MINERAL RESOURCE EVALUATION OF THE PROPOSED SHAWS BEND RESERVOIR SITE

by

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INTRODUCTION

The purpose of this report is to evaluate the mineral resources in the proposed Shaws Bend reservoir and dam site area (fig. 1), referred to in this report as the contract area. The proposed reservoir area is located on the Colorado River floodplain extending north from Columbus, in Colorado County, to 8 mi northwest of La Grange in Fayette County. The four evaluated resources include oil and gas, sand and gravel, near-surface and deep-basin lignite, and uranium. No other mineral resources are known to occur in the contract area in amounts significantly greater than the background levels present in all rocks.

GEOLOGY

Cenozoic strata ranging in age from late Eocene to Quaternary are exposed along the reservoir site as follows: the Caddell, Wellborn, Manning, and Whitsett Formations of the Jackson Group and the Catahoula, Oakville, Fleming, and Willis Formations (figs. 1 and 2). Fluviatile terraces and alluvium are also present. Strike of the bedrock units is northeast-southwest, and dip is from 1 to 4 degrees toward the Texas coast. Faults are rarely expressed at the surface. The deposits are composed of interbedded clay, silt, and sand or sandstone except for the Willis Formation, which is composed of gravel and sand. The strata are fluvial and deltaic in origin except for the Caddell Formation, which is of marine origin.

OIL AND GAS

Three major oil and gas trends cross the contract area: the Wilcox, the Austin Chalk, and the Stuart City - Edwards reef complex (fig. 3). Each trend will be considered in more detail in the following sections. Figures 4 and 5 show the location of all wells within the contract area;

