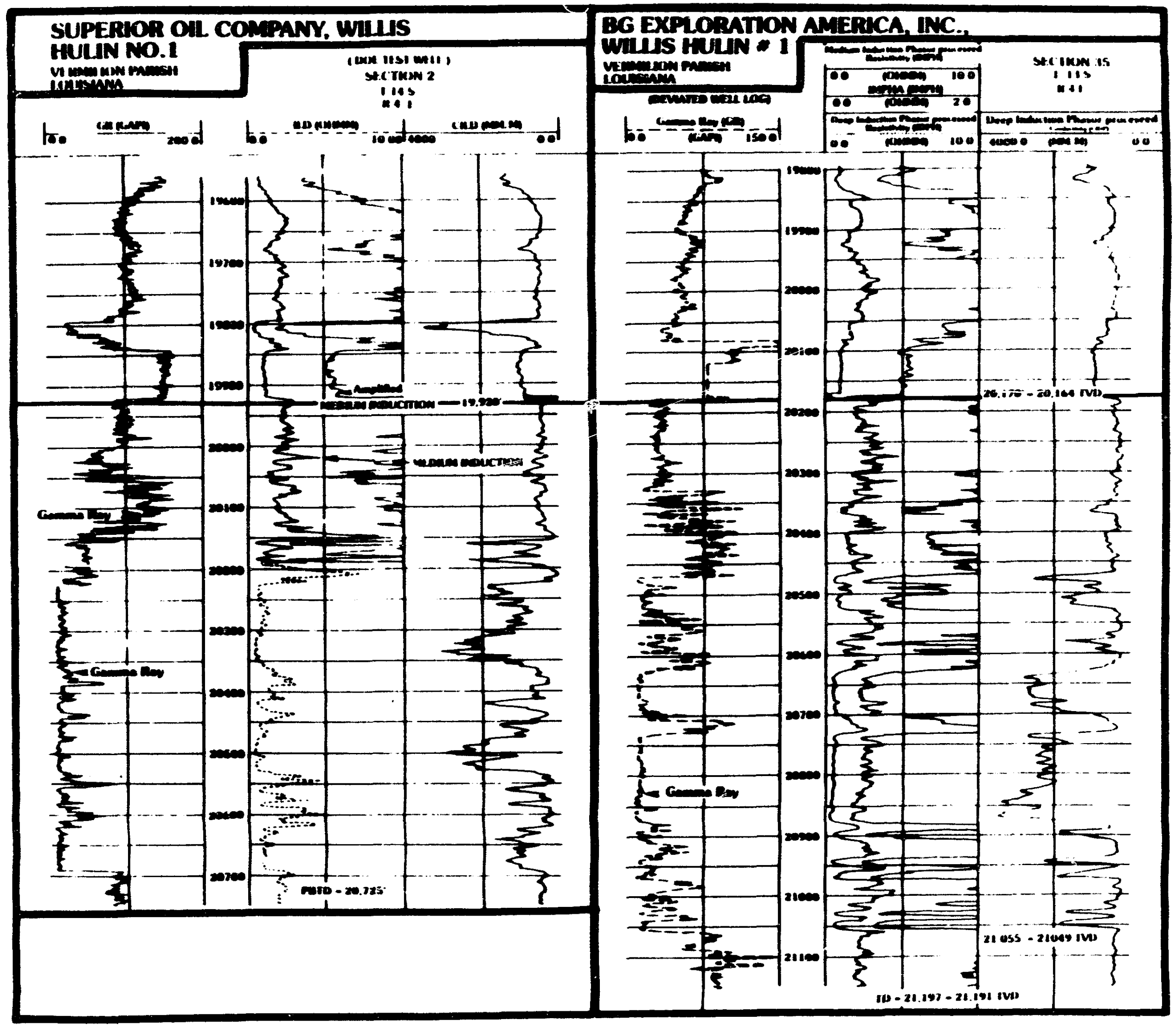


Figure 2. Stratigraphic comparison of electric logs from the DOE geopressured-geothermal test well drilled in 1978 to the British Gas Exploration America, Inc., well drilled in 1991; the GP/GT sand section tested in the DOE test well is shalier, thicker, and structurally lower in the British Gas well.

REFERENCE

John, C. J. 1991. Hulin prospect geology, Pp. 97-115 in Technical Support for geopressured-geothermal Well Activities in Louisiana. Unpublished annual report for the period 1 December 1988 to 31 December 1990. Baton Rouge: Louisiana Geological Survey. 185 p.

APPENDIX A

PREFACE TO

GLADY'S McCALL GEOPRESSURE-GEOTHERMAL TEST WELL SITE

FIRST ORDER RE-LEVELING

The purpose of this survey was to re-level through and establish elevations for existing bench marks along LA Hwy #82, and along the western side of the Rockefeller Wildlife Refuge, and into the well site.

The re-leveling was performed in July 1992, and was accomplished utilizing procedures and equipment identical to that used by the National Geodetic Survey for their First Order Class I Leveling.

The re-leveling began on Bench Mark GM-1 and the elevation established in 1981 was used for this survey. The caps are missing from Bench Marks GM-6 and GM-8. Bench Mark GM-22 was destroyed in 1988. Bench Mark GM-5 was destroyed in 1990. Bench Marks GM-4 and GM-7 were searched for, but not recovered.

Page 1 and page 2 shows the results of the re-leveling. Page 3 is a Location Map which shows the approximate location of all bench marks established in 1981, 1985 and 1987.

Pages 4 through 7 contain the recovery data and description for each bench mark and the elevations established from this re-leveling.

GLADYS McCALL

GEOPRESSURE-GEOTHERMAL TEST WELL SITE

FIRST ORDER LEVELING

feet ↓

STATION TO STATION	PUBLISHED ELEVATION (USCGGS)	DIFFERENCE IN ELEVATION (D.E.) USCGGS D.E.	FORWARD RUN	BACKWARD RUN	MEAN D.E.	LENGTH OF SECTION (KILOMETERS)	ALLOWABLE ERROR IN SECTION	ACTUAL ERROR IN SECTION	ELEVATION FROM THIS LEVELING
GM - 1									8.521
			+1.0792	-1.0835	+1.0813	1.646	0.013	0.004	
S-213	9.580								9.602
		-0.554	-3.2543	+3.2543	-3.2543	1.123	0.010	0.000	
GM - 2									6.348
			+2.6919	-2.6957	+2.6938	0.637	0.008	0.004	
T-213	9.026								9.042
		-3.554	-3.5189	+3.5238	-3.5213	1.451	0.012	0.005	
TT-186	5.472								5.521
		-0.111	-0.1243	+0.1212	-0.1228	1.889	0.013	0.003	
U-213									5.398
			-1.7132	+1.7134	-1.7133	0.864	0.009	0.000	
GM - 3									3.684
			-0.6075	+0.6105	-0.6090	2.912	0.017	0.003	
GM - 6									3.075
			-1.7430	+1.7350	-1.7390	1.900	0.014	0.008	
GM - 8									1.336
			+1.1531	-1.1452	+1.1492	1.572	0.012	0.008	
GM - 9									2.486

* - CLOSURE CRITERIA FOR FIRST ORDER LEVELS
*** - NEW BENCH MARK ESTABLISHED BY THIS SURVEY
ALL DATA SHOWN UNLESS NOTED IS EXPRESSED IN U.S. SURVEY FEET

DATE: JULY, 1992

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, N.C.

GLADYS McCALL

GEOPRESSURE-GEOTHERMAL TEST WELL SITE

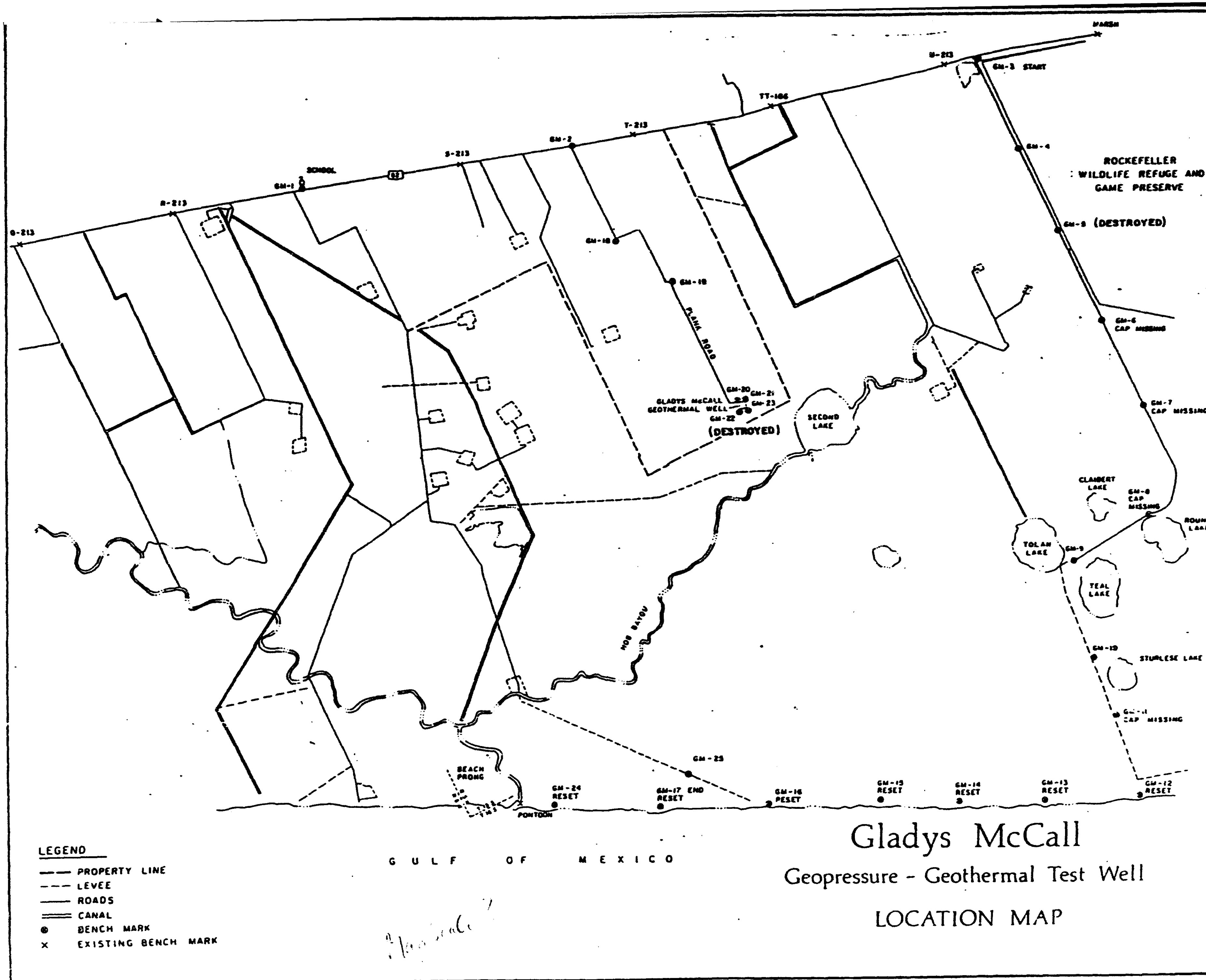
FIRST ORDER LEVELING

STATION TO STATION	PUBLISHED ELEVATION (USC&GS)	DIFFERENCE IN ELEVATION (D.E.) USC&GS D.E.	FORWARD RUN	BACKWARD RUN	MEAN D.E.	LENGTH OF SECTION (KILOMETERS)	ALLOWABLE ERROR IN SECTION	ACTUAL ERROR IN SECTION	ELEVATION FROM THIS LEVELING
GM - 2									6.348
			-2.4867	+2.4890	-2.4879	1.106	0.010	0.002	
GM - 18									3.860
			-1.7260	+1.7229	-1.7245	0.952	0.009	0.003	
GM - 19									2.136
			+0.3801	-0.3747	+0.3774	1.456	0.012	0.005	
GM - 20									2.513
			+0.8307	-0.8300	+0.8304	0.083	0.003	0.0007	
GM - 21									3.343
			-2.0531	+2.0527	-2.0529	0.116	0.003	0.0004	
GM - 23									1.291
			+0.8413	-0.8408	+0.8410	0.080	0.003	0.0005	
WELL HEAD									2.132

* - CLOSURE CRITERIA FOR FIRST ORDER LEVELS
*** - NEW BENCH MARK ESTABLISHED BY THIS SURVEY
ALL DATA SHOWN UNLESS NOTED IS EXPRESSED IN U.S. SURVEY FEET

DATE: JULY, 1992

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, N.C.



Gladys McCall

Geopressure - Geothermal Test Well

LOCATION MAP

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-1 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	8.521	2.5972
November, 1988	8.521	2.5972
July, 1990	8.521	2.5972
July, 1992	8.521	2.5972

DESCRIPTION: Vicinity - Cameron Parish, L.A. #82, in the southeast corner of Section #8, R-5-W, T-15-S.

To reach from the post office in Grand Chenier, go 4.55 miles southeast along L.A. #82 to the Grand Chenier Elementary School, and the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 84', with an aluminum cap stamped LSU BM-GM-1-1981 and set in a 4" PVC pipe 0.3' below ground.

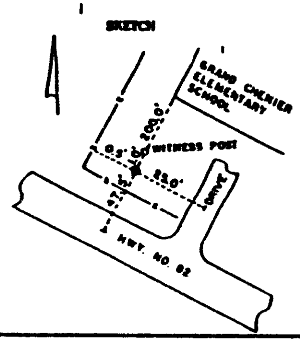
The station is located 16,000'± from the Gladys McCall well site in azimuth 143°.

Recovered November, 1988

Recovered July, 1990

RECOVERED JULY, 1992

SKETCH



SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-2 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	6.336	1.9312
June, 1984	6.336	1.9312
November, 1988	6.348	1.9349
July, 1990	6.327	1.9285
July, 1992	6.348	1.9348

DESCRIPTION: Vicinity - Cameron Parish LA #82, in the northwest center of Section #15, R-5-W, T-15-S.

To reach from the post office in Grand Chenier, go southeast along LA #82 6.3 miles to the entrance to the Gladys McCall Well Site, and the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 72', with an aluminum cap, stamped L.S.U. - BM-GM-2, 1981 and set in a 4" PVC pipe 0.3' below ground.

The station is located 10,200'± from the Gladys McCall Well Site in azimuth 172°.

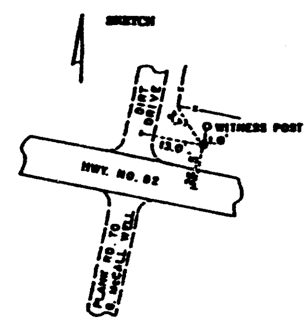
RECOVERED JUNE, 1984

RECOVERED NOVEMBER 1988.

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SKETCH



SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-3 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	3.669	1.1183
June, 1984	3.655	1.1140
December, 1985	3.655	1.1140
June, 1987	3.655	1.1140
November, 1988	3.682	1.1223
July, 1990	3.673	1.1195
July, 1992	3.684	1.1229

DESCRIPTION: Vicinity - Cameron Parish LA #82 The northeast corner of Section #24 R-5-W, T-15-S.

To reach from the post office in Grand Chenier, go southeast along LA #82 11.05 miles to the northwest corner of the Rockefeller Wildlife Refuge, and the station on the right.

The monument is a stainless steel rod driven to refusal, a depth of 76', an aluminum cap stamped L.S.U. BM GM-3-1981, and set in a 4" PVC pipe 0.3' below ground.

The station is located 13,300' ± from the Gladys McCall Well Site in azimuth 239° - 30'.

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985

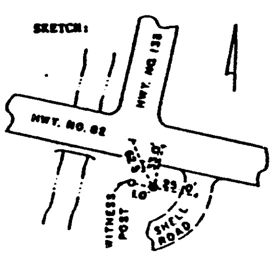
RECOVERED JUNE, 1987

RECOVERED NOVEMBER 1988

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SKETCH:



SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-4 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	3.843	1.1713
June, 1984	3.831	1.1677
December, 1985	3.829	1.1671
June, 1987	3.826	1.1662
November, 1988	3.874	1.1808
July, 1990	3.846	1.1723

DESCRIPTION: Vicinity - Cameron Parish

On the east edge and near the center of Section #24, R-5-W, T-15-S.

To reach from the northwest corner of the Rockefeller Wildlife Refuge, and LA #82, go south along the west boundary road 0.6 miles to the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 76', with an aluminum cap stamped L.S.U. BM, GM-4-1981, and set in a 4" PVC pipe 0.3' below ground.

The station is located 13,300' ± from the Gladys McCall Well Site in azimuth 239° - 30'.

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985

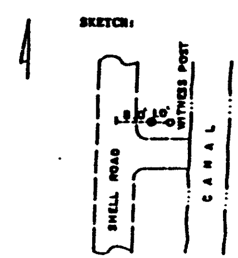
RECOVERED JUNE, 1987

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

DESTROYED JULY, 1992

SKETCH:



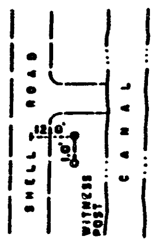
SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-5 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	2.785	0.8489
June, 1984	2.783	0.8483
December, 1985	2.775	0.8458
June, 1987	2.773	0.8452
November, 1988	2.819	0.8592

SKETCH



DESCRIPTION: Vicinity - Cameron Parish

on the east edge and near the north quarter of Section #25, R-5-W, T-15-S.

To reach from the northwest corner of the Rockefeller Wildlife Refuge, and LA #82 go south along the west boundary road 1.3 miles to a turnout, and the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 60', with an aluminum cap stamped L.S.U. BM GM-5, 1981, and set i: a 4" PVC pipe 0.3' belo... ...nd.

The station i: located 11,400' Gladys McCall Well Site in az...

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985

RECOVERED JUNE, 1987

RECOVERED NOVEMBER, 1988

DESTROYED JULY, 1990

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-6 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	3.111	0.9482
June, 1984	3.107	0.9470
December, 1985	3.047	0.9287
June, 1987	3.048	0.9290
November, 1988	3.089	0.9415
July, 1990	3.067	0.9348
July, 1992	3.075	0.9373

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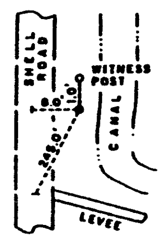


DESCRIPTION: Vicinity - Cameron Parish

On the east edge, and near the southeast corner of Section #25, R-5-W, T-15-S.

To reach from the northwest corner of the Rockefeller Wildlife Refuge, and LA #82, go south along the west boundary road 1.85 miles to the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 80', with an aluminum cap stamped L.S.U. BM, GM-6, 1981, and set in a 4" PVC pipe 0.3' below ground.

The station is located 11,800' ± from the Gladys McCall Well Site in azimuth 283°.

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985
(Cap missing, shot on top of rod)

RECOVERED JUNE, 1987
(Cap missing, shot on top of rod)

RECOVERED NOVEMBER, 1988
(Cap missing, shot on top of rod)

RECOVERED JULY, 1990

RECOVERED JULY, 1992

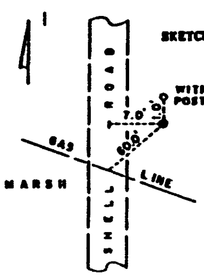
SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-7 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	1.756	0.5352
June, 1984	1.751	0.5337
December, 1985	1.742	0.5310
June, 1987	1.705	0.5197
November, 1988	1.745	0.5319
July, 1990	1.733	0.5282

SKETCH:



DESCRIPTION: Vicinity - Cameron Parish

On the east edge and near the center of Section #36, R-5-W, T-15-S.

To reach from the northwest corner of the Rockefeller Wildlife Refuge, and LA#82, go south along the west boundary road 2.4 miles to the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 88', with an aluminum cap stamped LSU BM-GM-7-1981, and set in a 4" PVC pipe 0.3' below ground.

The station is located 12,600' ± from the Gladys McCall Well Site in azimuth 295° - 30'.

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985

RECOVERED JUNE, 1987
(Cap missing, shot on top of rod)

RECOVERED NOVEMBER, 1988
(Cap missing, shot on top of rod)

RECOVERED JULY, 1990

DESTROYED JULY, 1992

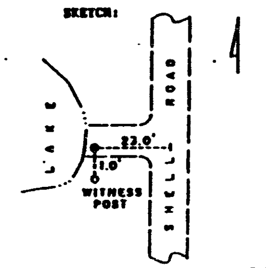
SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-8 DATUM: NGVD 1929

DATE OF SURVEY	ELEVATION FEET	ELEVATION METERS
September, 1981	1.352	0.4121
June, 1984	1.344	0.4097
December, 1985	1.342	0.4090
June, 1987	1.305	0.3978
November, 1988	1.341	0.4087
July, 1990	1.336	0.4072
July, 1992	1.336	0.4072

SKETCH:



DESCRIPTION: Vicinity - Cameron Parish

In the northeast corner of Section 1, R-5-W, T-16-S.

To reach from the northwest corner of the Rockefeller Wildlife Refuge, and LA #82, go south along the west boundary road 3.05 miles to a turn out, and the station on the right.

The monument is a stainless steel rod driven to a depth of 100', with an aluminum cap stamped L.S.U. BM-GM-8-1981, and set in a 4" PVC pipe 0.03' below ground.

The station is located 14,200' ± from the Gladys McCall Well Site, in azimuth 307°.

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985

RECOVERED JUNE, 1987
(cap missing, shot on top of rod)

RECOVERED NOVEMBER, 1988
(cap missing, shot on top of rod)

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-9	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
September, 1981	2.467	0.7519
June, 1984	2.463	0.7507
December, 1985	2.453	0.7477
June, 1987	2.461	0.7501
November, 1988	2.496	0.7608
July, 1990	2.494	0.7602
July, 1992	2.486	0.7577

DESCRIPTION: Vicinity - Cameron Parish

In the northwest corner of Section #1, R-5-W, T-16-S.

To reach from the northwest corner of the Rockefeller Wildlife Refuge, and LA #82 go south and west along the west boundary road 3.95 miles to the end of the road, and th the station on the right.