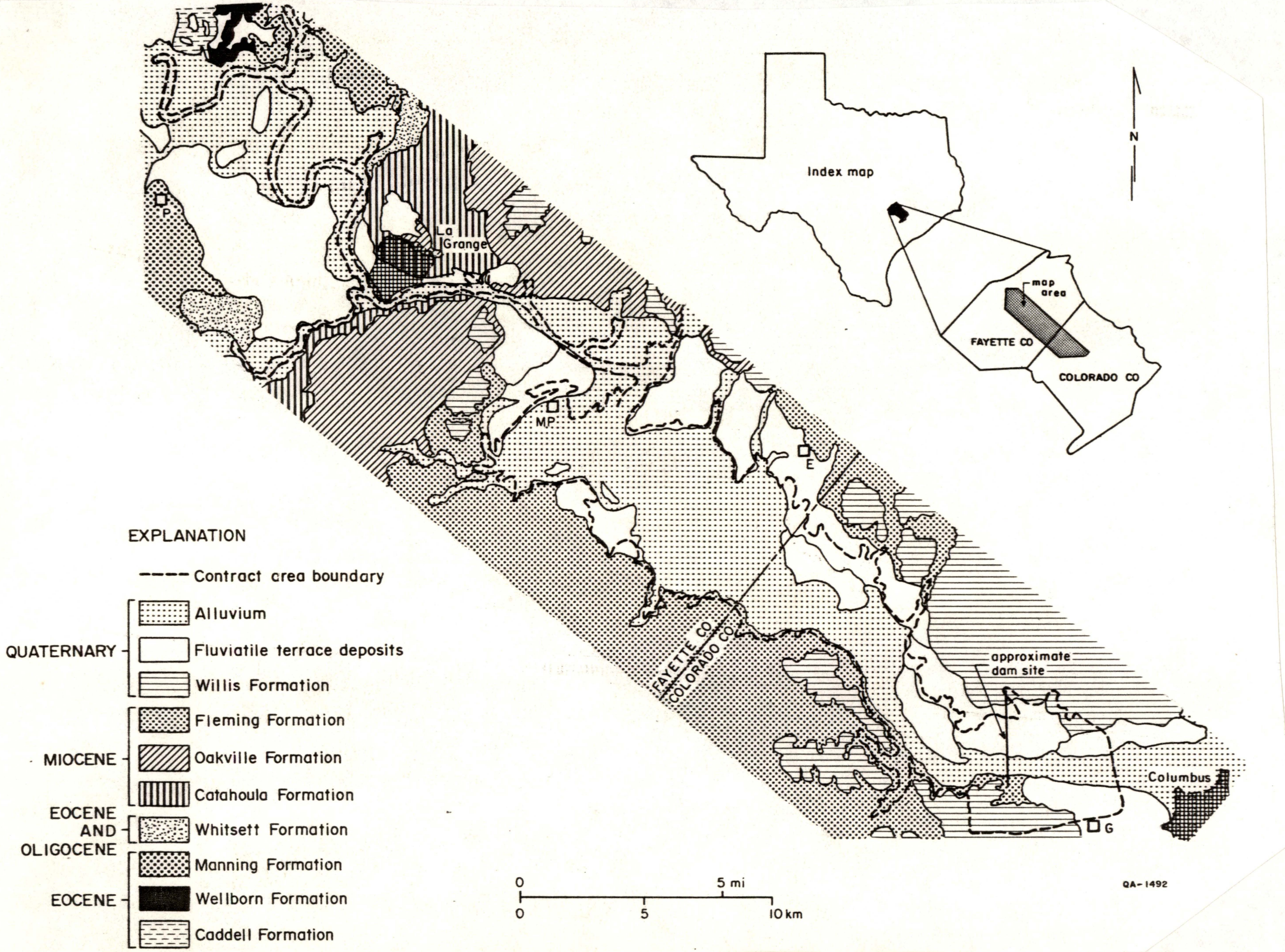

Figure 1. Geologic map of the proposed Shaws Bend reservoir site (contract area) (from Barnes, 1974) (P = Plum, MP = Mullins Prairie, E = Ellinger, G = Glidden).

Erathem	System	Series	Group or Formation	Major Lithology	Mineral Resource (potential or known)	
CENOZOIC	Quaternary	Recent	Alluvium	Clay, sand, and gravel	Sand and gravel	SURFACE
		Pleistocene	Fluviatile terrace deposits	Clay, gravel, and sand	Sand and gravel	
			Willis Fm.	Gravel, sand, and clay	Sand and gravel	
	Tertiary	Miocene	Fleming Fm.	Clay and sand		
			Oakville Fm.	Sand	Uranium	
			Catahoula Fm.	Sand	Uranium	
		Eocene-Oligocene	Whitsett Fm.	Sand	Uranium	
		Eocene	Manning Fm.	Clay	Lignite, uranium	
			Wellborn Fm.	Sandstone	Lignite	
			Caddell Fm.	Clay		
			Yegua Fm.	Sandstone	Lignite	SUBSURFACE
			Cook Mountain Fm.	Clay		
			Sparta Fm.	Sandstone		
			Weches Fm.	Clay		
			Queen City Fm.	Sandstone		
			Reklaw Fm.	Clay		
		Eocene / Paleocene	Wilcox Group (Carrizo Fm. included)	Sandstone	Oil and gas	
		Paleocene	Midway Group	Clay		
MESOZOIC	Cretaceous	Upper Cretaceous	Navarro Group	Clay		
			Taylor Group (Pecan Gap Fm. incl.)	Clay and marl		
			Austin Group	Limestone and shale	Oil and gas	
			Eagle Ford Gp.	Shale and limestone		
		Lower Cretaceous	Edwards-Stuart City	Limestone	Oil and gas	

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Figure 2. Generalized stratigraphic column for the proposed Shaws Bend reservoir site.