The monument is a stainless steel rod driven to a depth of 100' with an aluminum cap stamped L.S.U. BM-GM-9-1981, and set in a 4" PVC pipe 0.3' below ground.

The station is located 12,000' ± from the Gladys McCall Well Site, in azimuth 323°.

RECOVERED JUNE, 1984

RECOVERED DECEMBER, 1985

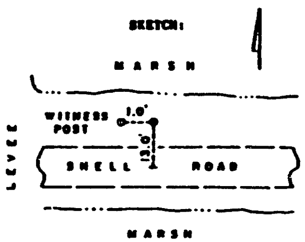
RECOVERED JUNE, 1987

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SKETCH:



SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-18	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
September, 1981	3.851	1.1738
June, 1984	3.848	1.1729
November, 1988	3.855	1.1750
July, 1990	3.831	1.1677
July, 1992	3.860	1.1765

DESCRIPTION: Vicinity - Cameron Parish
Near the north quarter of Section #22, R-5-W, T-15-S.

To reach from the intersection of the plank road to the Gladys McCall Well Site, and LA #82, go south along the plank road 0.65 miles to a 90° turn to the left, and the station on the right.

The monument is a stainless steel rod driven to refusal, a depth of 84', with an aluminum cap stamped L.S.U. BM-GM-18-1981, and set in a 4" PVC pipe projecting 0.5' above ground.

The station is located 6,600'± from the Gladys McCall Well Site in azimuth 165°

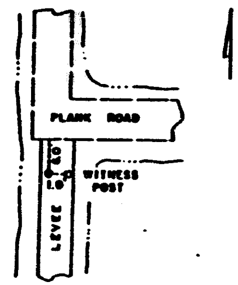
RECOVERED JUNE, 1984

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SKETCH



SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-19	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
September, 1981	2.127	0.6483
June, 1984	2.122	0.6468
November, 1988	2.132	0.6498
July, 1990	2.106	0.6419
July, 1992	2.136	0.6510

DESCRIPTION: Vicinity - Cameron Parish
Near the center of Section #22, R-5-W, T-15-S.

To reach from the intersection of the plank road to the Gladys McCall Well Site, and LA #82, go south along the plank road 1.25 miles to the station on the left.

The monument is a stainless steel rod driven to refusal, a depth of 58', with an aluminum cap stamped L.S.U. BM-GM-19-1981, and set in a 4" PVC pipe flush with the ground.

The station is located 4,100'± from the Gladys McCall Well Site in azimuth 175°.

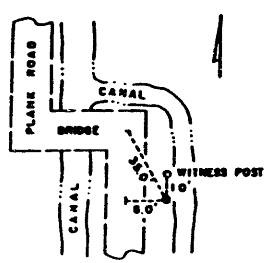
RECOVERED JUNE, 1984

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SKETCH



SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-20	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
September, 1981	2.499	0.7617
June, 1984	2.498	0.7614
November, 1988	2.513	0.7660
July, 1990	2.477	0.7550
July, 1992	2.513	0.7659

DESCRIPTION: Vicinity - Cameron Parish
Near the center of Section #27, R-5-W, T-15-S.

To reach from the intersection of the plank road to the Gladys McCall Well Site, and LA #82, go south along the plank road 2.0 miles to the well site, and the station in the northwest corner of the protection levee around the site.

The monument is a stainless steel rod drive to refusal, a depth of 80', with an aluminum cap stamped L.S.U. BM-GM-20-1981, and set in a 4" PVC pipe, flush with the ground.

The station is located 275'± northwest of the well head.

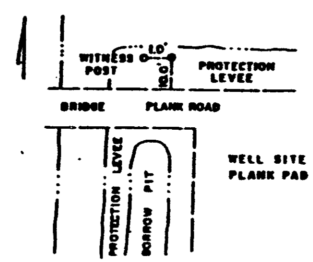
RECOVERED JUNE, 1984

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SKETCH



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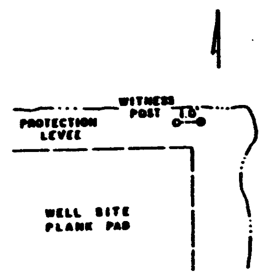
BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-21	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
September, 1981	3.329	1.0147
June, 1984	3.332	1.0156
November, 1988	3.344	1.0193
July, 1990	3.308	1.0083
July, 1992	3.343	1.0189

SKETCH



DESCRIPTION: Vicinity - Cameron Parish
Near the center of Section #27, R-5-W, T-15-S.

To reach from the intersection of the plank road to the Gladys McCall Well Site, and LA #82, go south along the plank road 2.0 miles to the well site, and the station in the northeast corner of the protection levee around the well site.

The monument is a stainless steel rod driven to refusal, a depth of 92', with an aluminum cap stamped L.S.U. BM-GM-21 1981, and set in a 4" PVC pipe flush with the ground.

The station is located 260'± northeast of the well head.

RECOVERED JUNE, 1984

RECOVERED NOVEMBER 1988

RECOVERED JULY, 1990

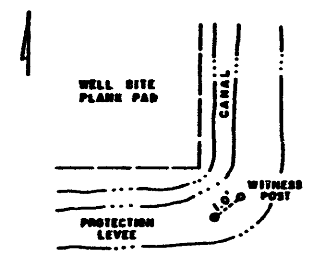
RECOVERED JULY, 1992

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK GM-22	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
September, 1981	1.279	0.3898
June, 1984	1.282	0.3908
November, 1988	1.292	0.3938
July, 1990	1.256	0.3828
July, 1992	1.291	0.3935

SKETCH



DESCRIPTION: Vicinity - Cameron Parish
Near the center of Section #27, R-5-W, T-15-S.

To reach from the intersection of the plank road to the Gladys McCall Well Site, and LA #82, go south 2.0 miles to the well site, and the station in the southeast corner of the protection levee around the well site.

The monument is a stainless steel rod driven to refusal, a depth of 88', with an aluminum cap stamped L.S.U. BM-GM-22-1981, and set in a 4" PVC pipe flush with the ground.

The station is located 200'± southeast of the well head.

RECOVERED JUNE, 1984

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

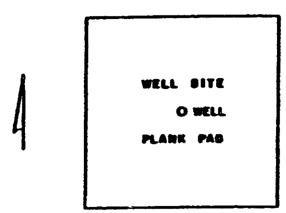
RECOVERED JULY, 1992

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

BENCH MARK DATA
U. S. DEPARTMENT OF ENERGY
GLADYS McCALL
GEOPRESSURE - GEOTHERMAL TEST WELL
CAMERON PARISH, LOUISIANA

BENCH MARK Well Head	DATUM: NGVD 1929	
DATE OF SURVEY	ELEVATION	
	FEET	METERS
June, 1984	2.282	0.6956
November, 1988	2.132	0.6498
July, 1990	2.067	0.6300
July, 1992	2.132	0.6498

SKETCH



DESCRIPTION: Vicinity - Cameron Parish
Near the center of Section #27, R-5-W, T-15-S.

To reach from the intersection of the Plank Road to the Gladys McCall Well Site, and LA #82, go south 2.0 miles to the well site.

Top of bolt on south, southeast side of well head just east of the first valve above ground on south side of well head.

RECOVERED NOVEMBER, 1988

RECOVERED JULY, 1990

RECOVERED JULY, 1992

SURVEY BY
JACK R. RAGLAND, RLS
ASHEBORO, NORTH CAROLINA

APPENDIX B

PLEASANT BAYOU GEOTHERMAL WELL SITE
BRAZORIA COUNTY, TEXAS
SUBSIDENCE MONITORING PROJECT
REPORT

Prepared by: Vernon F. Meyer & Assoc., Inc.
October 12, 1992

Purpose

To conduct the re-leveling of the Pleasant Bayou Well Site as part of an ongoing environmental monitoring program. First Order, Class I leveling is performed to monitor subsidence of previously installed benchmarks established by the National Geodetic Survey (NGS) and Vernon F. Meyer & Associates (VFM) in the area of the Pleasant Bayou geopressured test well.

Methods

Reconnaissance VFM's leveling crew traveled to Alvin, Texas on Tuesday August 18, 1992. Reconnaissance was performed the following day. During the reconnaissance, the NGS level line #105 benchmark L-1274 was found. This benchmark was previously reported as destroyed. Benchmarks E-752 and BRZ-5 were confirmed as being destroyed. The United States Coast & Geodetic Survey (USC&GS) benchmark BL-26 appeared to have been disturbed as the concrete monument was leaning to one side. All other reference benchmarks were recovered in excellent condition.

Equipment The field crew consisted of four men: a recorder, an instrumentman, and two rodmen/pacers. Differences in elevation were observed with a Wild NA2 automatic geodetic level (S/N 437047) fitted with a parallel plate optical micrometer. One set of Kern one-centimeter double scale matched leveling rods were utilized for the leveling task. The double scales aid in detecting "blunders" in observation. Rod readings were observed to the tenth of a millimeter. A Hewlett Packard "HP-97" programmable printing calculator was used to record the observations. The program used by the HP-97 insures that the strict tolerances of first order leveling are met.

Procedures Re-leveling of the project site was performed under the same methods as performed by previous re-leveling surveys. Leveling observations proceeded by running forward and backward between sets of benchmarks. This forward and backward running is termed a "double-run" and constitutes one "section" of a complete level line. Each section must meet a closure tolerance as specified by NGS and is compared to the difference between the forward and backward elevation differences in a section. After all sections have been run and have met section closure specifications, the entire level line or loop is evaluated for closure. Evaluation of the level observations are based upon the average difference in elevation between the forward and backward runs of each section.

Observing procedures are such that systematic errors are kept to a minimum and blunders are detected. Individual backsight and foresight distances are physically measured to insure balanced sight lengths. The principle of balancing sight lengths cancels the effects of earth curvature and atmospheric refraction (air-glass-air) errors and error in collimation of the level (line of sight not perpendicular to the vertical axis of the level). Collimation errors (C-factor) are applied to the imbalance of the backsight-foresight distances upon completion of a level line.

Chronology Leveling observations began August 19, 1992 and continued through September 19, 1992. Due to Hurricane Andrew threatening the Louisiana coast and the leveling crewmen's homes, the field party demobilized to Louisiana August 25, 1992. The leveling party returned to Liverpool, Texas September 16, 1992 and completed all observations September 19, 1992.

The leveling operation commenced from the NGS level line #101 benchmark LIVERPOOL 1931. Level sections were run southwesterly along County Road 171 and included sections to and between benchmarks LIVERPOOL RM 4, LIVERPOOL RM 2 and C-1209. Leveling then proceeded southeasterly along County Road 203 tieing to benchmarks BL-26, L-1274, E-752(Spike 1990), F-752 and crossing Chocolate Bayou to BRZ-1 at the well site. A spur line was made to BRZ-2 and the required double-run was observed (NOAA p. 3-51). A single-run loop was observed around the well site to benchmarks BRZ-1, BRZ-3, BRZ-4, and BRZ-6. Loop closure was determined at BRZ-1. Benchmark BRZ-5 had been destroyed, reportedly by bulldozer activity southeast of the well site. Section running was continued from BRZ-1 east leaving the well site area to BRZ-6, thence northwest along a gravel road to BRZ-7, northeasterly to BRZ-8, and to BRZ-9 at Hwy 2917. From BRZ-9 double-run leveling continued northwesterly along Hwy 2917 and Nolen Road to BRZ-10, BRZ-11, and BRZ-12. From BRZ-12 leveling proceeded northwesterly to the Missouri Pacific Railroad and NGS level line #101, thence continuing southwest along said railroad tracks and level line to benchmark A-1208 on railroad abutment on the north bank of Chocolate Bayou. A final level section tie was made to LIVERPOOL 1931 to complete the main level loop. This section provides a check to the integrity of benchmark C-1209.

Results

19.41 kilometers (12.06 miles) of double-run first order levels and 2.01 kilometers (1.25 miles) of single-run first order levels were observed throughout the project area. All leveling adhered to NGS procedures and specifications for First Order, Class I leveling.

As stated above, a complete loop was run encompassing the project area. Allowable loop closure is determined by the NGS specification of 4.0mm x square root of the distance travelled in kilometers. Closure for the main loop was 0.0135 meters. The allowable error for 21.42 kilometers (19.41km + 2.01km) was 0.0185 meters. The closure for the single-run loop around the well site was 0.0014 meters with an allowable error of 0.0057 meters. All leveling observation closures met NGS specifications.

Elevations of project benchmarks are referenced to the 1979 NGS adjusted elevation of the deep rod mark of C-1209 in Liverpool, Texas. The mark is a first order, class B 5/8 inch copper coated rod driven to gradual refusal at a depth of 20 feet (NGS, p.7) Differences in elevation between the two deep rod marks C-1209 and A-1208 are shown graphically in Figure 1. Theoretically, a smooth line or curve would be an ideal representation of gradual subsidence. However, the years between 1988 and 1992 illustrate a rapid change in the difference in elevation between the two marks. Elevation differences originating from C-1209 to the USC&GS shallow benchmarks on the south side of the main level loop also show rapid movement. Elevation differences between A-1208 and VFM's deep rod marks (BRZ's) on the north side of the main loop model the expected smooth curve. Figure 4 illustrates graphs similar to those in Figure 1, however, now a comparison is made between C-1209 and the deep rod marks on the north side of the main level loop. Again, the graphs depict the rapid movement now associated with the NGS benchmark C-1209. Additionally, a comparison is made between A-1208 and a shallow mark on the south side of the main loop. The graph of A-1208 illustrates its' trademark smooth curve. From this data, we can conclude that C-1209 has moved rapidly between years 1988 and 1992 and since 1984 the overall movement has been downward. Figure 3 represents the subsidence of a shallow USC&GS mark: LIVERPOOL 1931. The mark is a large concrete post set approximately 3-4 feet under ground with 0.5 feet remaining above the ground surface. This form of benchmark is typical of the other shallow marks in the project area. The graph combines elevation differences from both deep marks C-1209 and A-1208. The apparent mirror image and intersection of level observations are due to the direction of travel the leveling line differences represent. The graphs would be nearly identical if the differences flowed from one benchmark to the other. LIVERPOOL 1931 has subsided approximately 13 centimeters since 1984. Figure 4 illustrates the rising of VFM's deep rod marks at the well site with respect to benchmark C-1209. However, if C-1209 is falling, and falling faster than the well site benchmarks, then the well site would appear to be rising. When C-1209 is held fixed, BRZ-1 through 6 are shown to be rising at an average rate of 8mm over eight years or 1mm/year.

Recommendations

Validation of the controlling benchmarks C-1209 and A-1208 needs to be proven. This can be acquired by either of two methods.

1) Additional First Order, Class I spirit leveling to at least three First Order, Class A vertical benchmarks. This would involve leveling several additional kilometers.

2) Use of the Global Positioning System (GPS) technology. GPS would allow the acquisition of more stable vertical control from areas independent of the geological activity local to the geothermal well site. Ellipsoidal heights could be determined to sub-centimeter accuracy with statistical analysis. An error "budget" could be assigned to all benchmarks and this same error tolerance could be met with each subsequent survey. Use of GPS techniques is more cost-effective than traditional spirit leveling.

Conclusion

The August-September 1992 First Order, Class I leveling was completed using the same procedures and specifications as was adhered to in previous surveys since 1984. Sub-centimeter accuracy was achieved during each re-survey. However, the stability of controlling benchmarks is questioned. The resulting survey of 1992 disproves the hypothesis that many of the project benchmarks are falling (sinking) rapidly. The results from the graphs (Figures 1 through 4) illustrate that all marks are now continuing on a smooth curve as expected. Some geologic activity did take place west of Chocolate Bayou effecting benchmark elevations. It is strongly suggested that one of the recommendations stated above be considered in order to more accurately determine subsidence.

REFERENCE DOCUMENTS

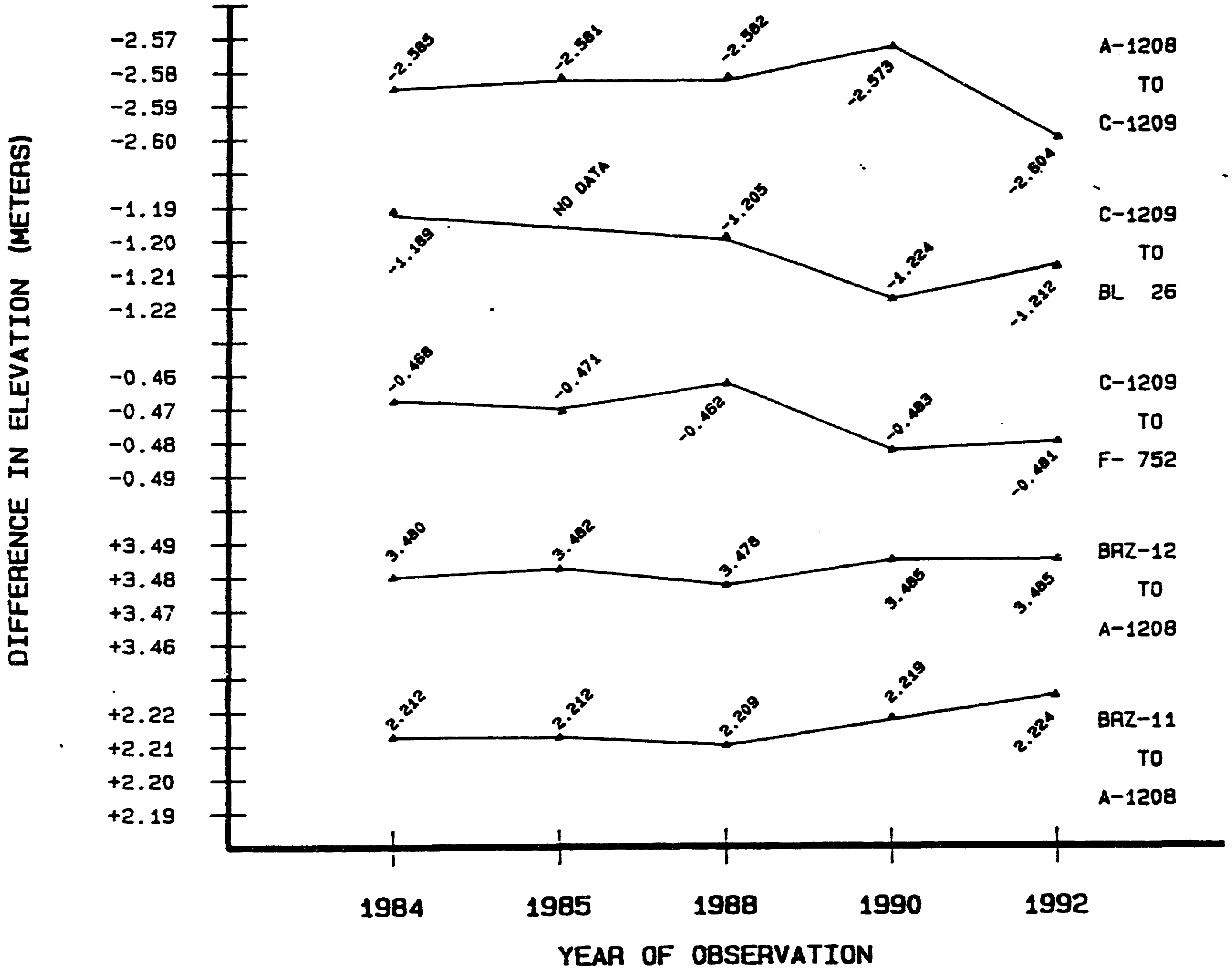
U.S. Department of Commerce, National Geodetic Survey. Vertical Control Data, Quad 290952, Texas, 1973. NOAA, Rockville, Md. 20852.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. NOAA Manual NOS NGS 3, Geodetic Leveling. NOAA, Rockville, Md. 20852.