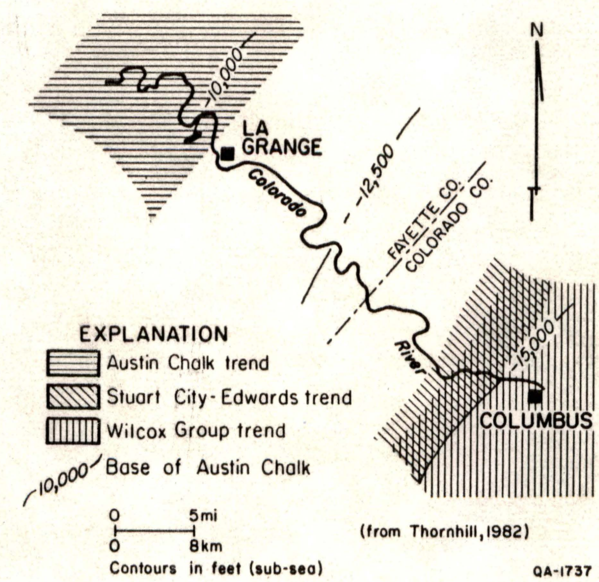


Figure 3. Oil and gas trends in the contract area and structure contours on the base of the Austin Chalk. See figure 1 for contract area boundary.

producing wells are indicated. Legal location, total depth, and producing zones of these wells are listed in table 1 (tables begin on p. 37). All production and well statistics in this report are from Railroad Commission of Texas records and Dwight's reports (1980a, 1980b).

Wilcox Group

The only current production within the contract area is from the Wilcox Group. Wilcox fields intersecting the contract area include the Columbus oil and gas, the Columbus West gas, and the Glidden gas fields (fig. 6). Wilcox strata display an upper delta-front and marine destructional sequence (those sediments above the 7C sand, figs. 7 and 8) and a lower delta-plain and prodelta sequence (those sediments below the 7C sand) (Fisher and McGowen, 1967). Wilcox sediments are gray, medium- to fine-grained sandstones, siltstones, claystones, and lignites. Oil and gas are found most commonly in the more permeable sands and silts; the hydrocarbons have migrated from downdip source rocks.

Columbus Field

The Columbus field, discovered in 1944, extends into the contract area near Columbus in Colorado County. Production reached its height in the 1960's; current activity is limited to the northwestern part of the field. The hydrocarbon trapping mechanism for the Columbus field is probably a combination of (1) a rollover anticline bounded by an updip growth fault and (2) sand pinch-outs on the northeast and southwest (fig. 9). Hydrocarbons are driven out primarily by expansion of the gas cap.

Production History

Production increased to more than 22,000 MMcf/year and nearly 600,000 barrels/year during the late 1960's for the more than 50 gas and oil reservoirs in the Columbus field (figs. 10, 11, and 12). Most of the hydrocarbon production was from a depth of 9,000 to 10,000 ft. Gas injection into the 7C reservoir was initiated in 1957 (Cities Service Oil Company, 1970). The 7C zone is not listed in figure 11 because it was grouped under the general Columbus field