FIGURE 1

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS

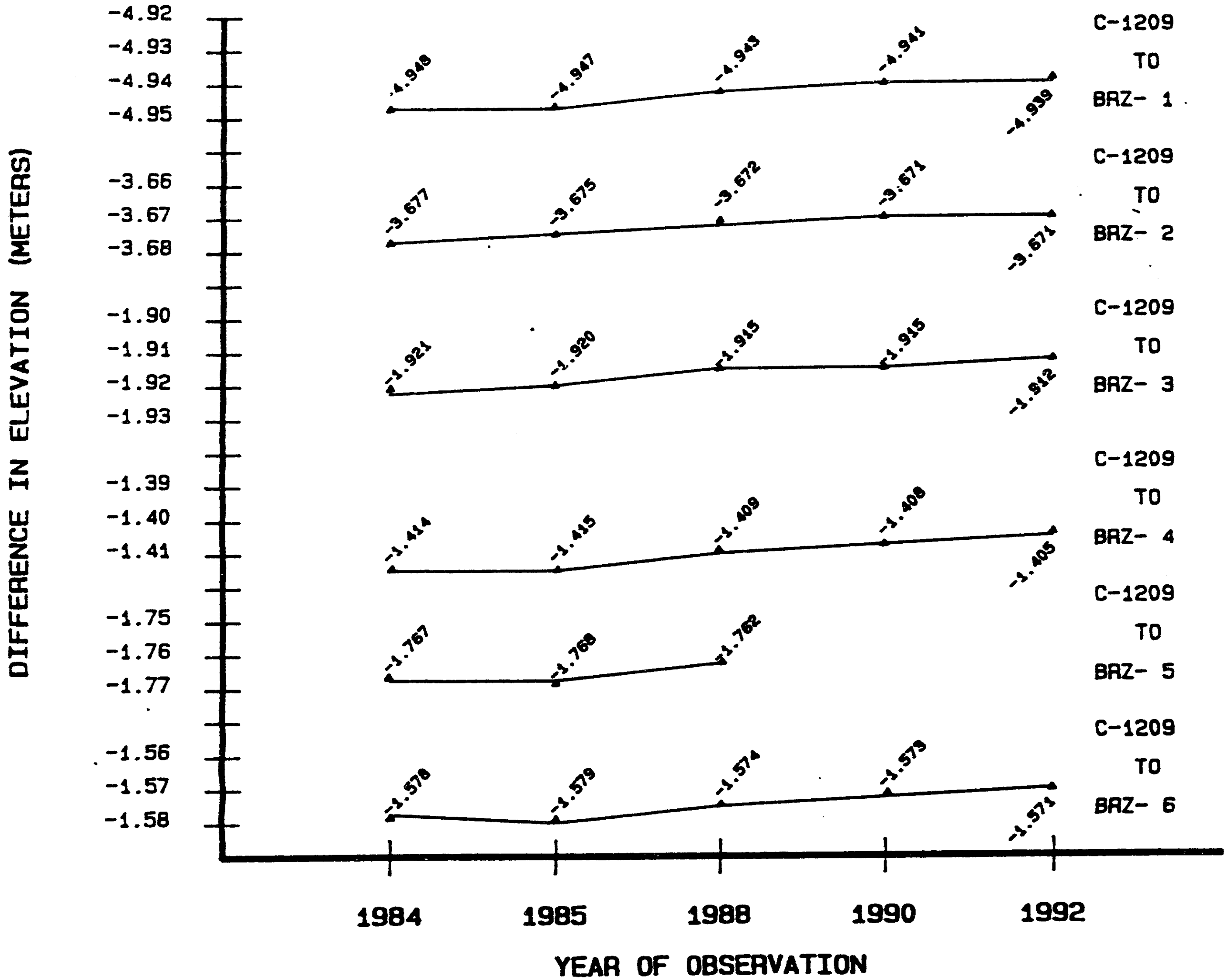
BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS



leveling graph - 23[0.391]PF: GRAPHS 301 02-Oct-92 09:37 AM / LANCE-1

FIGURE 2

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS
BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS

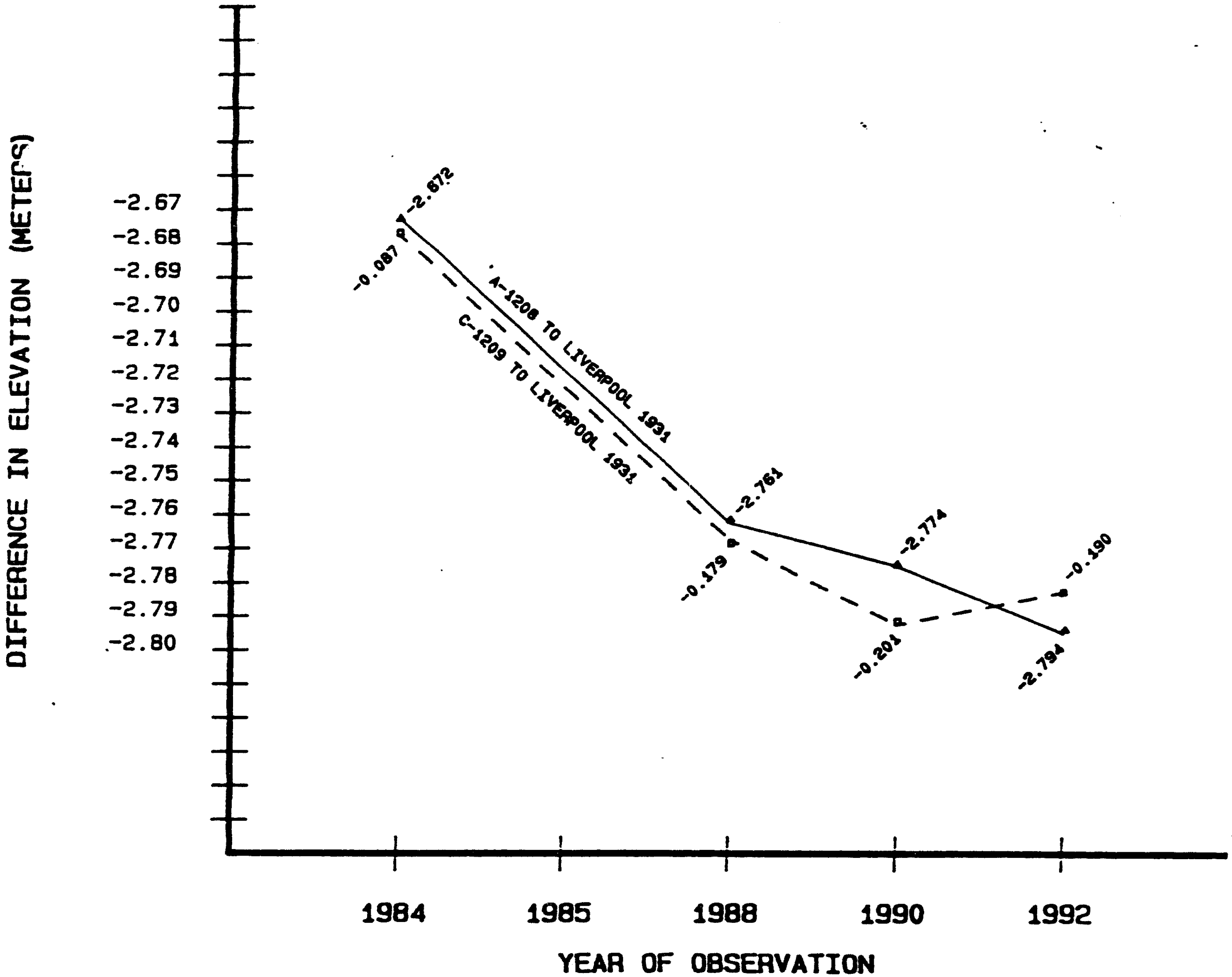


LEVELING GRAPH 2 - 23 [0. 391] PF: GRAPHS 302 01-Oct-92 06: 47 PM / LANCE-1

FIGURE 3

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS

BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS

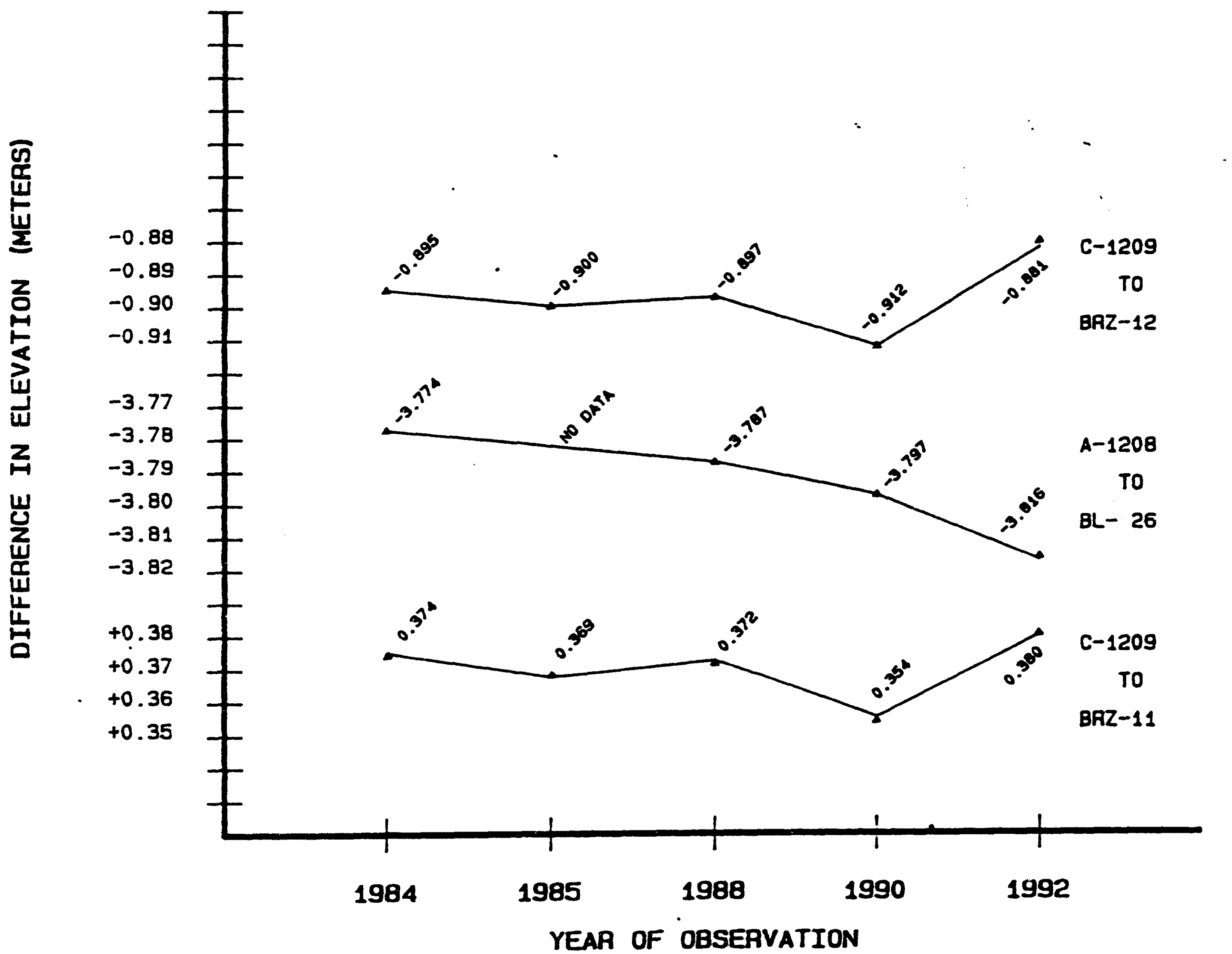


LEVELING GRAPH 3 - 23 [0, 391] PF: GRAPHS 303 02-Oct-92 08:59 AM / LANCE-1

FIGURE 4

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS

BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS



LEVELING GRAPH 4 - 23 [0, 391] PF: GRAPHS 304 02-Oct-92 12:25 PM / LANCE-1

NOAA FORM 76-187 (76)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEODETIC LEVELING FIELD ABSTRACT

SHEET 1 OF SHEETS 3

TITLE

Pleasant Bayou Geothermal Well
Brazoria County, Texas

August - September, 1992

DISTANCE UNITS: KM SM · D/F.E. UNITS: MT FT

			Mo./Day	F/R	DISTANCE Δ/Σ	D	-(B+F) Δ/Σ	D/F.E.
	FROM							
001	TO	Liverpool 1931						5.67075
	FROM	Liverpool 1931	8/22	F	0.04	-0.0021	0.4	-0.00230
			8/22	B	0.03	+0.0025		5.66845
0002	TO	Liverpool RM4			0.04			
	FROM	Liverpool RM4	8/22	F	0.29	+0.3497	1.2	+0.34910
			8/22	B	0.29	-0.3485		5.66845
0003	TO	Liverpool RM2			0.33			
								6.01755
	FROM	Liverpool RM2	8/22	F	0.04	-0.1565	0.1	-0.15655
			8/22	B	0.03	+0.1566		
0004	TO	C-1209 (Held This Survey)			0.37			5.861
	FROM	Loop Check						5.84750
						Error		(0.01350)
	TO					Allowable		0.01851
	FROM	C-1209	8/22	F	1.25	-1.2110	1.5	-1.21175
			8/22	B	1.26	+1.2125		
0005	TO	BL-26			1.62			(4.64925)
	FROM	BL-26	8/22	F	1.75	+0.1419	2.9	+0.14045
			8/22	B	1.75	-0.1390		
0006	TO	L-1274			3.37			4.78970
			8/22	F	1.85	+0.8519	void	
	FROM	L-1274	8/23	B	1.85	-0.8421	0.7	+0.84175
			8/23	F/R	1.85	+0.8414		
0007	TO	E-752 (Spike)			5.22			5.63145
	FROM	E-752 (Spike)	8/23	F	1.47	-0.2490	4.4	-0.25120
			8/23	B	1.46	+0.2534		
0008	TO	F-752			6.69			5.38025
	FROM	F-752	8/23	F	0.56	-4.4574	2.0	-4.45840
			8/23	B	0.55	+4.4594		
0009	TO	BRZ-1			7.25			0.92185

SUPERSEDES NOAA FORM 76-148 (11-72) WHICH IS OBSOLETE AND EXISTING STOCK SHOULD BE DESTROYED UPON RECEIPT OF REVISION.

U.S. Government Printing Office

OAA FORM 76-187 (3-76)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEODETIC LEVELING FIELD ABSTRACT

GZ L

SHEET 2 OF 3 SHEETS

TITLE

Pleasant Bayou Geothermal Well
Brazoria County, Texas

August - September, 1992

DISTANCE UNITS: KM SM — D/F.E. UNITS: MT FT

		No. Day	F/R	DISTANCE Δ/Σ	D	-(B+F) Δ/Σ	D/F.E.
		9/16	F	0.34	+1.2709	void	
FROM	BR Z-1 (SPUR)	9/16	B	0.34	-1.2676	1.3	+1.26825
		9/16	F/R	0.34	+1.2689		
0010 TO	BR Z-2			7.59			(2.19010)
FROM	BRZ-1 (Well Site Loop)	9/16	F	0.34	+3.0272		+3.0272
0011 TO	BRZ-3			7.93			(3.94905)
FROM	BRZ-3	9/16	F	0.27	+0.5074		+0.50740
0012 TO	BRZ-4			8.20			(4.45645)
FROM	BRZ-4	9/16	F	0.72	-0.1665		-0.16650
0014 TO	BRZ-6			8.92			(4.28995)
FROM	BRZ-6	9/16	F	0.68	-3.3659	1.6	-3.3667
		9/16	B	0.68	+3.3675		
0009 TO	BRZ-1			9.60			0.92325
FROM	Well Site Loop Check						0.92185
					Error		(0.00140)
TO					Allowable		0.00567
FROM	BRZ-6	9/16	F	1.11	+0.6203	4.2	+0.62240
		9/16	B	1.10	-0.6245		
0015 TO	BRZ-7			10.71			(4.91235)
FROM	BRZ-7	9/16	F	1.67	+0.2993	4.6	+0.30160
		9/16	B	1.68	-0.3039		
0016 TO	BRZ-8			12.38			5.21395
		9/17	F	1.51	-0.3188	void	
FROM	BRZ-8	9/17	B	1.51	+0.3092	0.3	-0.30935
		9/17	B/R	1.52	-0.3144	void	
0017 TO	BRZ-9	9/19	F/R	1.51	-0.3095		4.90460
				13.89			
FROM	BRZ-9	9/17	F	1.87	+0.7919	4.7	+0.79425
		9/17	B	1.87	-0.7966		
0018 TO	BRZ-10			15.76			5.69885

SUPERSEDES NOAA FORM 76-146 (11-72) WHICH IS OBSOLETE AND EXISTING STOCK SHOULD BE DESTROYED UPON RECEIPT OF REVISION.

U.S. Government Printing Office

A FORM 76-187 U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEODETIC LEVELING FIELD ABSTRACT

SHEET 3 OF SHEETS 3

Pleasant Bayou Geothermal Well
Brazoria County, Texas

August - September, 1992

DISTANCE UNITS: KM SM		D/F.E. UNITS: MT FT	Mo. Day	F/R	DISTANCE Δ/Σ	D	-(B+F) Δ/Σ	D/F.E.
	-30- FROM	BRZ - 10	9/18	F	1.69	+0.5281	0.9	+0.52855
			9/18	B	1.71	-0.5290		
19	TO	BRZ - 11			17.45			6.22740
	-30- FROM	BRZ - 11	9/18	F	1.64	-1.2596	2.8	-1.26100
			9/18	B	1.65	+1.2624		
20	TO	BRZ - 12			19.09			4.9664
	-30- FROM	BRZ - 12	9/18	F	0.87	+3.4857	1.3	+3.48505
			9/18	B	0.87	-3.4844		
021	TO	A- 12 08			19.96			8.45145
	-30- FROM	A - 12 08	9/18	F	1.46	-2.7943	0.2	-2.79420
			9/18	B	1.47	+2.7941		
01	TO	Liverpool 1931			21.42			5.65725

SUPERSEDES NOAA FORM 76-186 (11-72) WHICH IS OBSOLETE AND EXISTING STOCK SHOULD BE DESTROYED UPON RECEIPT OF REVISION.

U.S. Government Printing Office: 1977 - 765-009/111

Revised Benchmark Descriptions (1992)

BRZ-1 (Well Area)
Located northwest of Pleasant Bayou test wells, at dead-end of east-west gravel road north of well area; 123 feet northwest of the Northwest corner of fence enclosing well site; 158 feet west of a 6 foot steel pipe with elbow joint on top (2 feet above ground surface); 97 feet west-southwest of Northeast portion of freshwater pond; 42 feet southeast of East bank of said pond.

Mark is a stainless steel rod with bullet tip driven 52 feet to refusal encased by a 6 inch PVC pipe (cap missing).

BRZ-2 (Well Area)
Located north of Pleasant Bayou test wells; approximately 0.30 Km (984.2 feet) north-northeast of benchmark BRZ-1; 125 feet east of top bank of Chocolate Bayou 14 feet northwest of cleared pasture; 10 feet east of the remains of a 8 inch Tallow tree; 100 feet southwest of a cluster of three Live Oak trees.

Mark is a stainless steel rod with bullet tip driven 52 feet to refusal encased by a 6 inch PVC pipe with cap. Painted orange.

BRZ-3 (Well Area)
Located south of Pleasant Bayou test wells along fence; approximately 0.32 Km (1049.9 feet) southeast of benchmark BRZ-1; 8.0 feet south of the east-west fence along the south boundary of test well site; located approximately at the midpoint of the southern boundary fence.

Mark is a stainless steel rod with bullet tip driven 24 feet to refusal encased by a 6 inch PVC pipe with cap. Painted orange.

BRZ-4 (Well Area)
Located south of the Pleasant Bayou test wells; approximately 0.25 Km (820.2 feet) south of benchmark BRZ-3; 9.0 feet north of lone 6 inch twin trunk Tallow tree in pasture; 337 feet west-southwest of Houston Gas Pipeline vent in pasture; 297 feet west of centerline of pipeline.

Mark is a stainless steel rod with bullet tip driven 24 feet to refusal encased by a 6 inch PVC pipe (cap missing).

BRZ-5 (Well Area)
Mark destroyed by bulldozer before 1990.

BRZ-6 (Well Area)
Located east of Pleasant Bayou test wells and near the southwest end of the north-south airstrip and in the southwest quadrant of the intersection of gravel road leading to well area and the

BRZ-6 (con't)
gravel road parallel with airstrip; 23 feet west of the centerline of north-south gravel road; 52.5 feet west of north-south fenceline; 46 feet south of centerline of gravel road to well site; 3.5 feet north of power pole #11900; 144 feet southwest of center of metal cattlegap.

Mark is a stainless steel rod with bullet tip driven 56 feet to refusal encased by a 6 inch PVC pipe with cap. Painted orange.

BRZ-7
Located 3/4 mile north of Pleasant Bayou test wells at northwest corner of airstrip and gravel roads; 68 feet northwest of center of gravel road intersection; 23 feet west of centerline of north-south gravel road; 45.2 feet east of power pole with transformer; 6 feet southeast of power pole #11550.

Mark is a stainless steel rod with bullet tip driven 44 feet to refusal encased by a 6 inch PVC pipe (cap broken).

BRZ-8
Located along gravel road to well site; 1.45 Km from intersection of gravel road to well site and HWY 2917; 4.8 feet northwest of Northwest corner cattlegap; 14.5 feet west of centerline of north-south gravel road; 3.8 feet north of Northwest fence corner; 27.8 feet west of East fence corner.

Mark is a stainless steel rod with aluminum cap driven 40 feet to refusal encased by a 6 inch PVC pipe (cap missing).

BRZ-9
Located at the intersection of gravel road leading to well site and HWY 2917; at entrance to Pleasant Bayou well site; 29.5 feet west of centerline of north-south gravel road; 29.8 feet southwest of Southwest corner of cattlegap; 36.2 feet south of south right-of-way fence of HWY 2917; 94 feet south of centerline HWY 2917; 6.5 feet south of power pole.

Mark is a stainless steel rod with bullet tip driven 52 feet to refusal encased by a 6 inch PVC pipe with cap.

BRZ-10
Located 0.5 miles west of intersection of Nolen Road and HWY 2917 at corner of Nolen Road and County Road #200; 41.5 feet east of centerline C.R.200; 31.3 feet north of centerline of Nolen Road; 25.3 feet northeast of stop sign; 61.5 feet north-northeast of power pole with stub; 40.5 feet southeast of C.R.200 sign.

Mark is a stainless steel rod with bullet tip driven 80 feet to refusal encased by a 6 inch PVC pipe (cap missing).

BRZ-11
Located 1.5 miles west of the intersection of Nolen Road and HWY 2917; on northeast shoulder of Nolen Road at intersection with dirt trail; 28.5 feet southwest of fence corner; 38.5 feet north of centerline of Nolen Road; 39.5 feet northwest of centerline of dirt trail; 82 feet northwest of power pole; 5.5 feet south of old fence line.

Mark is a stainless steel rod with aluminum cap driven 40 feet to refusal encased in a 6 inch PVC pipe.

BRZ-12
Located 1.2 northeast of Liverpool, Texas; at intersection of Nolen Road and northeast-southwest asphalt highway; 33 feet north of centerline of said highway; 20 feet west of centerline of Nolen Road; 7 feet north of power pole.

Mark is a stainless steel rod with bullet tip driven 80 feet to refusal encased by a 6 inch PVC pipe with cap.

APPENDIX C

PLEASANT BAYOU GEOTHERMAL WELL SITE
BRAZORIA COUNTY, TEXAS
SUBSIDENCE MONITORING PROJECT
REPORT

Prepared by: Vernon F. Meyer & Assoc., Inc.
November 7, 1993

Purpose

To conduct First Order, Class I differential leveling in the vicinity of Pleasant Bayou geothermal well sites. Differential elevations were determined for use in a comparison study of similar surveys in past years.

Methods

Reconnaissance Vernon F. Meyer and Associates (VFM) leveling crew personnel traveled to Alvin, TX September 30, 1993. Bench mark recovery was conducted on the same day. All benchmarks used in the survey were recovered in good condition.