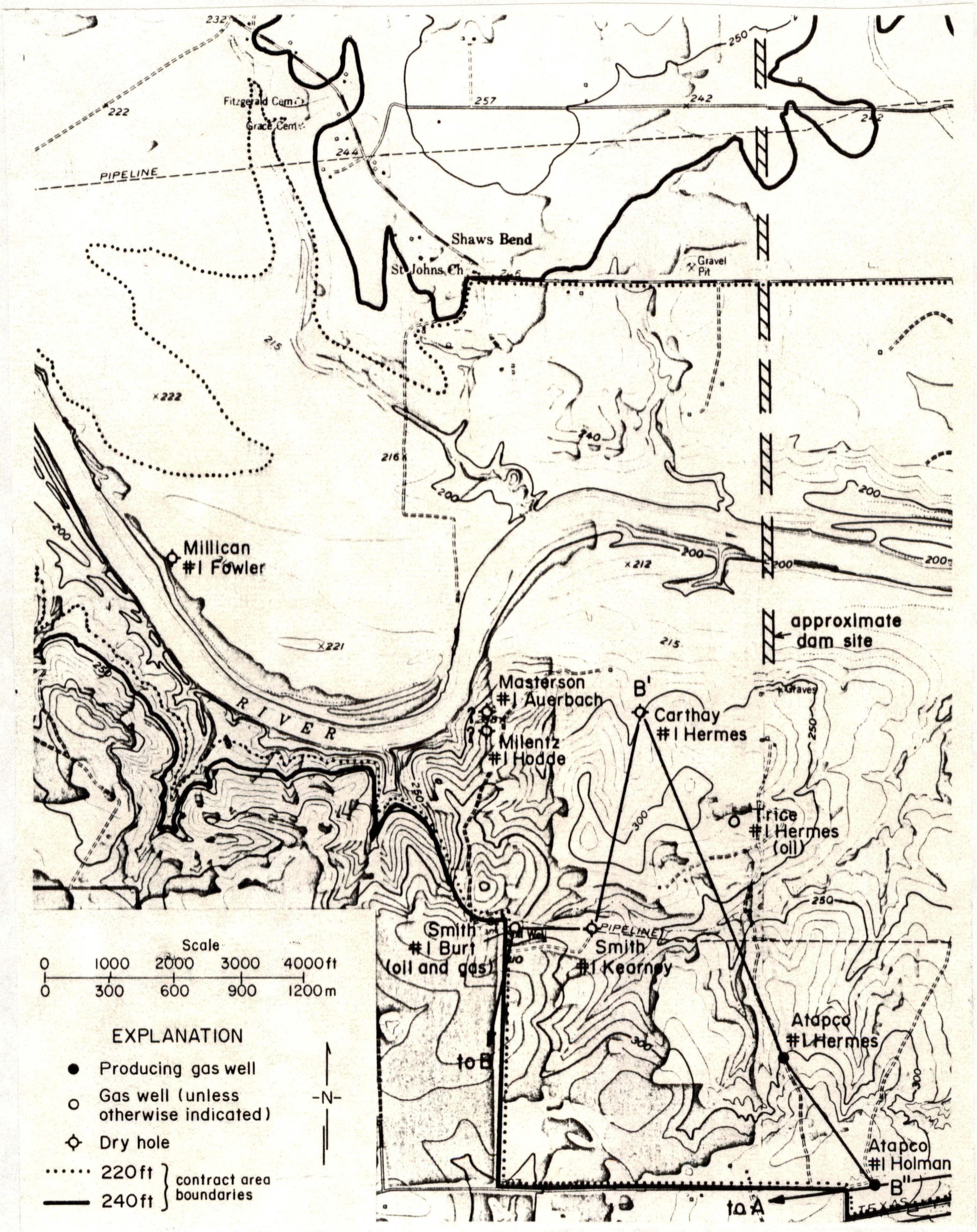
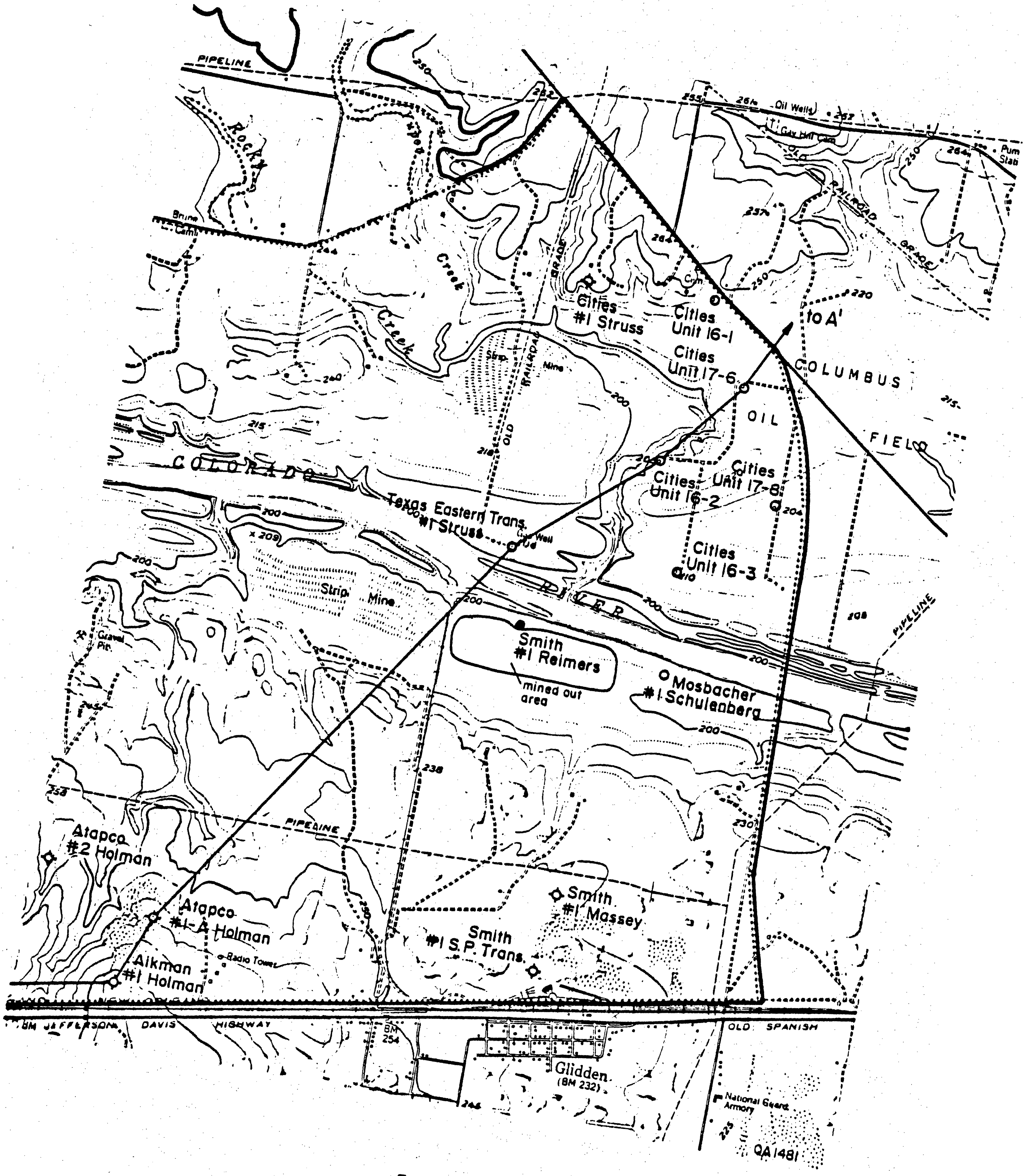