Personnel and Equipment The field crew was comprised of five members: a recorder, an instrument man, two rodmen and a pacer. A WILD NA2 automatic level (S/N 437047) fitted with a parallel plate optical micrometer was used for all observations. The level rods used were a set of KERN one-centimeter double-scale matched rods with attached leveling bubbles and bipod legs. This instrumentation configuration allowed rod readings to be made to the tenth of a millimeter.

A CMT PC-5 handheld computer with the National Geodetic Survey (NGS) leveling program, "VERTPGM", was used in the field to record all observations. This software program acts as a quality control factor by ensuring that observations and procedures fall within the criteria specific to the desired order of accuracy.

Procedures The field procedures employed were the same as previous surveys performed by VFM. More specifically, a collimation error value was determined each morning before leveling operations began. This value was subsequently accounted for by the NGS software. Leveling observations were recorded by observing "forward" and "backward" differential elevations between two benchmarks, thus completing a "double-run" of particular sections. All backsight and foresight distances were physically measured to ensure balanced site lengths. Before a section was deemed satisfactory, forward and backward differential elevation misclosures were evaluated by the NGS software to ensure that all parameters were within acceptable tolerances.

Chronology

Leveling observations began October 1, 1993 and concluded on October 7, 1993. Commencing at NGS level line # 101, benchmark Liverpool 1931, double-run level sections were run along county road 171. Sections were run to benchmarks Liverpool RM 4, Liverpool RM 2, and C-1209. The leveling crew then proceeded southeasterly along county road 203 to tie into benchmarks BL-26, L-1274, TBM E 752 (Spike 1990), F-752 and across Chocolate Bayou to BRZ-1 at the well site. A spur line was double-run to benchmark BRZ-2. A single-run loop was then begun from benchmark BRZ-1 and touching on benchmarks BRZ-3, BRZ-4, BRZ-6 and closing back on BRZ-1. Double-run sections were then run from BRZ-1 east to BRZ-6 then northwesterly along a gravel road to BRZ-7, northeasterly to BRZ-8 and then to BRZ-9 at the intersection of Highway 2917 and the gravel road. From BRZ-9, double-run leveling continued northwesterly along Highway 2917 and Nolen Road to benchmarks BRZ-10, BRZ-11 and BRZ-12. The run then continued northwesterly to the Missouri-Pacific Railroad heading southwesterly along the railroad tracks to benchmark A-1208. A final double-run level line was then made back to Liverpool 1931, completing the level loop.

Results

19.9 kilometers (12.4 miles) of double-run First Order levels and 2.0 kilometers (1.2 miles) of single-run First Order levels were run throughout the project area. NGS procedures and specifications for First Order Class I leveling were enforced throughout the leveling operations. Allowable loop misclosure was determined using NGS specifications of 4.00 millimeters times the square root of the distance travelled (in kilometers). The misclosure for the main loop was 0.0120 meters. The allowable misclosure was 0.0178 meters. The misclosure for the single-run loop around the well site was 0.0014 meters with an allowable misclosure of 0.0056 meters. All misclosures were within NGS tolerances.

Elevations of all project benchmarks are referenced to the 1979 adjusted elevation (5.861 m) of C-1209, a deep rod benchmark in Liverpool, Texas. The mark is a First Order, Class B benchmark (NGS, p.7). Pleasant Bayou Geothermal Well Site benchmarks, as determined by Vernon F. Meyer and Associates during the month of October, 1993 are listed in Table 1. Figures 1 through 4 present a graphic representation of benchmark elevations as determined by VFM since 1984. The geodetic leveling field abstract, NOAA FORM 76-187 is enclosed for review.

SITE	ELEV (m)	SITE	ELEV (m)
A 1208	8.460	BL 26	4.630
BRZ-1	0.942	BRZ-2	2.213
BRZ-3	3.970	BRZ-4	4.476
BRZ-6	4.310	BRZ-7	4.930
BRZ-8	5.228	BRZ-9	4.913
BRZ-10	5.708	BRZ-11	6.238
BRZ-12	4.974	F 752	5.375
L 1274	4.791	LIVERPOOL RM 2	6.017
LIVERPOOL RM 4	5.641	LIVERPOOL 1931	5.638
TBM E 752	5.630		

TABLE 1: 1993 PROJECT ELEVATIONS (m)

REFERENCE DOCUMENTS:

U.S. Department of Commerce, National Geodetic Survey. Vertical Control Data, Quad 290952, Texas, 1973. NOAA, Rockville, Md. 20852.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. NOAA Manual NOS NGS 3, Geodetic Leveling. NOAA, Rockville, Md. 20852.

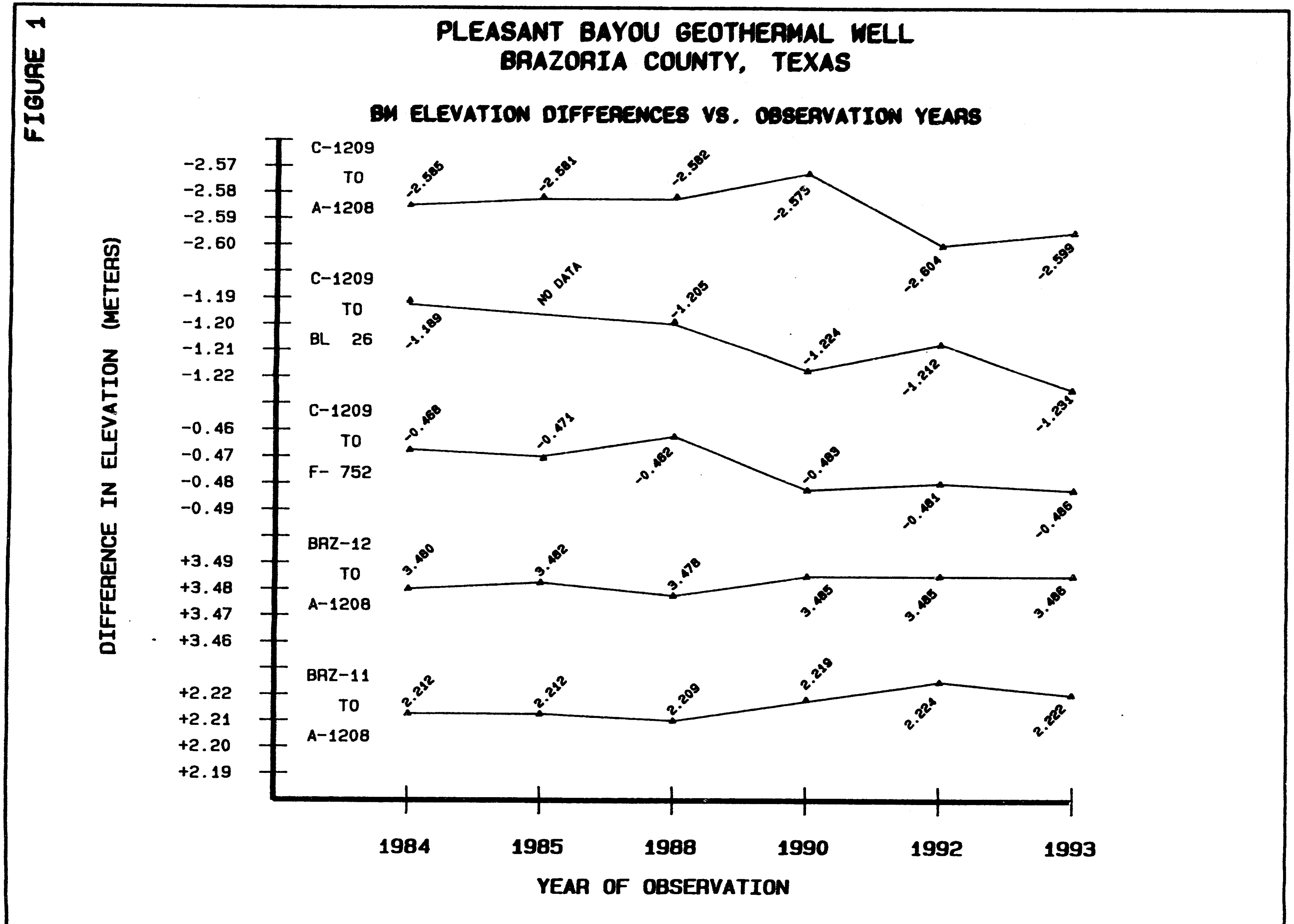


FIGURE 1
PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS
BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS
DIFFERENCE IN ELEVATION (METERS)
-2.57
-2.58
-2.59
-2.60
-1.19
-1.20
-1.21
-1.22
-0.46
-0.47
-0.48
-0.49
+3.49
+3.48
+3.47
+3.46
+2.22
+2.21
+2.20
+2.19
C-1209 TO A-1208
-2.585
-2.581
-2.582
-2.575
-2.604
-2.599
C-1209 TO BL 26
-1.189
NO DATA
-1.205
-1.224
-1.212
-1.231
C-1209 TO F- 752
-0.468
-0.471
-0.462
-0.483
-0.481
-0.486
BRZ-12 TO A-1208
3.480
3.482
3.478
3.485
3.485
3.486
BRZ-11 TO A-1208
2.212
2.212
2.209
2.219
2.224
2.222
1984
1985
1988
1990
1992
1993
YEAR OF OBSERVATION

FIGURE 2

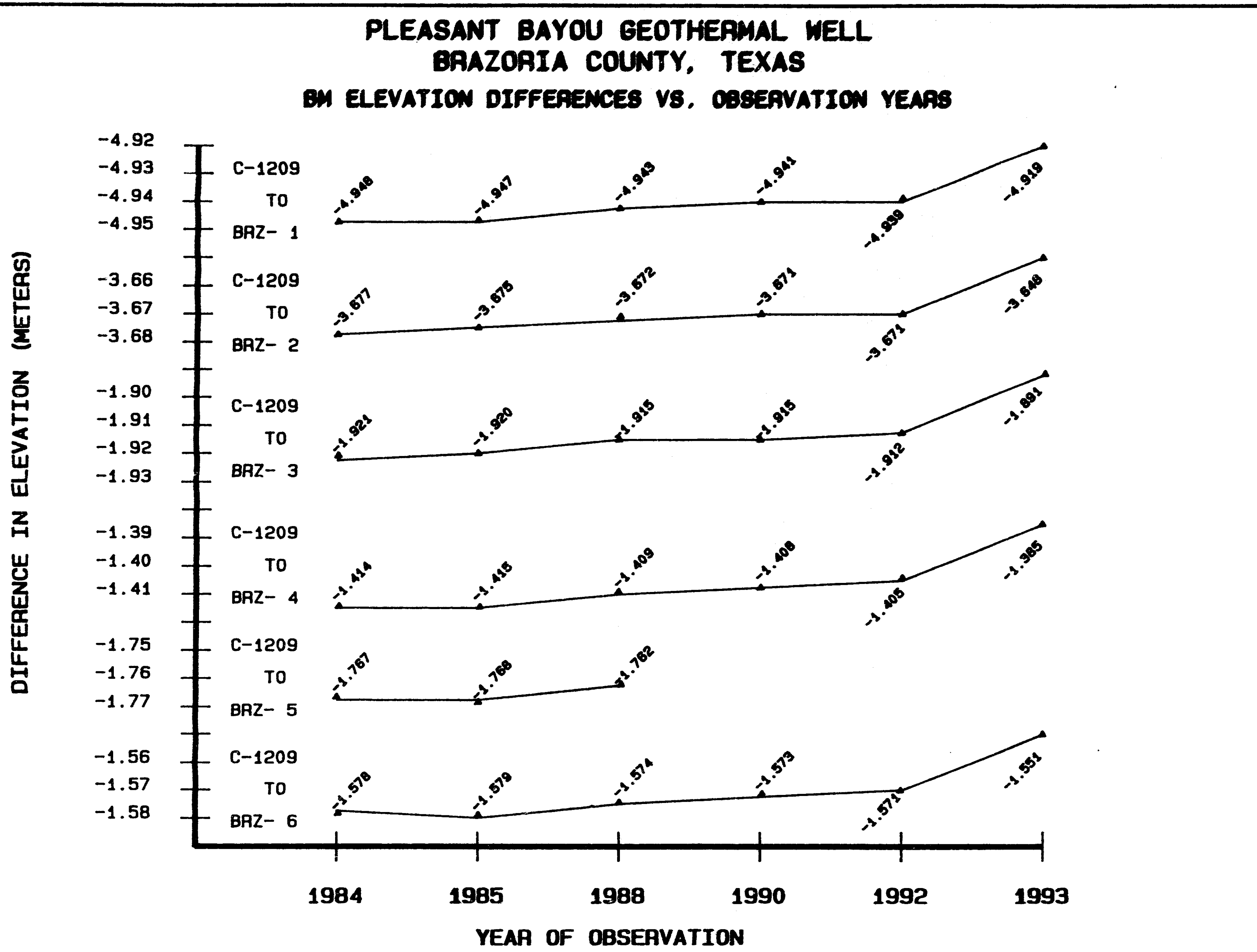

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS
BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS
DIFFERENCE IN ELEVATION (METERS)
C-1209 TO BRZ- 1
-4.92
-4.93
-4.94
-4.95
-4.948
-4.947
-4.943
-4.941
-4.939
-4.919
C-1209 TO BRZ- 2
-3.66
-3.67
-3.68
-3.677
-3.675
-3.672
-3.671
-3.671
-3.648
C-1209 TO BRZ- 3
-1.90
-1.91
-1.92
-1.93
-1.921
-1.920
-1.915
-1.915
-1.912
-1.891
C-1209 TO BRZ- 4
-1.39
-1.40
-1.41
-1.414
-1.415
-1.409
-1.408
-1.405
-1.385
C-1209 TO BRZ- 5
-1.75
-1.76
-1.77
-1.767
-1.768
-1.762
C-1209 TO BRZ- 6
-1.56
-1.57
-1.58
-1.578
-1.579
-1.574
-1.573
-1.571
-1.551
1984
1985
1988
1990
1992
1993
YEAR OF OBSERVATION

FIGURE 3

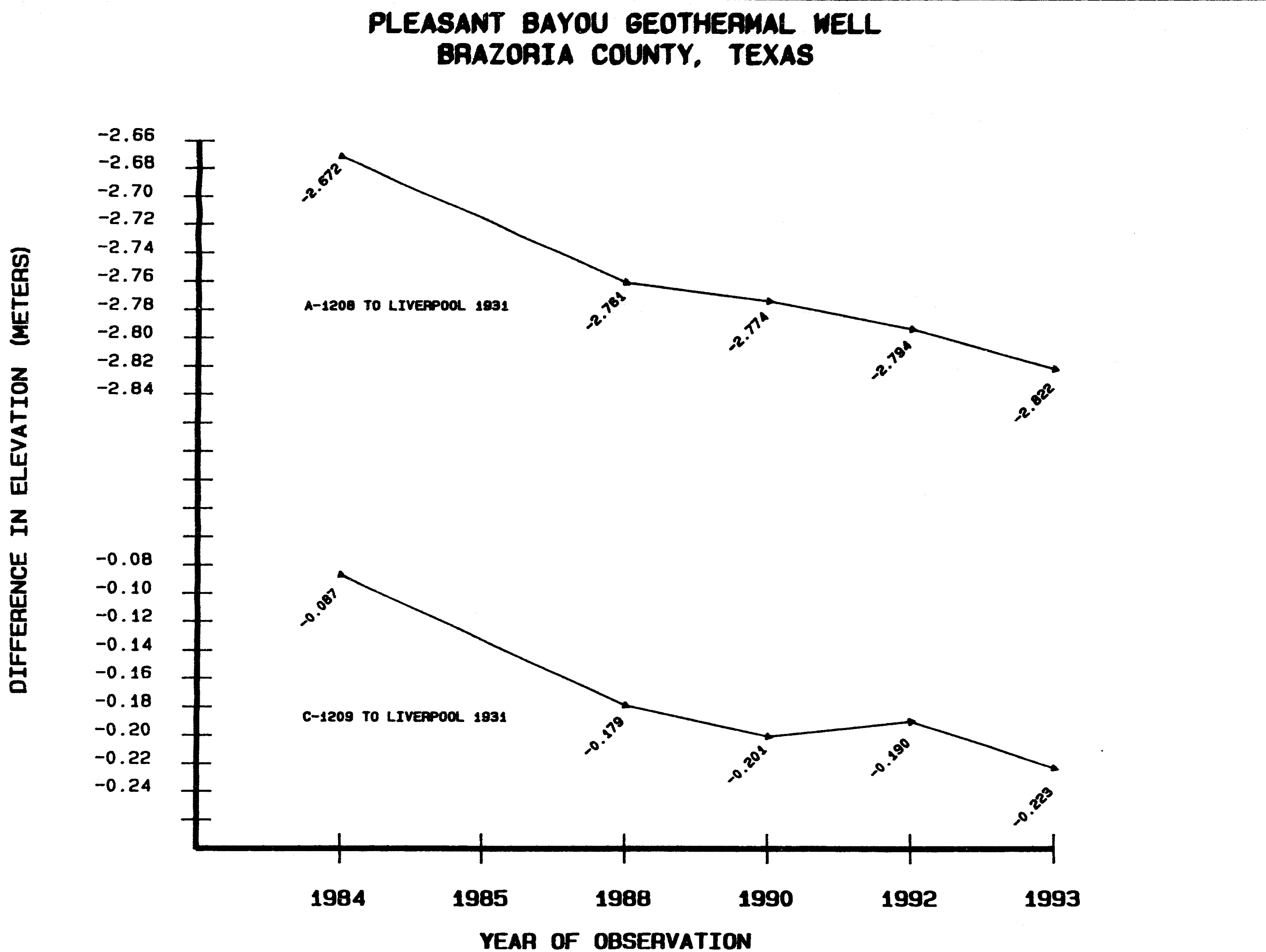
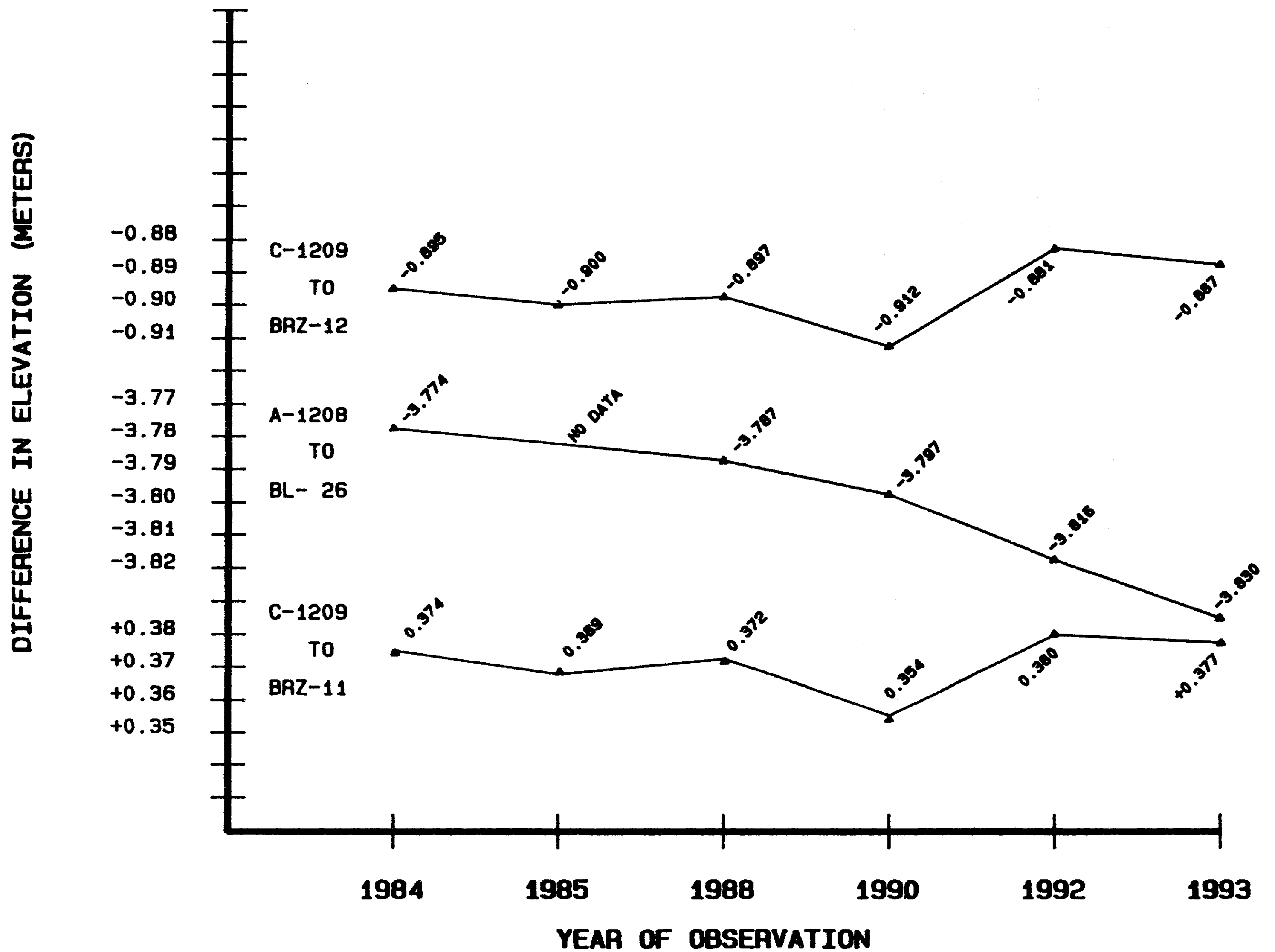

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS
DIFFERENCE IN ELEVATION (METERS)
-2.66
-2.68
-2.70
-2.72
-2.74
-2.76
-2.78
-2.80
-2.82
-2.84
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
-0.22
-0.24
A-1208 TO LIVERPOOL 1931
-2.672
-2.761
-2.774
-2.794
-2.822
C-1209 TO LIVERPOOL 1931
-0.087
-0.179
-0.201
-0.190
-0.223
1984
1985
1988
1990
1992
1993
YEAR OF OBSERVATION