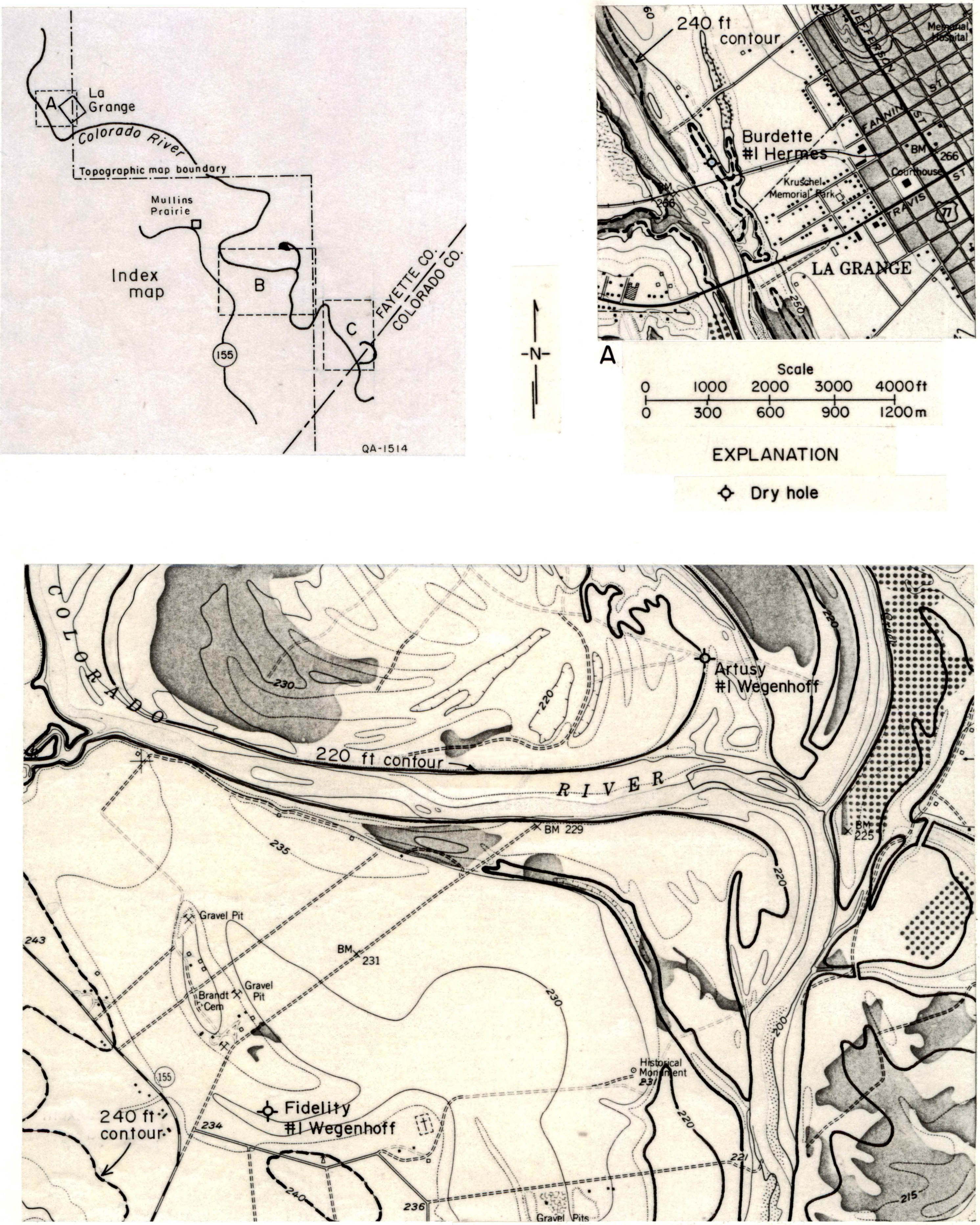