FIGURE 4

PLEASANT BAYOU GEOTHERMAL WELL
BRAZORIA COUNTY, TEXAS

BM ELEVATION DIFFERENCES VS. OBSERVATION YEARS



AA FORM 76-187 (.78)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEODETIC LEVELING FIELD ABSTRACT

Z L

SHEET 1 OF 3 SHEETS

TITLE

Brazoria County, Texas
Geothermal Well
Pleasant Bayou

October, 1993

DISTANCE UNITS: KM SM   D/F.E. UNITS: MT FT

No.		Station	Mo./Day	F/B	DISTANCE Δ/Σ	D	-(B+F) Δ/Σ	D/F.E.
	30 FROM							
101	TO	Liverpool 1993 (1931)						5.63787
	30 FROM	Liverpool 1993	10/01	F	0.06	+0.00370	+.00025	+0.00358
			10/01	B	0.06	-0.00345		
102	TO	Liverpool RM 4			0.06		+.00025	5.64145
	30 FROM	Liverpool RM 4	10/01	F	0.29	+0.37550	+.00025	+0.37538
			10/01	B	0.29	-0.37525		
103	TO	Liverpool RM2			0.35		+.00050	6.01683
	30 FROM	Liverpool RM2	10/01	F	0.03	-0.15570	+.00025	-0.15583
			10/01	B	0.03	+0.15595		
104	TO	C 1209 (Held This Survey)			0.38		+.00075	5.861
	30 FROM	C 1209	10/01	F	1.24	-1.2326	-.00024	-1.23140
			10/01	B	1.24	+1.2302		
105	TO	BL 26			1.62		+.00051	4.62960
	30 FROM	BL 26	10/02	F	1.70	+0.16000	-.00270	+0.16135
			10/02	B	1.70	-0.16270		
106	TO	L 1274			3.32		-.00219	4.79095
	30 FROM	L 1274	10/02	F	1.81	+0.83785	-.00355	+0.83963
			10/03	B	1.82	-0.84140		
107	TO	TBM E 752			5.135		-.00574	5.63058
	30 FROM	TBM E 752	10/03	F	1.43	-0.25715	-.00390	-0.25520
			10/03	B	1.43	+0.25325		
108	TO	F 752			6.565		-.00964	5.37538
	30 FROM	F 752	10/04	F	0.53	-4.43340	-.00045	-4.43318
			10/04	B	0.53	+4.43295		
109	TO	BRZ-1			7.095		-.01009	0.94220
	30 FROM	BRZ-1 (SPUR)	10/04	F	0.33	+1.27065	+.00010	+1.27060
			10/04	B	0.33	-1.27055		
110	TO	BRZ-2			7.425		+.00010	2.21280

AA FORM 76-187
(76)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEODETIC LEVELING FIELD ABSTRACT

SHEET 2 OF SHEETS 3

Brazoria County, Texas
Geothermal Well
Pleasant Bayou

October, 1993

DISTANCE UNITS: KM SM — D/F.E. UNITS: MT FT

No.		Line	Mo./Day	F/B	DISTANCE Δ/Σ	D	-(B+F) Δ/Σ	D/F.E.
	30 FROM	BRZ-1 (LOOP AROUND WELL)	10/04	F	0.33	+3.02550		+3.02550
11	TO	BRZ-3			7.755			3.96970
	30 FROM	BRZ-3	10/04	F	0.26	+0.50670		+0.50670
12	TO	BRZ-4			8.015			4.47640
	30 FROM	BRZ-4	10/04	F	0.78	-0.16620		-0.16620
13	TO	BRZ-6			8.795			4.31020
	30 FROM	BRZ-6	10/04	F	0.67	-3.36620	+.00085	-3.36663
			10/04	B	0.67	+3.36705		
09	TO	BRZ-1			9.465		-.00924	0.94358
	30 FROM	BRZ-6	10/05	F	1.09	+0.61920	-.00035	+0.61938
			10/05	B	1.08	-0.61955		
14	TO	BRZ-7			10.55		-.00959	4.92958
	30 FROM	BRZ-7	10/05	F	1.64	+0.29605	-.00510	+0.29860
			10/05	B	1.64	-0.30115		
15	TO	BRZ-8			12.19		-.01469	5.22818
	30 FROM	BRZ-8	10/05	F	1.48	-0.31545	-.00150	-0.31470
			10/05	B	1.48	+0.31395		
16	TO	BRZ-9			13.67		-.01619	4.91348
	30 FROM	BRZ-9	10/06	F	1.81	+0.79305	-.00225	+0.79418
			10/06	B	1.81	-0.79530		
17	TO	BRZ-10			15.48		-.01844	5.70766
	30 FROM	BRZ-10	10/06	F	1.66	+0.53000	0.000	+0.53000
			10/06	B	1.66	-0.53000		
18	TO	BRZ-11			17.14		-.01844	6.23766
	30 FROM	BRZ-11	10/07	F	1.55	-1.26395	-.00100	-1.26345
			10/07	B	1.55	+1.26295		
19	TO	BRZ-12			18.69		-.01944	4.97421

SUPERSEDES NOAA FORM 76-148 (11-72) WHICH IS OBSOLETE AND EXISTING STOCK SHOULD BE DESTROYED UPON RECEIPT OF REVISION

NOAA FORM 76-187 (-76)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEODETIC LEVELING FIELD ABSTRACT

SHEET 3 OF 3 SHEETS

TITLE

Brazoria County, Texas
Geothermal Well
Pleasant Bayou

October, 1993

DISTANCE UNITS: KM SM — D/F.E. UNITS: MT FT

		Mo./Day	F/B	DISTANCE Δ/Σ	D	-(B+F) Δ/Σ	D/F.E.
30 FROM	BR Z-12	10/07	F	0.85	+3.48580	-.00040	+3.48600
		10/07	B	0.85	-3.48620		
020 TO	A 1208			19.54		-.01984	8.46021
		10/07	F	1.40	-2.81460		
30 FROM	A 1208	10/07	F	1.40	-2.81095	-.00130	-2.81030
		10/07	F	1.40	+2.80965		
021 TO	Liverpool 1931			20.94		-.02114	5.64991

SUPERSEDES NOAA FORM 76-149 (11-72) WHICH IS OBSOLETE AND EXISTING STOCK SHOULD BE DESTROYED UPON RECEIPT OF REVISION

APPENDIX D

PCI
PALEO CONTROL, INC.

GULF OF MEXICO
TEXAS AND LOUISIANA
ONSHORE AND OFFSHORE
INTERNATIONAL

5625 N.W. CENTRAL DR. D-100
HOUSTON, TEXAS 77092
OFFICE 713-690-4255

OCTOBER 8, 1991

BRITISH GAS
NO. 1 WILLIAM HULIN
35-13S-4E
VERMILION PH., LA.

9000 -21200	Sample Range Available and Examined.
	Sample Quality: Samples were examined concurrent with drilling and were of good quality. Varying amounts of "burned" shale were encountered below 17730'.

BIOSTRATIGRAPHIC SUMMARY

9000 - 9030	First sample - within ROBULUS "L" age section
10800-10830	Abundant ROBULUS SPP including common ROBULUS MAYERI VAR "54A" - noted for local correlative purposes.
11490-11520	ROBULUS CHAMBERSI (rare) with very rare DISCORBIS "B"
12270-12300	SIPHONINA DAVISI (very rare)
12420-12450	Rare, persistent SIPHONINA DAVISI
12660-12670	PLANULINA PALMERAE (extremely rare).
12870-12900	UVIGERINA HOWEI flood with rare PLANULINA PALMERAE and at 12900: common LIEBUSELLA SOLDANII and rare LENTICULINA HANSENI. This fauna represents the "PLANULINA PALMERAE assemblage" or "PLANULINA FAUNA (or faunal unit) No. 1" of other workers,
12990-13020	Faunal increase with abundant LENTICULINA HANSENI

BRITISH GAS
NO. 1 WILLIAM HULIN 35-13S-4E
BIOSTRATIGRAPHIC SUMMARY (contd)

13560-13590	Abundant EGGERELLA SP and at 13590; abundant UVIGERINA MULTISTRIATA with common BULIMINELLA CURTA. Noted for local correlative use.
14250-14280	Common MILIOLIDS with sparse TEXTULARIA ARTICULATA VAR. noted for local correlative use.
14700-14730	Abundant small EGGERELLA SP with common BULIMINA PUPOIDES. Noted for local correlative use.
14940-14970	Very abundant DISCORBIS BOLIVARENSIS with sparse TEXTULARIA ARTICULATA VAR. (For local correlative use).
15060-15090	Faunal increase with abundant Planktonic forams, sparse MILIOLIDS and rare BULIMINA INFLATA (for local correlative use).
16350-16380	Sparse large MILIOLIDS with sparse CRISTELLARIA SP at 16380'. Although most of the indicator forams are absent, there is a slight chance the fauna may represent the "LIEBUSELLA" or "PLANULINA FAUNA NO. 2" called by other workers in less expanded section.
18450-18480	Rare CYCLAMMINA CANCELLATA with rare CASSIDULINOIDES BRADYI and extremely rare GYROIDINA SCALATA. This may be related to the "CYCLAMMINA" or PLANULINA FAUNA NO. 3" developed in southwestern most Louisiana. This zone reportedly occurs near "CRISTELLARIA "R"
18780-18810	Slight faunal increase with rare LIEBUSELLA BYRAMENSIS and CRISTELLARIA SP (with large beads). This last species closely approaches "CRISTELLARIA "R" in morphology, but is not sufficiently well developed nor is the remainder of the fauna strong enough or diverse enough to call the regional zone on.
19890-19920	Slight faunal increase with rare GYROIDINA MIOCENICA VAR and common DISCORBIS BOLIVARENSIS. Noted for local correlative use.
21180-21200	Last sample - no older zones or locally useful correlative faunas were noted.

PALEOENVIRONMENTAL SUMMARY

9000 - 9090	Deep Inner Neritic
9090 - 9630	Inner Neritic
9630 -10170	Shallow Inner Neritic
10170-12420	Inner Neritic
12420-12870	Deep Inner Neritic
12870-12930	Middle Neritic

BRITISH GAS
NO. 1 WILLIAM HULIN 35-13S-4E
PALEOENVIRONMENTAL SUMMARY (contd)

12930-13200	Deep Inner Neritic
13200-13560	Inner Neritic
13560-13830	Deep Inner Neritic
13830-14220	Inner Neritic
14220-14340	Deep Inner Neritic
14340-14430	Inner to Deep Inner Neritic
14430-14700	Inner Neritic
14700-14760	Deep Inner Neritic
14760-14940	Inner Neritic
14940-14970	Inner to Deep Inner Neritic
14970-15060	Inner Neritic
15060-15150	Deep Inner Neritic
15150-15990	Inner Neritic
15990-16050	Inner to Deep Inner Neritic
16050-16260	Inner Neritic
16260-16590	Inner to Deep Inner Neritic
16590-17070	Deep Inner Neritic
17070-17400	Inner Neritic
17400-17460	Inner to Deep Inner Neritic
17460-17580	Inner Neritic
17580-17700	Inner to Deep Inner Neritic
17700-18450	Inner Neritic
18450-19020	Deep Inner Neritic
19020-19800	Not Representative (very rare forams) but probably Inner Neritic
19800-19980	Inner to Deep Inner Neritic
19980-20160	Inner Neritic
20160-20370	Not Representative (cement and sand) but possibly Inner Neritic
20370-21200	Not Representative (sand, sandstone and burned shale) but possibly Inner Neritic.

APPENDIX E

ANALYST: R. MANN 5-NOV-91 11:13:10 PROGRAM: GSHOT 007.E08

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*                 *
*   SCHLUMBERGER  *
*                 *
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VELOCITY SURVEY SUMMARY

COMPANY : BRITISH GAS EXPL & PROD
WELL : WILLIS HULIN NO. 1
FIELD : SOUTH ERATH
COUNTY : VERMILION
STATE : LOUISIANA
COUNTRY : USA
REFERENCE: SEISMI000711791

SURFACE GEOMETRY TABLE

ELEVATION OF KELLY BUSHING (KB) ABOVE MEAN SEA LEVEL	31.20 FT
ELEVATION OF SEISMIC REFERENCE DATUM (SRD) ABOVE MSL	0.00 FT
ELEVATION OF GROUND LEVEL ABOVE SRD	4.00 FT
VELOCITY OF MEDIUM FROM SOURCE TO SURFACE SENSOR	5000.00 FT/SEC
VELOCITY OF MEDIUM FROM SOURCE TO SRD	5000.00 FT/SEC

SOURCE POSITION TABLE

SOURCE ELEVATION ABOVE SRD	SOURCE DISTANCE FROM WELLHEAD	SOURCE AZIMUTH FROM NORTH	DEPTH RANGE FROM	TO
-6.0 FT	175.0 FT	310.0 DEG	99999.0	0.0 FT

Schlumberger

SURFACE SENSOR TABLE

SURFACE SENSOR ELEVATION ABOVE SRD	SURFACE SENSOR DISTANCE FROM WELLHEAD	SURFACE SENSOR AZIMUTH FROM NORTH	DEPTH RANGE FROM	TO
-6.0 FT	175.0 FT	310.0 DEG	99999.0	0.0 FT

SOURCE ELEVATION TABLE

	TIME FROM SURFACE SENSOR TO SOURCE	TIME FROM SOURCE TO SRD	
	0.00 mS	1.20 mS	

DEVIATED WELL RECEIVER GEOMETRY TABLE

LEVEL NO	MEASURED DEPTH FROM KB	VERTICAL DEPTH FROM KB	VERTICAL DEPTH FROM SRD	EAST WEST COORDINATES	NORTH SOUTH COORDINATES	GEOPHONE OFFSET	GEOPHONE AZIMUTH
1	1500.0 FT	1499.5 FT	1468.3 FT	-31.2 FT	-13.9 FT	34.1 FT	-114.0 DEG
2	2000.0 FT	1999.4 FT	1968.2 FT	-37.9 FT	-21.5 FT	43.6 FT	-119.6 DEG
3	2500.0 FT	2499.3 FT	2468.1 FT	-42.6 FT	-28.0 FT	50.9 FT	-123.4 DEG
4	3000.0 FT	2999.2 FT	2968.0 FT	-47.7 FT	-37.5 FT	60.7 FT	-128.2 DEG
5	3300.0 FT	3299.1 FT	3267.9 FT	-50.6 FT	-41.0 FT	65.2 FT	-129.0 DEG
6	4000.0 FT	3999.1 FT	3967.9 FT	-53.8 FT	-45.7 FT	70.6 FT	-130.4 DEG
7	4500.0 FT	4499.1 FT	4467.9 FT	-56.3 FT	-46.3 FT	72.9 FT	-129.5 DEG
8	5000.0 FT	4999.0 FT	4967.8 FT	-59.5 FT	-47.5 FT	76.1 FT	-128.6 DEG
9	5500.0 FT	5499.0 FT	5467.8 FT	-62.4 FT	-47.5 FT	78.4 FT	-127.3 DEG
10	6000.0 FT	5999.0 FT	5967.8 FT	-64.8 FT	-45.8 FT	79.4 FT	-125.2 DEG
11	6500.0 FT	6499.0 FT	6467.8 FT	-66.8 FT	-45.5 FT	80.8 FT	-124.2 DEG
12	7000.0 FT	6999.0 FT	6967.8 FT	-68.0 FT	-49.6 FT	84.2 FT	-126.1 DEG
13	7500.0 FT	7498.9 FT	7467.7 FT	-70.5 FT	-54.9 FT	89.4 FT	-127.9 DEG
14	8000.0 FT	7998.8 FT	7967.6 FT	-76.0 FT	-58.8 FT	96.0 FT	-127.7 DEG
15	8500.0 FT	8498.8 FT	8467.6 FT	-81.3 FT	-62.7 FT	102.7 FT	-127.6 DEG
16	9000.0 FT	8998.8 FT	8967.6 FT	-86.1 FT	-63.7 FT	107.1 FT	-126.5 DEG
17	9500.0 FT	9498.8 FT	9467.6 FT	-90.5 FT	-62.5 FT	110.0 FT	-124.6 DEG
18	10000.0 FT	9998.8 FT	9967.6 FT	-88.3 FT	-60.1 FT	106.8 FT	-124.3 DEG
19	10500.0 FT	10498.7 FT	10467.5 FT	-86.0 FT	-57.7 FT	103.6 FT	-123.9 DEG
20	11000.0 FT	10998.7 FT	10967.5 FT	-83.7 FT	-55.3 FT	100.4 FT	-123.4 DEG
21	11500.0 FT	11498.7 FT	11467.5 FT	-81.5 FT	-52.9 FT	97.1 FT	-123.0 DEG
22	12000.0 FT	11998.6 FT	11967.4 FT	-79.2 FT	-50.5 FT	93.9 FT	-122.5 DEG
23	12500.0 FT	12498.6 FT	12467.4 FT	-76.9 FT	-48.1 FT	90.7 FT	-122.0 DEG
24	13000.0 FT	12998.9 FT	12967.7 FT	-76.2 FT	-40.8 FT	86.5 FT	-118.2 DEG
25	13500.0 FT	13499.2 FT	13468.0 FT	-75.8 FT	-32.8 FT	82.6 FT	-113.4 DEG
26	14000.0 FT	13999.2 FT	13968.0 FT	-77.3 FT	-25.7 FT	81.4 FT	-108.4 DEG
27	15000.0 FT	14998.8 FT	14967.6 FT	-86.8 FT	-17.7 FT	88.6 FT	-101.5 DEG
28	15500.0 FT	15498.3 FT	15467.1 FT	-81.9 FT	-21.5 FT	84.7 FT	-104.7 DEG
29	16000.0 FT	15998.2 FT	15967.0 FT	-84.9 FT	-18.2 FT	86.8 FT	-102.1 DEG
30	16500.0 FT	16498.2 FT	16467.0 FT	-85.2 FT	-14.0 FT	86.4 FT	-99.3 DEG
31	16650.0 FT	16648.1 FT	16616.9 FT	-85.4 FT	-12.4 FT	86.3 FT	-98.2 DEG
32	16700.0 FT	16698.1 FT	16666.9 FT	-86.8 FT	-11.0 FT	87.5 FT	-97.2 DEG
33	16750.0 FT	16748.1 FT	16716.9 FT	-88.2 FT	-9.6 FT	88.7 FT	-96.2 DEG
34	16800.0 FT	16798.1 FT	16766.9 FT	-89.5 FT	-8.2 FT	89.9 FT	-95.2 DEG
35	16850.0 FT	16848.0 FT	16816.8 FT	-90.9 FT	-6.8 FT	91.2 FT	-94.3 DEG
36	16900.0 FT	16898.0 FT	16866.8 FT	-92.3 FT	-5.4 FT	92.5 FT	-93.4 DEG
37	16950.0 FT	16948.0 FT	16916.8 FT	-93.7 FT	-4.1 FT	93.8 FT	-92.5 DEG
38	17000.0 FT	16998.0 FT	16966.8 FT	-95.1 FT	-2.7 FT	95.1 FT	-91.6 DEG
39	17050.0 FT	17047.9 FT	17016.7 FT	-96.5 FT	-1.3 FT	96.5 FT	-90.8 DEG
40	17100.0 FT	17097.9 FT	17066.7 FT	-97.9 FT	0.1 FT	97.9 FT	-90.0 DEG
41	17150.0 FT	17147.9 FT	17116.7 FT	-99.2 FT	1.5 FT	99.2 FT	-89.1 DEG
42	17200.0 FT	17197.8 FT	17166.6 FT	-100.1 FT	3.6 FT	100.2 FT	-88.0 DEG
43	17250.0 FT	17247.8 FT	17216.6 FT	-101.0 FT	5.6 FT	101.2 FT	-86.8 DEG
44	17300.0 FT	17297.7 FT	17266.5 FT	-101.9 FT	7.7 FT	102.2 FT	-85.7 DEG
45	17350.0 FT	17347.7 FT	17316.5 FT	-102.7 FT	9.8 FT	103.2 FT	-84.6 DEG
46	17400.0 FT	17397.6 FT	17366.4 FT	-103.3 FT	11.9 FT	104.0 FT	-83.4 DEG
47	17450.0 FT	17447.6 FT	17416.4 FT	-104.0 FT	14.1 FT	104.9 FT	-82.3 DEG

Schlumberger

48	17500.0 FT	17497.5 FT	17466.3 FT	-104.6 FT	16.3 FT	105.9 FT	-81.1 DEG
49	17550.0 FT	17547.5 FT	17516.3 FT	-104.5 FT	18.5 FT	106.1 FT	-79.9 DEG
50	17600.0 FT	17597.4 FT	17566.2 FT	-103.9 FT	20.8 FT	105.9 FT	-78.7 DEG
51	17650.0 FT	17647.4 FT	17616.2 FT	-103.2 FT	23.0 FT	105.8 FT	-77.4 DEG
52	17700.0 FT	17697.3 FT	17666.1 FT	-102.6 FT	25.3 FT	105.6 FT	-76.2 DEG
53	17750.0 FT	17747.2 FT	17716.0 FT	-101.9 FT	27.5 FT	105.6 FT	-74.9 DEG
54	17800.0 FT	17797.2 FT	17766.0 FT	-101.3 FT	29.8 FT	105.6 FT	-73.6 DEG
55	17850.0 FT	17847.1 FT	17815.9 FT	-99.0 FT	31.2 FT	103.8 FT	-72.5 DEG
56	17900.0 FT	17897.0 FT	17865.8 FT	-96.7 FT	32.7 FT	102.0 FT	-71.3 DEG
57	17950.0 FT	17946.9 FT	17915.7 FT	-94.4 FT	34.1 FT	100.3 FT	-70.1 DEG
58	18000.0 FT	17996.9 FT	17965.7 FT	-92.1 FT	35.5 FT	98.7 FT	-68.9 DEG
59	18050.0 FT	18046.8 FT	18015.6 FT	-69.8 FT	37.0 FT	97.1 FT	-67.6 DEG
60	18100.0 FT	18096.7 FT	18065.5 FT	-87.5 FT	38.4 FT	95.5 FT	-66.3 DEG
61	18150.0 FT	18146.6 FT	18115.4 FT	-85.2 FT	39.8 FT	94.0 FT	-64.9 DEG
62	18200.0 FT	18196.6 FT	18165.4 FT	-82.7 FT	40.8 FT	92.2 FT	-63.7 DEG
63	18250.0 FT	18246.5 FT	18215.3 FT	-80.0 FT	41.3 FT	90.0 FT	-62.7 DEG
64	18300.0 FT	18296.4 FT	18265.2 FT	-77.3 FT	41.8 FT	87.9 FT	-61.6 DEG
65	18350.0 FT	18346.3 FT	18315.1 FT	-74.6 FT	42.3 FT	85.8 FT	-60.5 DEG
66	18400.0 FT	18396.3 FT	18365.1 FT	-72.0 FT	42.7 FT	83.7 FT	-59.3 DEG
67	18450.0 FT	18446.2 FT	18415.0 FT	-69.3 FT	43.2 FT	81.7 FT	-58.0 DEG
68	18500.0 FT	18496.1 FT	18464.9 FT	-67.3 FT	44.9 FT	80.9 FT	-56.3 DEG
69	18550.0 FT	18546.1 FT	18514.9 FT	-65.4 FT	46.6 FT	80.3 FT	-54.5 DEG
70	18600.0 FT	18596.0 FT	18564.8 FT	-63.5 FT	48.3 FT	79.8 FT	-52.8 DEG
71	18650.0 FT	18645.9 FT	18614.7 FT	-61.6 FT	50.0 FT	79.3 FT	-50.9 DEG
72	18700.0 FT	18695.9 FT	18664.7 FT	-59.7 FT	51.7 FT	79.0 FT	-49.1 DEG
73	18780.0 FT	18775.8 FT	18744.6 FT	-56.7 FT	54.9 FT	78.9 FT	-45.9 DEG
74	18790.0 FT	18785.7 FT	18754.5 FT	-56.3 FT	55.3 FT	79.0 FT	-45.5 DEG
75	18850.0 FT	18845.6 FT	18814.4 FT	-54.2 FT	58.0 FT	79.3 FT	-43.0 DEG
76	18900.0 FT	18895.6 FT	18864.4 FT	-52.3 FT	60.2 FT	79.8 FT	-41.0 DEG
77	18950.0 FT	18945.5 FT	18914.3 FT	-50.5 FT	62.4 FT	80.3 FT	-39.0 DEG
78	19000.0 FT	18995.4 FT	18964.2 FT	-48.7 FT	64.6 FT	80.9 FT	-37.0 DEG
79	19050.0 FT	19045.3 FT	19014.1 FT	-46.8 FT	66.2 FT	81.1 FT	-35.3 DEG
80	19100.0 FT	19095.3 FT	19064.1 FT	-44.9 FT	67.6 FT	81.1 FT	-33.6 DEG
81	19150.0 FT	19145.2 FT	19114.0 FT	-43.0 FT	69.0 FT	81.3 FT	-31.9 DEG
82	19200.0 FT	19195.1 FT	19163.9 FT	-41.0 FT	70.4 FT	81.4 FT	-30.2 DEG
83	19250.0 FT	19245.1 FT	19213.9 FT	-39.1 FT	71.7 FT	81.7 FT	-28.6 DEG
84	19300.0 FT	19295.0 FT	19263.8 FT	-37.2 FT	73.1 FT	82.0 FT	-26.9 DEG
85	19349.9 FT	19344.9 FT	19313.7 FT	-35.3 FT	74.5 FT	82.4 FT	-25.3 DEG
86	19400.0 FT	19394.9 FT	19363.7 FT	-33.4 FT	75.8 FT	92.9 FT	-23.8 DEG
87	19450.0 FT	19444.9 FT	19413.7 FT	-31.7 FT	77.0 FT	83.3 FT	-22.4 DEG
88	19500.0 FT	19494.8 FT	19463.6 FT	-30.1 FT	78.1 FT	83.7 FT	-21.1 DEG
89	19550.0 FT	19544.8 FT	19513.6 FT	-28.4 FT	79.2 FT	84.2 FT	-19.7 DEG
90	19600.0 FT	19594.7 FT	19563.5 FT	-26.8 FT	80.4 FT	84.7 FT	-18.4 DEG
91	19650.0 FT	19644.7 FT	19613.5 FT	-25.1 FT	81.5 FT	85.3 FT	-17.1 DEG
92	19701.0 FT	19695.6 FT	19664.4 FT	-23.4 FT	92.7 FT	85.9 FT	-15.8 DEG
93	19751.0 FT	19745.6 FT	19714.4 FT	-21.7 FT	83.8 FT	86.6 FT	-14.5 DEG
94	19801.0 FT	19795.6 FT	19764.4 FT	-21.1 FT	84.8 FT	87.4 FT	-14.0 DEG
95	19851.0 FT	19845.6 FT	19814.4 FT	-20.7 FT	85.8 FT	88.3 FT	-13.6 DEG
96	19901.0 FT	19895.6 FT	19864.4 FT	-20.3 FT	86.9 FT	89.2 FT	-13.2 DEG
97	19951.0 FT	19945.5 FT	19914.3 FT	-20.1 FT	87.9 FT	90.2 FT	-12.9 DEG
98	20001.0 FT	19995.5 FT	19964.3 FT	-21.7 FT	89.5 FT	92.1 FT	-13.6 DEG
99	20051.0 FT	20045.4 FT	20014.2 FT	-23.3 FT	91.1 FT	94.0 FT	-14.3 DEG
100	20101.0 FT	20095.4 FT	20064.2 FT	-24.9 FT	92.7 FT	96.0 FT	-15.0 DEG
101	20151.0 FT	20145.3 FT	20114.1 FT	-26.5 FT	94.3 FT	97.9 FT	-15.7 DEG
102	20201.0 FT	20195.3 FT	20164.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
103	20251.0 FT	20245.3 FT	20214.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
104	20301.0 FT	20295.3 FT	20264.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
105	20351.0 FT	20345.3 FT	20314.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
106	20401.0 FT	20395.3 FT	20364.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
107	20451.0 FT	20445.3 FT	20414.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG

108	20501.0 FT	20495.3 FT	20464.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
109	20551.0 FT	20545.3 FT	20514.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
110	20601.0 FT	20595.3 FT	20564.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
111	20651.0 FT	20645.3 FT	20614.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
112	20701.0 FT	20695.3 FT	20664.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
113	20751.0 FT	20745.3 FT	20714.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
114	20801.0 FT	20795.3 FT	20764.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
115	20851.0 FT	20845.3 FT	20814.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
116	20901.0 FT	20895.3 FT	20864.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
117	20951.0 FT	20945.3 FT	20914.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
118	21001.0 FT	20995.3 FT	20964.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
119	21051.0 FT	21045.3 FT	21014.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
120	21101.0 FT	21095.3 FT	21064.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
121	21151.0 FT	21145.3 FT	21114.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG
122	21171.0 FT	21165.3 FT	21134.1 FT	-27.1 FT	95.0 FT	98.8 FT	-16.0 DEG

COMPANY : BRITISH GAS EXPL & PROD WELL : WILLIS HULIN NO. 1

LEVEL NO	MEASURED DEPTH FROM KB	VERTICAL DEPTH FROM SRD	MEASURED TIME FROM SURFACE SENSOR TO GEO	VERTICAL TIME FROM SOURCE TO GEOPHONE	VERTICAL TIME FROM SRD/GEO.	AVERAGE VELOCITY SRD/GEO.	DELTA DEPTH	DELTA TIME	INTERVAL VELOCITY
	FT	FT	mS	mS	mS	FT/S	FT	mS	FT/S
1	1500.0	1468.3	260.8	259.2	260.4	5639			
2	2000.0	1968.2	330.7	329.5	330.7	5951	499.9	70.3	7106
3	2500.0	2468.1	417.0	416.0	417.2	5915	499.9	86.5	5779
4	3000.0	2968.0	480.9	480.1	481.3	6167	499.8	64.0	7805
5	3300.0	3267.9	513.1	512.4	513.6	6363	300.0	32.3	9291
6	4000.0	3967.9	613.3	612.7	613.9	6464	699.9	100.3	6977
7	4500.0	4467.9	676.5	676.0	677.2	6598	500.0	63.3	7901
8	5000.0	4967.8	737.3	736.8	738.0	6731	500.0	60.9	8215
9	5500.0	5467.8	795.8	795.4	796.6	6864	500.0	58.6	8538
10	6000.0	5967.8	853.4	853.0	854.2	6986	500.0	57.7	8673
11	6500.0	6467.8	911.9	911.6	912.8	7086	500.0	58.5	8542
12	7000.0	6967.8	968.6	968.3	969.5	7187	500.0	56.7	8815
13	7500.0	7467.7	1023.8	1023.5	1024.7	7288	499.9	55.2	9055
14	8000.0	7967.6	1076.1	1075.8	1077.0	7398	499.9	52.3	9555
15	8500.0	8467.6	1128.8	1128.5	1129.7	7495	500.0	52.7	9485
16	9000.0	8967.6	1179.5	1179.3	1180.5	7597	500.0	50.7	9858
17	9500.0	9467.6	1230.7	1230.5	1231.7	7687	500.0	51.2	9761
18	10000.0	9967.6	1277.6	1277.4	1278.6	7796	500.0	46.9	10656
19	10500.0	10467.5	1324.1	1323.9	1325.1	7899	500.0	46.5	10748
20	11000.0	10967.5	1371.4	1371.2	1372.4	7991	500.0	47.3	10567
21	11500.0	11467.5	1417.3	1417.1	1418.3	8085	500.0	45.9	10890
22	12000.0	11967.4	1464.9	1464.8	1465.9	8164	500.0	47.6	10501
23	12500.0	12467.4	1510.9	1510.8	1512.0	8246	500.0	46.0	10867
							500.3	49.7	10063

COMPANY : BRITISH GAS EXPL & PROD WELL : WILLIS HULIN NO. 1

LEVEL NO	MEASURED DEPTH FROM KB	VERTICAL DEPTH FROM SRD	MEASURED TIME FROM SURFACE SENSOR TO GEO	VERTICAL TIME FROM SOURCE TO GEOPHONE	VERTICAL TIME FROM SRD/GEO.	AVERAGE VELOCITY SRD/GEO.	DELTA DEPTH	DELTA TIME	INTERVAL VELOCITY
	FT	FT	mS	mS	mS	FT/S	FT	mS	FT/S
24	13000.0	12967.7	1560.6	1560.5	1561.7	8304			
25	13500.0	13468.0	1613.0	1612.9	1614.1	8344	500.3	52.4	9545
26	14000.0	13968.0	1663.8	1663.7	1664.9	8390	500.0	50.8	9840
27	15000.0	14967.6	1763.0	1762.9	1764.1	8484	999.6	99.2	10074
28	15500.0	15467.1	1807.8	1807.7	1808.9	8550	499.5	44.8	11150
29	16000.0	15967.0	1852.8	1852.7	1853.9	8613	499.9	45.0	11108
30	16500.0	16467.0	1901.8	1901.7	1902.9	8653	500.0	49.0	10202
31	16650.0	16616.9	1917.9	1917.8	1919.0	8659	150.0	16.1	9314
32	16700.0	16666.9	1923.5	1923.4	1924.6	8660	50.0	5.6	8921
33	16750.0	16716.9	1929.3	1929.2	1930.4	8560	50.0	5.8	8613
34	16800.0	16766.9	1934.6	1934.5	1935.7	8662	50.0	5.3	9426
35	16850.0	16816.8	1939.9	1939.8	1941.0	8664	50.0	5.3	9426
36	16900.0	16866.8	1945.4	1945.3	1946.6	8665	50.0	5.5	9084
37	16950.0	16916.8	1950.7	1950.7	1951.8	8667	50.0	5.3	9426
38	17000.0	16966.8	1956.1	1956.1	1957.3	8669	50.0	5.4	9251
39	17050.0	17016.7	1960.9	1960.8	1962.1	8673	50.0	4.8	10407
40	17100.0	17066.7	1965.9	1965.8	1967.1	8676	50.0	5.0	9992
41	17150.0	17116.7	1971.2	1971.2	1972.3	8678	50.0	5.3	9427
42	17200.0	17166.6	1976.1	1976.1	1977.3	8682	50.0	4.9	10190
43	17250.0	17216.6	1981.5	1981.5	1982.7	8684	50.0	5.4	9247
44	17300.0	17266.5	1986.3	1986.3	1987.5	8688	50.0	4.8	10403
45	17350.0	17316.5	1991.8	1991.8	1993.0	8689	50.0	5.5	9079
46	17400.0	17366.4	1996.7	1996.7	1997.9	8693	49.9	4.9	10190
							49.9	5.0	9987

COMPANY : BRITISH GAS EXPL & PROD WELL : WILLIS HULIN NO. 1

LEVEL NO	MEASURED DEPTH FROM KB	VERTICAL DEPTH FROM SRD	MEASURED TIME FROM SURFACE SENSOR TO GEO	VERTICAL TIME FROM SOURCE TO GEOPHONE	VERTICAL TIME FROM SRD/GEO.	AVERAGE VELOCITY SRD/GEO.	DELTA DEPTH	DELTA TIME	INTERVAL VELOCITY
	FT	FT	mS	mS	mS	FT/S	FT	mS	FT/S
47	17450.0	17416.4	2001.7	2001.7	2002.9	8696			
48	17500.0	17466.3	2007.3	2007.3	2008.5	8696	49.9	5.6	8917
49	17550.0	17516.3	2012.8	2012.8	2014.0	8697	49.9	5.5	9078
50	17600.0	17566.2	2018.2	2018.2	2019.4	8699	49.9	5.4	9246
51	17650.0	17616.2	2022.5	2022.5	2023.7	8705	49.9	4.3	11610
52	17700.0	17666.1	2027.3	2027.3	2028.5	8709	49.9	4.8	10402
53	17750.0	17716.0	2031.9	2031.9	2033.1	8714	49.9	4.6	10853
54	17800.0	17766.0	2036.9	2036.9	2038.1	8717	49.9	5.0	9986
55	17850.0	17815.9	2041.9	2041.9	2043.1	8720	49.9	5.0	9984
56	17900.0	17865.8	2046.7	2046.7	2047.9	8724	49.9	4.8	10400
57	17950.0	17915.7	2051.5	2051.5	2052.7	8729	49.9	4.8	10400
58	18000.0	17965.7	2057.0	2057.0	2058.2	8729	49.9	5.5	9076
59	18050.0	18015.6	2062.1	2062.1	2063.3	8732	49.9	5.1	9788
60	18100.0	18065.5	2067.3	2067.3	2068.5	8734	49.9	5.2	9601
61	18150.0	18115.4	2072.1	2072.1	2073.3	8738	49.9	4.8	10400
62	18200.0	18165.4	2076.0	2076.0	2077.2	8745	49.9	3.9	12803
63	18250.0	18215.3	2080.3	2080.3	2081.5	8751	49.9	4.3	11612
64	18300.0	18265.2	2085.4	2085.4	2086.6	8754	49.9	5.1	9790
65	18350.0	18315.1	2089.7	2089.7	2090.9	8760	49.9	4.3	11612
66	18400.0	18365.1	2095.1	2095.1	2096.3	8761	49.9	5.4	9246
67	18450.0	18415.0	2100.5	2100.5	2101.7	8762	49.9	5.4	9247
68	18500.0	18464.9	2106.3	2106.3	2107.5	8762	49.9	5.8	8610
69	18550.0	18514.9	2111.7	2111.7	2112.9	8763	49.9	5.4	9248
							49.9	5.8	8610

COMPANY : BRITISH GAS EXPL & PROD WELL : WILLIS HULIN NO. 1

LEVEL NO	MEASURED DEPTH FROM KB (FT)	VERTICAL DEPTH FROM SRD (FT)	MEASURED TIME FROM SURFACE SENSOR TO GEO (mS)	VERTICAL TIME FROM SOURCE TO GEOPHONE (mS)	VERTICAL TIME FROM SRD/GEO. (mS)	AVERAGE VELOCITY SRD/GEO. (FT/S)	DELTA DEPTH (FT)	DELTA TIME (mS)	INTERVAL VELOCITY (FT/S)
70	18600.0	18564.8	2117.5	2117.5	2118.7	8762			
71	18650.0	18614.7	2122.4	2122.4	2123.6	8766	49.9	4.9	10192
72	18700.0	18664.7	2127.3	2127.3	2128.5	8769	49.9	4.9	10191
73	18780.0	18744.6	2134.6	2134.6	2135.8	8776	79.9	7.3	10943
74	18790.0	18754.5	2135.5	2135.5	2136.7	8777	10.0	0.9	11096
75	18850.0	18814.4	2141.6	2141.6	2142.8	8780	59.9	6.1	9819
76	18900.0	18864.4	2146.4	2146.4	2147.6	8784	49.9	4.8	10400
77	18950.0	18914.3	2150.3	2150.3	2151.5	8791	49.9	3.9	12799
78	19000.0	18964.2	2154.6	2154.6	2155.8	8797	49.9	4.3	11609
79	19050.0	19014.1	2159.2	2159.2	2160.4	8801	49.9	4.6	10857
80	19100.0	19064.1	2163.5	2163.5	2164.7	8807	49.9	4.3	11614
81	19150.0	19114.0	2167.4	2167.4	2168.6	8814	49.9	3.9	12809
82	19200.0	19163.9	2171.8	2171.8	2173.0	8819	49.9	4.4	11350
83	19250.0	19213.9	2176.1	2176.1	2177.3	8825	49.9	4.3	11616
84	19300.0	19263.8	2180.7	2180.7	2181.9	8829	49.9	4.6	10857
85	19349.9	19313.7	2185.0	2185.0	2186.2	8834	49.8	4.3	11593
86	19400.0	19363.7	2189.3	2189.3	2190.5	8840	50.0	4.3	11640
87	19450.0	19413.7	2193.1	2193.1	2194.3	8847	50.0	3.8	13149
88	19500.0	19463.6	2197.2	2197.2	2198.4	8854	50.0	4.1	12187
89	19550.0	19513.6	2201.4	2201.4	2202.6	8859	50.0	4.2	11897
90	19600.0	19563.5	2205.9	2205.9	2207.1	8864	50.0	4.5	11102
91	19650.0	19613.5	2209.8	2209.8	2211.0	8871	50.0	3.9	12812
92	19701.0	19664.4	2213.6	2213.6	2214.8	8879	51.0	3.8	13412
							50.0	4.5	11104

COMPANY : BRITISH GAS EXPL & PROD WELL : WILLIS HULIN NO. 1

LEVEL NO	MEASURED DEPTH FROM KB	VERTICAL DEPTH FROM SRD	MEASURED TIME FROM SURFACE SENSOR TO GEO	VERTICAL TIME FROM SOURCE TO GEOPHONE	VERTICAL TIME FROM SRD/GEO.	AVERAGE VELOCITY SRD/GEO.	DELTA DEPTH	DELTA TIME	INTERVAL VELOCITY
	FT	FT	mS	mS	mS	FT/S	FT	mS	FT/S
93	19751.0	19714.4	2218.1	2218.1	2219.3	8883			
94	19801.0	19764.4	2222.9	2222.9	2224.1	8887	50.0	4.8	10413
95	19851.0	19814.4	2227.4	2227.4	2228.6	8891	50.0	4.5	11108
96	19901.0	19864.4	2231.8	2231.8	2233.0	8896	50.0	4.4	11360
97	19951.0	19914.3	2236.1	2236.1	2237.3	8901	50.0	4.3	11623
98	20001.0	19964.3	2240.2	2240.2	2241.4	8907	49.9	4.1	12179
99	20051.0	20014.2	2244.6	2244.6	2245.8	8912	49.9	4.4	11349
100	20101.0	20064.2	2248.0	2248.0	2249.2	8921	49.9	3.4	14685
101	20151.0	20114.1	2251.4	2251.4	2252.6	8929	49.9	3.4	14685
102	20201.0	20164.1	2255.5	2255.5	2256.7	8935	50.0	4.1	12187
103	20251.0	20214.1	2260.1	2260.1	2261.3	8939	50.0	4.6	10870
104	20301.0	20264.1	2263.5	2263.5	2264.7	8948	50.0	3.4	14707
105	20351.0	20314.1	2267.0	2267.0	2268.2	8956	50.0	3.5	14284
106	20401.0	20364.1	2270.0	2270.0	2271.2	8966	50.0	3.0	16667
107	20451.0	20414.1	2273.6	2273.6	2274.8	8974	50.0	3.6	13888
108	20501.0	20464.1	2277.6	2277.6	2278.8	8980	50.0	4.0	12500
109	20551.0	20514.1	2281.2	2281.2	2282.4	8988	50.0	3.6	13889
110	20601.0	20564.1	2284.5	2284.5	2285.7	8997	50.0	3.3	15151
111	20651.0	20614.1	2288.0	2288.0	2289.2	9005	50.0	3.5	14285
112	20701.0	20664.1	2291.0	2291.0	2292.2	9015	50.0	3.0	16667
113	20751.0	20714.1	2294.6	2294.6	2295.8	9023	50.0	3.6	13888
114	20801.0	20764.1	2298.5	2298.5	2299.7	9029	50.0	3.9	12820
115	20851.0	20814.1	2301.9	2301.9	2303.1	9038	50.0	3.4	14704
							50.0	3.5	14286