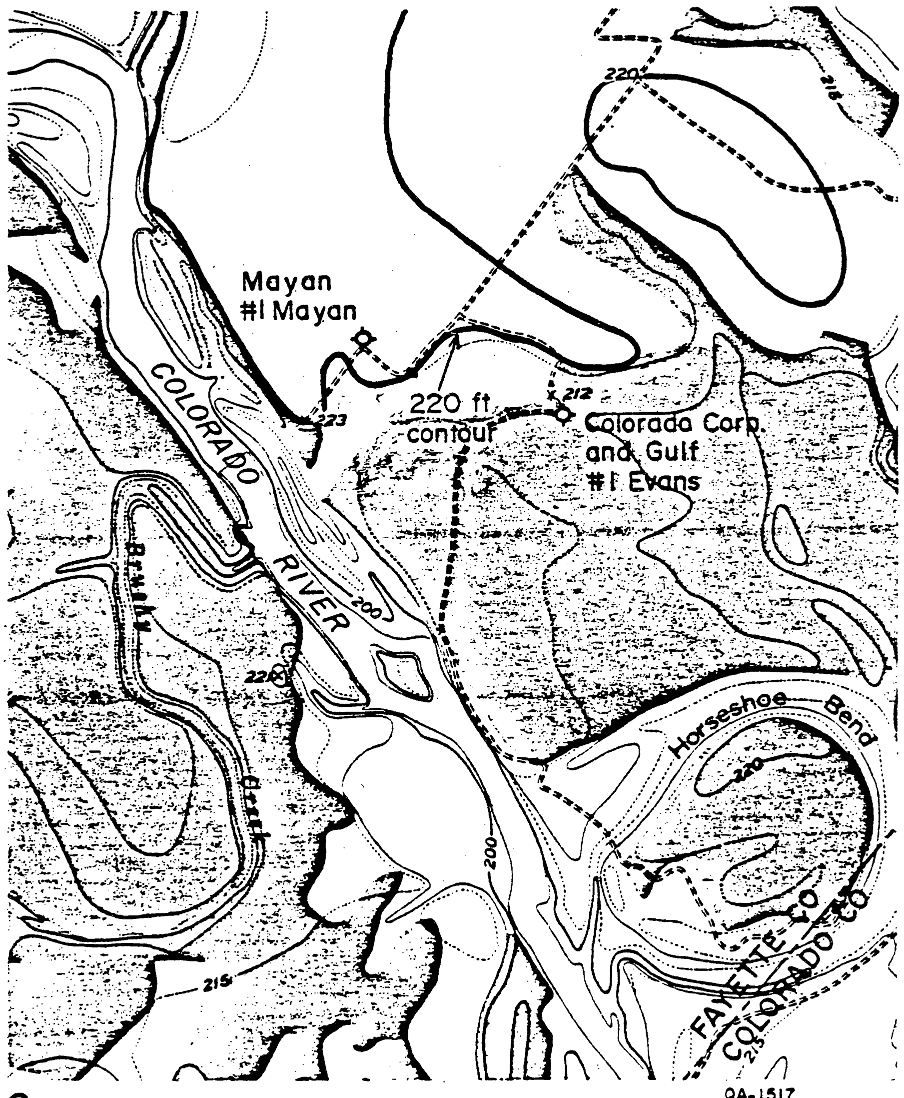
Figure 4. Location of all wells within the contract area south of Shaws Bend. Cross-section lines shown are for figures 7 and 8.