COMPANY : BRITISH GAS EXPL & PROD WELL : WILLIS HULIN NO. 1

LEVEL NO	MEASURED DEPTH FROM KB	VERTICAL DEPTH FROM SRD	MEASURED TIME FROM SURFACE SENSOR TO GEO	VERTICAL TIME FROM SOURCE TO GEOPHONE	VERTICAL TIME FROM SRD/GEO.	AVERAGE VELOCITY SRD/GEO.	DELTA DEPTH	DELTA TIME	INTERVAL VELOCITY
	FT	FT	mS	mS	mS	FT/S	FT	mS	FT/S
116	20901.0	20864.1	2305.4	2305.4	2306.6	9046			
117	20951.0	20914.1	2308.8	2308.8	2310.0	9054	50.0	3.4	14706
118	21001.0	20964.1	2312.2	2312.2	2313.4	9062	50.0	3.4	14704
119	21051.0	21014.1	2315.7	2315.7	2316.9	9070	50.0	3.5	14286
120	21101.0	21064.1	2319.1	2319.1	2320.3	9078	50.0	3.4	14706
121	21151.0	21114.1	2322.5	2322.5	2323.7	9087	50.0	3.4	14706
122	21171.0	21134.1	2324.0	2324.0	2325.2	9089	20.0	1.5	13334

APPENDIX F

FINAL ✓ S

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC 1, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
0.000	0.	7.	13.	20.	26.	33.	39.	46.	53.	59.
.020	66.	72.	79.	86.	92.	99.	105.	112.	118.	125.
.040	132.	138.	145.	151.	158.	164.	171.	178.	184.	191.
.060	197.	204.	211.	217.	224.	230.	237.	243.	250.	257.
.080	263.	270.	276.	283.	289.	296.	303.	309.	316.	322.
.100	329.	336.	342.	349.	355.	362.	368.	375.	382.	388.
.120	395.	401.	408.	415.	421.	428.	434.	441.	447.	454.
.140	461.	467.	474.	480.	487.	493.	500.	507.	513.	520.
.160	526.	533.	540.	546.	553.	559.	566.	572.	579.	586.
.180	592.	599.	605.	612.	618.	625.	632.	638.	645.	651.
.200	658.	665.	671.	678.	684.	691.	697.	704.	711.	717.
.220	724.	730.	737.	743.	750.	757.	763.	770.	776.	783.
.240	790.	796.	803.	809.	816.	822.	829.	836.	842.	849.
.260	855.	862.	868.	875.	882.	888.	895.	901.	908.	915.
.280	921.	928.	934.	941.	947.	954.	961.	967.	974.	980.
.300	987.	993.	1000.	1007.	1013.	1020.	1026.	1033.	1040.	1046.
.320	1053.	1059.	1066.	1072.	1079.	1086.	1092.	1099.	1105.	1112.
.340	1119.	1125.	1132.	1138.	1145.	1151.	1158.	1165.	1171.	1178.
.360	1184.	1191.	1197.	1204.	1211.	1217.	1224.	1230.	1237.	1244.
.380	1250.	1257.	1263.	1270.	1276.	1283.	1290.	1296.	1303.	1309.
.400	1316.	1322.	1329.	1336.	1342.	1349.	1355.	1362.	1369.	1375.
.420	1382.	1388.	1395.	1401.	1408.	1415.	1421.	1428.	1434.	1441.
.440	1447.	1454.	1461.	1467.	1474.	1480.	1487.	1494.	1500.	1507.
.460	1513.	1520.	1526.	1533.	1540.	1546.	1553.	1559.	1566.	1572.
.480	1579.	1586.	1592.	1599.	1605.	1612.	1619.	1625.	1632.	1638.
.500	1645.	1651.	1658.	1665.	1671.	1678.	1684.	1691.	1698.	1704.
.520	1711.	1717.	1724.	1730.	1737.	1744.	1750.	1757.	1763.	1770.
.540	1776.	1783.	1790.	1796.	1803.	1809.	1816.	1823.	1829.	1836.
.560	1842.	1849.	1855.	1862.	1869.	1875.	1882.	1888.	1895.	1901.
.580	1908.	1915.	1921.	1928.	1934.	1941.	1948.	1954.	1961.	1967.
.600	1974.	1980.	1987.	1994.	2000.	2007.	2013.	2020.	2026.	2033.
.620	2040.	2046.	2053.	2059.	2066.	2073.	2079.	2086.	2092.	2099.
.640	2105.	2112.	2119.	2125.	2132.	2138.	2145.	2151.	2158.	2165.
.660	2171.	2178.	2184.	2191.	2198.	2204.	2211.	2217.	2224.	2230.
.680	2237.	2244.	2250.	2257.	2263.	2270.	2276.	2283.	2290.	2296.
.700	2303.	2309.	2316.	2323.	2329.	2336.	2342.	2349.	2355.	2362.
.720	2369.	2375.	2382.	2388.	2395.	2402.	2408.	2415.	2421.	2428.
.740	2434.	2441.	2448.	2454.	2461.	2467.	2474.	2480.	2487.	2494.
.760	2500.	2507.	2513.	2520.	2527.	2533.	2540.	2546.	2553.	2559.
.780	2566.	2573.	2579.	2586.	2592.	2599.	2605.	2612.	2619.	2625.
.800	2632.	2638.	2645.	2652.	2658.	2665.	2671.	2678.	2684.	2691.
.820	2698.	2704.	2711.	2717.	2724.	2730.	2737.	2744.	2750.	2757.
.840	2763.	2770.	2777.	2783.	2790.	2796.	2803.	2809.	2816.	2823.
.860	2829.	2836.	2842.	2849.	2855.	2862.	2869.	2875.	2882.	2888.
.880	2895.	2902.	2908.	2915.	2921.	2928.	2934.	2941.	2948.	2954.
.900	2961.	2967.	2974.	2980.	2987.	2994.	3000.	3007.	3013.	3020.
.920	3027.	3033.	3040.	3046.	3053.	3059.	3066.	3073.	3079.	3086.
.940	3092.	3099.	3106.	3112.	3119.	3125.	3132.	3138.	3145.	3152.
.960	3158.	3165.	3171.	3178.	3184.	3191.	3198.	3204.	3211.	3217.
.980	3224.	3231.	3237.	3244.	3250.	3257.	3263.	3270.	3277.	3283.
1.000	3290.	3296.	3303.	3309.	3316.	3323.	3329.	3336.	3342.	3349.

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
1.000	3290.	3296.	3303.	3309.	3316.	3323.	3329.	3336.	3342.	3349.
1.020	3356.	3362.	3369.	3375.	3382.	3388.	3395.	3402.	3408.	3415.
1.040	3421.	3428.	3434.	3441.	3448.	3454.	3461.	3467.	3474.	3481.
1.060	3487.	3494.	3500.	3507.	3513.	3520.	3527.	3533.	3540.	3546.
1.080	3553.	3559.	3566.	3573.	3579.	3586.	3592.	3599.	3606.	3612.
1.100	3619.	3625.	3632.	3638.	3645.	3652.	3658.	3665.	3671.	3678.
1.120	3685.	3691.	3698.	3704.	3711.	3717.	3724.	3731.	3737.	3744.
1.140	3750.	3757.	3763.	3770.	3777.	3783.	3790.	3796.	3803.	3810.
1.160	3816.	3823.	3829.	3836.	3842.	3849.	3856.	3862.	3869.	3875.
1.180	3882.	3888.	3895.	3902.	3908.	3915.	3921.	3928.	3935.	3941.
1.200	3948.	3954.	3961.	3967.	3974.	3983.	3991.	4000.	4008.	4017.
1.220	4026.	4034.	4043.	4052.	4060.	4069.	4077.	4086.	4095.	4103.
1.240	4112.	4121.	4129.	4138.	4146.	4155.	4164.	4172.	4181.	4190.
1.260	4198.	4207.	4215.	4224.	4233.	4241.	4250.	4258.	4267.	4276.
1.280	4284.	4293.	4302.	4310.	4319.	4327.	4336.	4345.	4353.	4362.
1.300	4371.	4379.	4388.	4396.	4405.	4414.	4422.	4431.	4440.	4448.
1.320	4457.	4465.	4474.	4483.	4491.	4500.	4508.	4517.	4526.	4534.
1.340	4543.	4552.	4560.	4569.	4577.	4586.	4595.	4603.	4612.	4621.
1.360	4629.	4638.	4646.	4655.	4664.	4672.	4681.	4690.	4698.	4707.
1.380	4715.	4724.	4733.	4741.	4750.	4758.	4767.	4776.	4784.	4793.
1.400	4802.	4810.	4819.	4827.	4836.	4845.	4853.	4862.	4871.	4879.
1.420	4888.	4896.	4905.	4914.	4922.	4931.	4940.	4948.	4957.	4965.
1.440	4974.	4982.	4990.	4998.	5006.	5014.	5022.	5030.	5038.	5046.
1.460	5054.	5062.	5070.	5078.	5086.	5094.	5102.	5110.	5118.	5126.
1.480	5134.	5142.	5150.	5158.	5166.	5174.	5182.	5190.	5198.	5206.
1.500	5214.	5222.	5230.	5238.	5246.	5254.	5262.	5270.	5278.	5286.
1.520	5294.	5302.	5310.	5318.	5326.	5334.	5342.	5350.	5358.	5366.
1.540	5374.	5382.	5390.	5398.	5406.	5414.	5422.	5430.	5438.	5446.
1.560	5454.	5462.	5470.	5478.	5486.	5494.	5502.	5510.	5518.	5526.
1.580	5534.	5542.	5550.	5558.	5566.	5574.	5582.	5590.	5598.	5606.
1.600	5614.	5622.	5630.	5638.	5646.	5654.	5662.	5670.	5678.	5686.
1.620	5694.	5702.	5710.	5718.	5726.	5734.	5742.	5750.	5758.	5766.
1.640	5774.	5782.	5790.	5798.	5806.	5814.	5822.	5830.	5838.	5846.
1.660	5854.	5862.	5870.	5878.	5886.	5894.	5902.	5910.	5918.	5926.
1.680	5934.	5942.	5950.	5958.	5966.	5974.	5982.	5991.	5999.	6007.
1.700	6015.	6024.	6032.	6040.	6048.	6057.	6065.	6073.	6081.	6090.
1.720	6098.	6106.	6114.	6123.	6131.	6139.	6148.	6156.	6164.	6172.
1.740	6181.	6189.	6197.	6205.	6214.	6222.	6230.	6238.	6247.	6255.
1.760	6263.	6272.	6280.	6288.	6296.	6305.	6313.	6321.	6329.	6338.
1.780	6346.	6354.	6362.	6371.	6379.	6387.	6395.	6404.	6412.	6420.
1.800	6429.	6437.	6445.	6453.	6462.	6470.	6478.	6486.	6495.	6503.
1.820	6511.	6519.	6528.	6536.	6544.	6553.	6561.	6569.	6577.	6586.
1.840	6594.	6602.	6610.	6619.	6627.	6635.	6643.	6652.	6660.	6668.
1.860	6676.	6685.	6693.	6701.	6710.	6718.	6726.	6734.	6743.	6751.
1.880	6759.	6767.	6776.	6784.	6792.	6800.	6809.	6817.	6825.	6834.
1.900	6842.	6850.	6858.	6867.	6875.	6883.	6891.	6900.	6908.	6916.
1.920	6924.	6933.	6941.	6949.	6957.	6966.	6974.	6985.	6995.	7006.
1.940	7017.	7027.	7038.	7048.	7059.	7070.	7080.	7091.	7102.	7112.
1.960	7123.	7134.	7144.	7155.	7165.	7176.	7187.	7197.	7208.	7219.
1.980	7229.	7240.	7251.	7261.	7272.	7283.	7293.	7304.	7314.	7325.
2.000	7336.	7346.	7357.	7368.	7378.	7389.	7400.	7410.	7421.	7431.

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S, R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

X

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
2.000	7336.	7346.	7357.	7368.	7378.	7389.	7400.	7410.	7421.	7431.
2.020	7442.	7453.	7463.	7474.	7485.	7495.	7506.	7517.	7527.	7538.
2.040	7548.	7559.	7570.	7580.	7591.	7602.	7612.	7623.	7634.	7644.
2.060	7655.	7665.	7676.	7687.	7697.	7708.	7719.	7729.	7740.	7751.
2.080	7761.	7772.	7783.	7793.	7804.	7814.	7825.	7836.	7846.	7857.
2.100	7868.	7878.	7889.	7900.	7910.	7921.	7931.	7942.	7953.	7963.
2.120	7974.	7984.	7993.	8003.	8012.	8022.	8031.	8041.	8050.	8060.
2.140	8069.	8079.	8088.	8098.	8107.	8117.	8126.	8136.	8145.	8155.
2.160	8164.	8174.	8184.	8193.	8203.	8212.	8222.	8231.	8241.	8250.
2.180	8260.	8269.	8279.	8288.	8298.	8307.	8317.	8326.	8336.	8345.
2.200	8355.	8364.	8374.	8384.	8393.	8403.	8412.	8422.	8431.	8441.
2.220	8450.	8460.	8469.	8479.	8488.	8498.	8507.	8517.	8526.	8536.
2.240	8545.	8555.	8564.	8574.	8584.	8593.	8603.	8612.	8622.	8631.
2.260	8641.	8650.	8660.	8669.	8679.	8688.	8698.	8707.	8717.	8726.
2.280	8736.	8745.	8755.	8764.	8774.	8784.	8793.	8803.	8812.	8822.
2.300	8831.	8841.	8850.	8860.	8869.	8879.	8888.	8898.	8907.	8917.
2.320	8926.	8936.	8945.	8955.	8964.	8974.	8985.	8995.	9006.	9016.
2.340	9027.	9037.	9048.	9058.	9069.	9079.	9090.	9100.	9111.	9121.
2.360	9132.	9142.	9153.	9163.	9174.	9185.	9195.	9206.	9216.	9227.
2.380	9237.	9248.	9258.	9269.	9279.	9290.	9300.	9311.	9321.	9332.
2.400	9342.	9353.	9363.	9374.	9385.	9395.	9406.	9416.	9427.	9437.
2.420	9448.	9458.	9469.	9479.	9490.	9500.	9511.	9521.	9532.	9542.
2.440	9553.	9563.	9574.	9585.	9595.	9606.	9616.	9627.	9637.	9648.
2.460	9658.	9669.	9679.	9690.	9700.	9711.	9721.	9732.	9742.	9753.
2.480	9763.	9774.	9785.	9795.	9806.	9816.	9827.	9837.	9848.	9858.
2.500	9869.	9879.	9890.	9900.	9911.	9921.	9932.	9942.	9953.	9963.
2.520	9974.	9984.	9994.	10005.	10015.	10025.	10035.	10045.	10056.	10066.
2.540	10076.	10086.	10096.	10107.	10117.	10127.	10137.	10147.	10158.	10168.
2.560	10178.	10188.	10198.	10209.	10219.	10229.	10239.	10250.	10260.	10270.
2.580	10280.	10290.	10301.	10311.	10321.	10331.	10341.	10352.	10362.	10372.
2.600	10382.	10392.	10403.	10413.	10423.	10433.	10443.	10454.	10464.	10474.
2.620	10484.	10494.	10505.	10515.	10525.	10535.	10545.	10556.	10566.	10576.
2.640	10586.	10596.	10607.	10617.	10627.	10637.	10647.	10658.	10668.	10678.
2.660	10688.	10698.	10709.	10719.	10729.	10739.	10750.	10760.	10770.	10780.
2.680	10790.	10801.	10811.	10821.	10831.	10841.	10852.	10862.	10872.	10882.
2.700	10892.	10903.	10913.	10923.	10933.	10943.	10954.	10964.	10974.	10985.
2.720	10996.	11007.	11018.	11030.	11041.	11052.	11063.	11074.	11085.	11096.
2.740	11107.	11118.	11130.	11141.	11152.	11163.	11174.	11185.	11196.	11207.
2.760	11218.	11230.	11241.	11252.	11263.	11274.	11285.	11296.	11307.	11318.
2.780	11330.	11341.	11352.	11363.	11374.	11385.	11396.	11407.	11418.	11430.
2.800	11441.	11452.	11463.	11474.	11485.	11496.	11507.	11518.	11530.	11541.
2.820	11552.	11563.	11574.	11585.	11596.	11607.	11618.	11630.	11641.	11652.
2.840	11663.	11674.	11685.	11696.	11707.	11718.	11730.	11741.	11752.	11763.
2.860	11774.	11785.	11796.	11807.	11818.	11830.	11841.	11852.	11863.	11874.
2.880	11885.	11896.	11907.	11918.	11930.	11941.	11952.	11963.	11974.	11987.
2.900	12000.	12012.	12025.	12038.	12051.	12064.	12077.	12089.	12102.	12115.
2.920	12128.	12141.	12153.	12166.	12179.	12192.	12205.	12218.	12230.	12243.
2.940	12256.	12269.	12282.	12295.	12307.	12320.	12333.	12346.	12359.	12371.
2.960	12384.	12397.	12410.	12423.	12436.	12448.	12461.	12474.	12483.	12491.
2.980	12500.	12508.	12517.	12526.	12534.	12543.	12552.	12560.	12569.	12577.
3.000	12586.	12595.	12603.	12612.	12621.	12629.	12638.	12646.	12655.	12664.

X

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
3.000	12586.	12595.	12603.	12612.	12621.	12629.	12638.	12646.	12655.	12664.
3.020	12672.	12681.	12690.	12698.	12707.	12715.	12724.	12733.	12741.	12750.
3.040	12758.	12767.	12776.	12784.	12793.	12802.	12810.	12819.	12827.	12836.
3.060	12845.	12853.	12862.	12871.	12879.	12888.	12896.	12905.	12914.	12922.
3.080	12931.	12940.	12948.	12957.	12965.	12974.	12983.	12992.	13001.	13010.
3.100	13019.	13029.	13038.	13047.	13056.	13065.	13074.	13083.	13092.	13101.
3.120	13110.	13119.	13129.	13138.	13147.	13156.	13165.	13174.	13183.	13192.
3.140	13201.	13210.	13219.	13229.	13238.	13247.	13256.	13265.	13274.	13283.
3.160	13292.	13301.	13310.	13319.	13329.	13338.	13347.	13356.	13365.	13374.
3.180	13383.	13392.	13401.	13410.	13419.	13429.	13438.	13447.	13456.	13465.
3.200	13474.	13484.	13494.	13504.	13514.	13524.	13534.	13544.	13554.	13564.
3.220	13574.	13584.	13594.	13604.	13614.	13624.	13634.	13644.	13654.	13664.
3.240	13674.	13684.	13694.	13704.	13714.	13724.	13734.	13744.	13754.	13764.
3.260	13774.	13784.	13794.	13804.	13814.	13824.	13834.	13844.	13854.	13864.
3.280	13874.	13884.	13894.	13904.	13914.	13924.	13934.	13944.	13954.	13964.
3.300	13974.	13983.	13993.	14002.	14012.	14021.	14031.	14040.	14049.	14059.
3.320	14068.	14078.	14087.	14097.	14106.	14116.	14125.	14134.	14144.	14153.
3.340	14163.	14172.	14182.	14191.	14200.	14210.	14219.	14229.	14238.	14248.
3.360	14257.	14266.	14276.	14285.	14295.	14304.	14314.	14323.	14332.	14342.
3.380	14351.	14361.	14370.	14380.	14389.	14399.	14408.	14417.	14427.	14436.
3.400	14446.	14455.	14465.	14474.	14483.	14492.	14500.	14509.	14518.	14527.
3.420	14535.	14544.	14553.	14562.	14570.	14579.	14588.	14597.	14606.	14614.
3.440	14623.	14632.	14641.	14649.	14658.	14667.	14676.	14685.	14693.	14702.
3.460	14711.	14720.	14728.	14737.	14746.	14755.	14763.	14772.	14781.	14790.
3.480	14799.	14807.	14816.	14825.	14834.	14842.	14851.	14860.	14869.	14878.
3.500	14886.	14895.	14904.	14913.	14921.	14930.	14939.	14948.	14956.	14965.
3.520	14974.	14987.	15000.	15012.	15025.	15038.	15051.	15064.	15077.	15089.
3.540	15102.	15115.	15128.	15141.	15153.	15166.	15179.	15192.	15205.	15218.
3.560	15230.	15243.	15256.	15269.	15282.	15295.	15307.	15320.	15333.	15346.
3.580	15359.	15371.	15384.	15397.	15410.	15423.	15436.	15448.	15461.	15474.
3.600	15484.	15494.	15504.	15514.	15524.	15534.	15544.	15554.	15564.	15574.
3.620	15584.	15594.	15604.	15614.	15624.	15634.	15644.	15654.	15664.	15674.
3.640	15684.	15694.	15704.	15714.	15724.	15734.	15744.	15754.	15764.	15774.
3.660	15784.	15794.	15804.	15814.	15824.	15834.	15844.	15854.	15864.	15874.
3.680	15884.	15894.	15904.	15914.	15924.	15934.	15944.	15954.	15964.	15974.
3.700	15984.	15997.	16009.	16022.	16034.	16047.	16059.	16072.	16085.	16097.
3.720	16110.	16122.	16135.	16147.	16160.	16172.	16185.	16198.	16210.	16223.
3.740	16235.	16248.	16260.	16273.	16286.	16298.	16311.	16323.	16336.	16348.
3.760	16361.	16373.	16386.	16399.	16411.	16424.	16436.	16449.	16461.	16474.
3.780	16484.	16494.	16504.	16514.	16524.	16534.	16544.	16554.	16564.	16574.
3.800	16584.	16594.	16604.	16614.	16624.	16634.	16644.	16654.	16664.	16674.
3.820	16684.	16694.	16704.	16714.	16724.	16734.	16744.	16754.	16764.	16774.
3.840	16784.	16794.	16804.	16814.	16824.	16834.	16844.	16854.	16864.	16874.
3.860	16884.	16894.	16904.	16914.	16924.	16934.	16944.	16954.	16964.	16974.
3.880	16983.	16993.	17002.	17012.	17021.	17031.	17040.	17049.	17059.	17068.
3.900	17078.	17087.	17096.	17106.	17115.	17125.	17134.	17144.	17153.	17162.
3.920	17172.	17181.	17191.	17200.	17210.	17219.	17228.	17238.	17247.	17257.
3.940	17266.	17276.	17285.	17294.	17304.	17313.	17323.	17332.	17341.	17351.
3.960	17360.	17370.	17379.	17389.	17398.	17407.	17417.	17426.	17436.	17445.
3.980	17455.	17464.	17475.	17486.	17497.	17508.	17519.	17530.	17541.	17553.
4.000	17564.	17575.	17586.	17597.	17608.	17619.	17630.	17641.	17652.	17663.

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
4.000	17564.	17575.	17586.	17597.	17608.	17619.	17630.	17641.	17652.	17663.
4.020	17674.	17685.	17696.	17707.	17718.	17730.	17741.	17752.	17763.	17774.
4.040	17785.	17796.	17807.	17818.	17829.	17840.	17851.	17862.	17873.	17884.
4.060	17895.	17907.	17918.	17929.	17940.	17951.	17962.	17973.	17984.	17995.
4.080	18005.	18016.	18027.	18037.	18048.	18059.	18069.	18080.	18091.	18101.
4.100	18112.	18122.	18133.	18144.	18154.	18165.	18176.	18186.	18197.	18208.
4.120	18218.	18229.	18240.	18250.	18261.	18272.	18282.	18293.	18304.	18314.
4.140	18325.	18335.	18346.	18357.	18367.	18378.	18389.	18399.	18410.	18421.
4.160	18431.	18442.	18452.	18462.	18473.	18483.	18493.	18503.	18513.	18524.
4.180	18534.	18544.	18554.	18564.	18575.	18585.	18595.	18605.	18615.	18626.
4.200	18636.	18646.	18656.	18666.	18677.	18687.	18697.	18707.	18718.	18728.
4.220	18738.	18748.	18758.	18769.	18779.	18789.	18799.	18809.	18820.	18830.
4.240	18840.	18850.	18860.	18871.	18881.	18891.	18901.	18911.	18922.	18932.
4.260	18942.	18955.	18967.	18980.	18992.	19005.	19017.	19030.	19042.	19055.
4.280	19067.	19080.	19092.	19105.	19117.	19130.	19142.	19155.	19167.	19180.
4.300	19192.	19205.	19217.	19230.	19242.	19255.	19267.	19280.	19292.	19305.
4.320	19317.	19330.	19343.	19355.	19368.	19380.	19393.	19405.	19418.	19430.
4.340	19443.	19455.	19468.	19480.	19493.	19505.	19518.	19530.	19543.	19555.
4.360	19568.	19580.	19593.	19605.	19618.	19630.	19643.	19655.	19668.	19680.
4.380	19693.	19706.	19718.	19731.	19743.	19756.	19768.	19781.	19793.	19806.
4.400	19818.	19831.	19843.	19856.	19868.	19881.	19893.	19906.	19918.	19931.
4.420	19943.	19956.	19968.	19981.	19993.	20006.	20018.	20031.	20043.	20056.
4.440	20068.	20081.	20094.	20106.	20119.	20131.	20144.	20156.	20169.	20181.
4.460	20194.	20206.	20219.	20231.	20244.	20256.	20269.	20281.	20294.	20306.
4.480	20319.	20331.	20344.	20356.	20369.	20381.	20394.	20406.	20419.	20431.
4.500	20444.	20457.	20469.	20482.	20494.	20507.	20520.	20532.	20545.	20557.
4.520	20570.	20583.	20595.	20608.	20621.	20633.	20646.	20658.	20671.	20684.
4.540	20696.	20709.	20721.	20734.	20747.	20759.	20772.	20784.	20797.	20810.
4.560	20822.	20835.	20847.	20860.	20873.	20885.	20898.	20911.	20923.	20936.
4.580	20948.	20961.	20974.	20986.	20999.	21011.	21024.	21036.	21047.	21059.
4.600	21071.	21082.	21094.	21106.	21117.	21129.	21141.	21152.	21164.	21176.
4.620	21188.	21199.	21211.	21223.	21234.	21246.	21258.	21269.	*21281.	21287.
4.640	21292.	21298.	21304.	21309.	21315.	21321.	21327.	21332.	21338.	21344.
4.660	21349.	21355.	21361.	21366.	21372.	21378.	21383.	21389.	21395.	21401.
4.680	21406.	21412.	21418.	21423.	21429.	21435.	21440.	21446.	21452.	21457.
4.700	21463.	21469.	21475.	21480.	21486.	21492.	21497.	21503.	21509.	21514.
4.720	21520.	21526.	21531.	21537.	21543.	21548.	21554.	21560.	21566.	21571.
4.740	21577.	21583.	21588.	21594.	21600.	21605.	21611.	21617.	21622.	21628.
4.760	21634.	21640.	21645.	21651.	21657.	21662.	21668.	21674.	21679.	21685.
4.780	21691.	21696.	21702.	21708.	21714.	21719.	21725.	21731.	21736.	21742.
4.800	21748.	21753.	21759.	21765.	21770.	21776.	21782.	21788.	21793.	21799.
4.820	21805.	21810.	21816.	21822.	21827.	21833.	21839.	21844.	21850.	21856.
4.840	21862.	21867.	21873.	21879.	21884.	21890.	21896.	21901.	21907.	21913.
4.860	21918.	21924.	21930.	21935.	21941.	21947.	21953.	21958.	21964.	21970.
4.880	21975.	21981.	21987.	21992.	21998.	22004.	22009.	22015.	22021.	22027.
4.900	22032.	22038.	22044.	22049.	22055.	22061.	22066.	22072.	22078.	22083.
4.920	22089.	22095.	22101.	22106.	22112.	22118.	22123.	22129.	22135.	22140.
4.940	22146.	22152.	22157.	22163.	22169.	22175.	22180.	22186.	22192.	22197.
4.960	22203.	22209.	22214.	22220.	22226.	22231.	22237.	22243.	22249.	22254.
4.980	22260.	22266.	22271.	22277.	22283.	22288.	22294.	22300.	22305.	22311.
5.000	22317.	22322.	22328.	22334.	22340.	22345.	22351.	22357.	22362.	22368.

Interpreted from Sonic

* LAST K shot Value

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
5.000	22317.	22322.	22328.	22334.	22340.	22345.	22351.	22357.	22362.	22368.
5.020	22374.	22379.	22385.	22391.	22396.	22402.	22408.	22414.	22419.	22425.
5.040	22431.	22436.	22442.	22448.	22453.	22459.	22465.	22470.	22476.	22482.
5.060	22488.	22493.	22499.	22505.	22510.	22516.	22522.	22527.	22533.	22539.
5.080	22544.	22550.	22556.	22562.	22567.	22573.	22579.	22584.	22590.	22596.
5.100	22601.	22607.	22613.	22618.	22624.	22630.	22636.	22641.	22647.	22653.
5.120	22658.	22664.	22670.	22675.	22681.	22687.	22692.	22698.	22704.	22710.
5.140	22715.	22721.	22727.	22732.	22738.	22744.	22749.	22755.	22761.	22766.
5.160	22772.	22778.	22783.	22789.	22795.	22801.	22806.	22812.	22818.	22823.
5.180	22829.	22835.	22840.	22846.	22852.	22857.	22863.	22869.	22875.	22880.
5.200	22886.	22892.	22897.	22903.	22909.	22914.	22920.	22926.	22931.	22937.
5.220	22943.	22949.	22954.	22960.	22966.	22971.	22977.	22983.	22988.	22994.
5.240	23000.	23005.	23011.	23017.	23023.	23028.	23034.	23040.	23045.	23051.
5.260	23057.	23062.	23068.	23074.	23079.	23085.	23091.	23097.	23102.	23108.
5.280	23114.	23119.	23125.	23131.	23136.	23142.	23148.	23153.	23159.	23165.
5.300	23170.	23176.	23182.	23188.	23193.	23199.	23205.	23210.	23216.	23222.
5.320	23227.	23233.	23239.	23244.	23250.	23256.	23262.	23267.	23273.	23279.
5.340	23284.	23290.	23296.	23301.	23307.	23313.	23318.	23324.	23330.	23336.
5.360	23341.	23347.	23353.	23358.	23364.	23370.	23375.	23381.	23387.	23392.
5.380	23398.	23404.	23410.	23415.	23421.	23427.	23432.	23438.	23444.	23449.
5.400	23455.	23461.	23466.	23472.	23478.	23484.	23489.	23495.	23501.	23506.
5.420	23512.	23518.	23523.	23529.	23535.	23540.	23546.	23552.	23558.	23563.
5.440	23569.	23575.	23580.	23586.	23592.	23597.	23603.	23609.	23614.	23620.
5.460	23626.	23631.	23637.	23643.	23649.	23654.	23660.	23666.	23671.	23677.
5.480	23683.	23688.	23694.	23700.	23705.	23711.	23717.	23723.	23728.	23734.
5.500	23740.	23745.	23751.	23757.	23762.	23768.	23774.	23779.	23785.	23791.
5.520	23797.	23802.	23808.	23814.	23819.	23825.	23831.	23836.	23842.	23848.
5.540	23853.	23859.	23865.	23871.	23876.	23882.	23888.	23893.	23899.	23905.
5.560	23910.	23916.	23922.	23927.	23933.	23939.	23945.	23950.	23956.	23962.
5.580	23967.	23973.	23979.	23984.	23990.	23996.	24001.	24007.	24013.	24018.
5.600	24024.	24030.	24036.	24041.	24047.	24053.	24058.	24064.	24070.	24075.
5.620	24081.	24087.	24092.	24098.	24104.	24110.	24115.	24121.	24127.	24132.
5.640	24138.	24144.	24149.	24155.	24161.	24166.	24172.	24178.	24184.	24189.
5.660	24195.	24201.	24206.	24212.	24218.	24223.	24229.	24235.	24240.	24246.
5.680	24252.	24258.	24263.	24269.	24275.	24280.	24286.	24292.	24297.	24303.
5.700	24309.	24314.	24320.	24326.	24332.	24337.	24343.	24349.	24354.	24360.
5.720	24366.	24371.	24377.	24383.	24388.	24394.	24400.	24405.	24411.	24417.
5.740	24423.	24428.	24434.	24440.	24445.	24451.	24457.	24462.	24468.	24474.
5.760	24479.	24485.	24491.	24497.	24502.	24508.	24514.	24519.	24525.	24531.
5.780	24536.	24542.	24548.	24553.	24559.	24565.	24571.	24576.	24582.	24588.
5.800	24593.	24599.	24605.	24610.	24616.	24622.	24627.	24633.	24639.	24645.
5.820	24650.	24656.	24662.	24667.	24673.	24679.	24684.	24690.	24696.	24701.
5.840	24707.	24713.	24719.	24724.	24730.	24736.	24741.	24747.	24753.	24758.
5.860	24764.	24770.	24775.	24781.	24787.	24793.	24798.	24804.	24810.	24815.
5.880	24821.	24827.	24832.	24838.	24844.	24849.	24855.	24861.	24866.	24872.
5.900	24878.	24884.	24889.	24895.	24901.	24906.	24912.	24918.	24923.	24929.
5.920	24935.	24940.	24946.	24952.	24958.	24963.	24969.	24975.	24980.	24986.
5.940	24992.	24997.	25003.	25009.	25014.	25020.	25026.	25032.	25037.	25043.
5.960	25049.	25054.	25060.	25066.	25071.	25077.	25083.	25088.	25094.	25100.
5.980	25106.	25111.	25117.	25123.	25128.	25134.	25140.	25145.	25151.	25157.
6.000	25162.	25168.	25174.	25180.	25185.	25191.	25197.	25202.	25208.	25214.

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
6.000	25162.	25168.	25174.	25180.	25185.	25191.	25197.	25202.	25208.	25214.
6.020	25219.	25225.	25231.	25236.	25242.	25248.	25253.	25259.	25265.	25271.
6.040	25276.	25282.	25288.	25293.	25299.	25305.	25310.	25316.	25322.	25327.
6.060	25333.	25339.	25345.	25350.	25356.	25362.	25367.	25373.	25379.	25384.
6.080	25390.	25396.	25401.	25407.	25413.	25419.	25424.	25430.	25436.	25441.
6.100	25447.	25453.	25458.	25464.	25470.	25475.	25481.	25487.	25493.	25498.
6.120	25504.	25510.	25515.	25521.	25527.	25532.	25538.	25544.	25549.	25555.
6.140	25561.	25567.	25572.	25578.	25584.	25589.	25595.	25601.	25606.	25612.
6.160	25618.	25623.	25629.	25635.	25640.	25646.	25652.	25658.	25663.	25669.
6.180	25675.	25680.	25686.	25692.	25697.	25703.	25709.	25714.	25720.	25726.
6.200	25732.	25737.	25743.	25749.	25754.	25760.	25766.	25771.	25777.	25783.
6.220	25788.	25794.	25800.	25806.	25811.	25817.	25823.	25828.	25834.	25840.
6.240	25845.	25851.	25857.	25862.	25868.	25874.	25880.	25885.	25891.	25897.
6.260	25902.	25908.	25914.	25919.	25925.	25931.	25936.	25942.	25948.	25954.
6.280	25959.	25965.	25971.	25976.	25982.	25988.	25993.	25999.	26005.	26010.
6.300	26016.	26022.	26028.	26033.	26039.	26045.	26050.	26056.	26062.	26067.
6.320	26073.	26079.	26084.	26090.	26096.	26101.	26107.	26113.	26119.	26124.
6.340	26130.	26136.	26141.	26147.	26153.	26158.	26164.	26170.	26175.	26181.
6.360	26187.	26193.	26198.	26204.	26210.	26215.	26221.	26227.	26232.	26238.
6.380	26244.	26249.	26255.	26261.	26267.	26272.	26278.	26284.	26289.	26295.
6.400	26301.	26306.	26312.	26318.	26323.	26329.	26335.	26341.	26346.	26352.
6.420	26358.	26363.	26369.	26375.	26380.	26386.	26392.	26397.	26403.	26409.
6.440	26415.	26420.	26426.	26432.	26437.	26443.	26449.	26454.	26460.	26466.
6.460	26471.	26477.	26483.	26488.	26494.	26500.	26506.	26511.	26517.	26523.
6.480	26528.	26534.	26540.	26545.	26551.	26557.	26562.	26568.	26574.	26580.
6.500	26585.	26591.	26597.	26602.	26608.	26614.	26619.	26625.	26631.	26636.
6.520	26642.	26648.	26654.	26659.	26665.	26671.	26676.	26682.	26688.	26693.
6.540	26699.	26705.	26710.	26716.	26722.	26728.	26733.	26739.	26745.	26750.
6.560	26756.	26762.	26767.	26773.	26779.	26784.	26790.	26796.	26802.	26807.
6.580	26813.	26819.	26824.	26830.	26836.	26841.	26847.	26853.	26858.	26864.
6.600	26870.	26876.	26881.	26887.	26893.	26898.	26904.	26910.	26915.	26921.
6.620	26927.	26932.	26938.	26944.	26949.	26955.	26961.	26967.	26972.	26978.
6.640	26984.	26989.	26995.	27001.	27006.	27012.	27018.	27023.	27029.	27035.
6.660	27041.	27046.	27052.	27058.	27063.	27069.	27075.	27080.	27086.	27092.
6.680	27097.	27103.	27109.	27115.	27120.	27126.	27132.	27137.	27143.	27149.
6.700	27154.	27160.	27166.	27171.	27177.	27183.	27189.	27194.	27200.	27206.
6.720	27211.	27217.	27223.	27228.	27234.	27240.	27245.	27251.	27257.	27263.
6.740	27268.	27274.	27280.	27285.	27291.	27297.	27302.	27308.	27314.	27319.
6.760	27325.	27331.	27336.	27342.	27348.	27354.	27359.	27365.	27371.	27376.
6.780	27382.	27388.	27393.	27399.	27405.	27410.	27416.	27422.	27428.	27433.
6.800	27439.	27445.	27450.	27456.	27462.	27467.	27473.	27479.	27484.	27490.
6.820	27496.	27502.	27507.	27513.	27519.	27524.	27530.	27536.	27541.	27547.
6.840	27553.	27558.	27564.	27570.	27576.	27581.	27587.	27593.	27598.	27604.
6.860	27610.	27615.	27621.	27627.	27632.	27638.	27644.	27650.	27655.	27661.
6.880	27667.	27672.	27678.	27684.	27689.	27695.	27701.	27706.	27712.	27718.
6.900	27723.	27729.	27735.	27741.	27746.	27752.	27758.	27763.	27769.	27775.
6.920	27780.	27786.	27792.	27797.	27803.	27809.	27815.	27820.	27826.	27832.
6.940	27837.	27843.	27849.	27854.	27860.	27866.	27871.	27877.	27883.	27889.
6.960	27894.	27900.	27906.	27911.	27917.	27923.	27928.	27934.	27940.	27945.
6.980	27951.	27957.	27963.	27968.	27974.	27980.	27985.	27991.	27997.	28002.
7.000	28008.	28014.	28019.	28025.	28031.	28037.	28042.	28048.	28054.	28059.

THE SUPERIOR OIL COMPANY
HULIN NO. 1
SEC I, T14S,R4E
VERMILION PH., LA.
TIME/DEPTH LISTING

	0.000	.002	.004	.006	.008	.010	.012	.014	.016	.018
7.000	28008.	28014.	28019.	28025.	28031.	28037.	28042.	28048.	28054.	28059.
7.020	28065.	28071.	28076.	28082.	28088.	28093.	28099.	28105.	28111.	28116.
7.040	28122.	28128.	28133.	28139.	28145.	28150.	28156.	28162.	28167.	28173.
7.060	28179.	28184.	28190.	28196.	28202.	28207.	28213.	28219.	28224.	28230.
7.080	28236.	28241.	28247.	28253.	28258.	28264.	28270.	28276.	28281.	28287.
7.100	28293.	28298.	28304.	28310.	28315.	28321.	28327.	28332.	28338.	28344.
7.120	28350.	28355.	28361.	28367.	28372.	28378.	28384.	28389.	28395.	28401.
7.140	28406.	28412.	28418.	28424.	28429.	28435.	28441.	28446.	28452.	28458.
7.160	28463.	28469.	28475.	28480.	28486.	28492.	28498.	28503.	28509.	28515.
7.180	28520.	28526.	28532.	28537.	28543.	28549.	28554.	28560.	28566.	28571.
7.200	28577.	28583.	28589.	28594.	28600.	28606.	28611.	28617.	28623.	28628.
7.220	28634.	28640.	28645.	28651.	28657.	28663.	28668.	28674.	28680.	28685.
7.240	28691.	28697.	28702.	28708.	28714.	28719.	28725.	28731.	28737.	28742.
7.260	28748.	28754.	28759.	28765.	28771.	28776.	28782.	28788.	28793.	28799.
7.280	28805.	28811.	28816.	28822.	28828.	28833.	28839.	28845.	28850.	28856.
7.300	28862.	28867.	28873.	28879.	28885.	28890.	28896.	28902.	28907.	28913.
7.320	28919.	28924.	28930.	28936.	28941.	28947.	28953.	28959.	28964.	28970.
7.340	28976.	28981.	28987.	28993.	28998.	29004.	29010.	29015.	29021.	29027.
7.360	29032.	29038.	29044.	29050.	29055.	29061.	29067.	29072.	29078.	29084.
7.380	29089.	29095.	29101.	29106.	29112.	29118.	29124.	29129.	29135.	29141.
7.400	29146.	29152.	29158.	29163.	29169.	29175.	29180.	29186.	29192.	29198.
7.420	29203.	29209.	29215.	29220.	29226.	29232.	29237.	29243.	29249.	29254.
7.440	29260.	29266.	29272.	29277.	29283.	29289.	29294.	29300.	29306.	29311.
7.460	29317.	29323.	29328.	29334.	29340.	29346.	29351.	29357.	29363.	29368.
7.480	29374.	29380.	29385.	29391.	29397.	29402.	29408.	29414.	29419.	29425.
7.500	29431.	29437.	29442.	29448.	29454.	29459.	29465.	29471.	29476.	29482.
7.520	29488.	29493.	29499.	29505.	29511.	29516.	29522.	29528.	29533.	29539.
7.540	29545.	29550.	29556.	29562.	29567.	29573.	29579.	29585.	29590.	29596.
7.560	29602.	29607.	29613.	29619.	29624.	29630.	29636.	29641.	29647.	29653.
7.580	29659.	29664.	29670.	29676.	29681.	29687.	29693.	29698.	29704.	29710.
7.600	29715.	29721.	29727.	29733.	29738.	29744.	29750.	29755.	29761.	29767.
7.620	29772.	29778.	29784.	29789.	29795.	29801.	29806.	29812.	29818.	29824.
7.640	29829.	29835.	29841.	29846.	29852.	29858.	29863.	29869.	29875.	29880.
7.660	29886.	29892.	29898.	29903.	29909.	29915.	29920.	29926.	29932.	29937.
7.680	29943.	29949.	29954.	29960.	29966.	29972.	29977.	29983.	29989.	29994.
7.700	30000.									

Louisiana State University

Center for Coastal, Energy, and Environmental Resources (CCEER)

CCEER is a group of organized research units and related academic programs managed through a college-like structure to facilitate innovative, cooperative research that leads to a better understanding of resources and environmental issues important to Louisiana and the Gulf of Mexico region. CCEER is increasing the use of its expertise in international programs through cooperative projects in other countries. Students benefit from CCEER research through participation in its academic programs in environmental studies, oceanography and coastal sciences, and nuclear science. An Information Services Division provides strong educational outreach to the schools and citizens of Louisiana. The units that comprise CCEER are as follows:

Basin Research Institute
Center for Energy Studies
Coastal Ecology Institute
Coastal Fisheries Institute
Coastal Studies Institute
Department of Oceanography and Coastal Sciences
Information Services Division
Institute for Environmental Studies
Mining and Mineral Resources Research Institute
Nuclear Science Center
Special Programs
Wetland Biogeochemistry Institute

For further information please contact

Office of the Executive Director
Center for Coastal, Energy, and Environmental Resources
Louisiana State University
E302 Howe-Russell Geoscience Complex
Baton Rouge, Louisiana 70803
(504) 388-6316