PIPELINE
Rocky
Creek
Brine
Oil Wells
Gay Hill Cem.
RAILROAD
GRADE
Cities
#1 Struss
Cities
Unit 16-1
to A'
Cities
Unit 17-6
COLUMBUS
OIL
FIELD
Cities
Unit 17-8
Cities
Unit 16-2
Cities
Unit 16-3
COLORADO
RIVER
Texas Eastern Trans.
#1 Struss
Strip Mine
Gravel Pit
Smith
#1 Reimers
mined out area
Mosbacher
#1 Schulenberg
Atapco
#2 Holman
Atapco
#1-A Holman
Aikman
#1 Holman
Radio Tower
Smith
#1 Massey
Smith
#1 S.P. Trans.
JEFFERSON DAVIS HIGHWAY
OLD SPANISH
BM 254
Glidden
(BM 232)
National Guard Armory
QA1481



La Grange
Colorado River
Topographic map boundary
Mullins Prairie
Index map
A
B
C
155
FAYETTE CO.
COLORADO CO.
QA-1514
N
240 ft contour
Memorial Hospital
JEFFERSON
FANNIN ST
ST
Burdette #1 Hermes
BM 266
Courthouse
Kruschel Memorial Park
BM 266
TRAVIS
77
LA GRANGE
250
A
Scale
0 1000 2000 3000 4000 ft
0 300 600 900 1200 m
EXPLANATION
Dry hole
COLORADO
RIVER
230
220
Artusy #1 Wegenhoff
220 ft contour
BM 229
BM 225
235
Gravel Pit
243
BM 231
Brandt Cem
Gravel Pit
230
200
155
Historical Monument
231
Fidelity #1 Wegenhoff
240 ft contour
234
220
240
221
236
Gravel Pits
215
B



C.

Figure 5. Location of all wells within the contract area north of Shaws Bend (at left and above). Locations approximate.

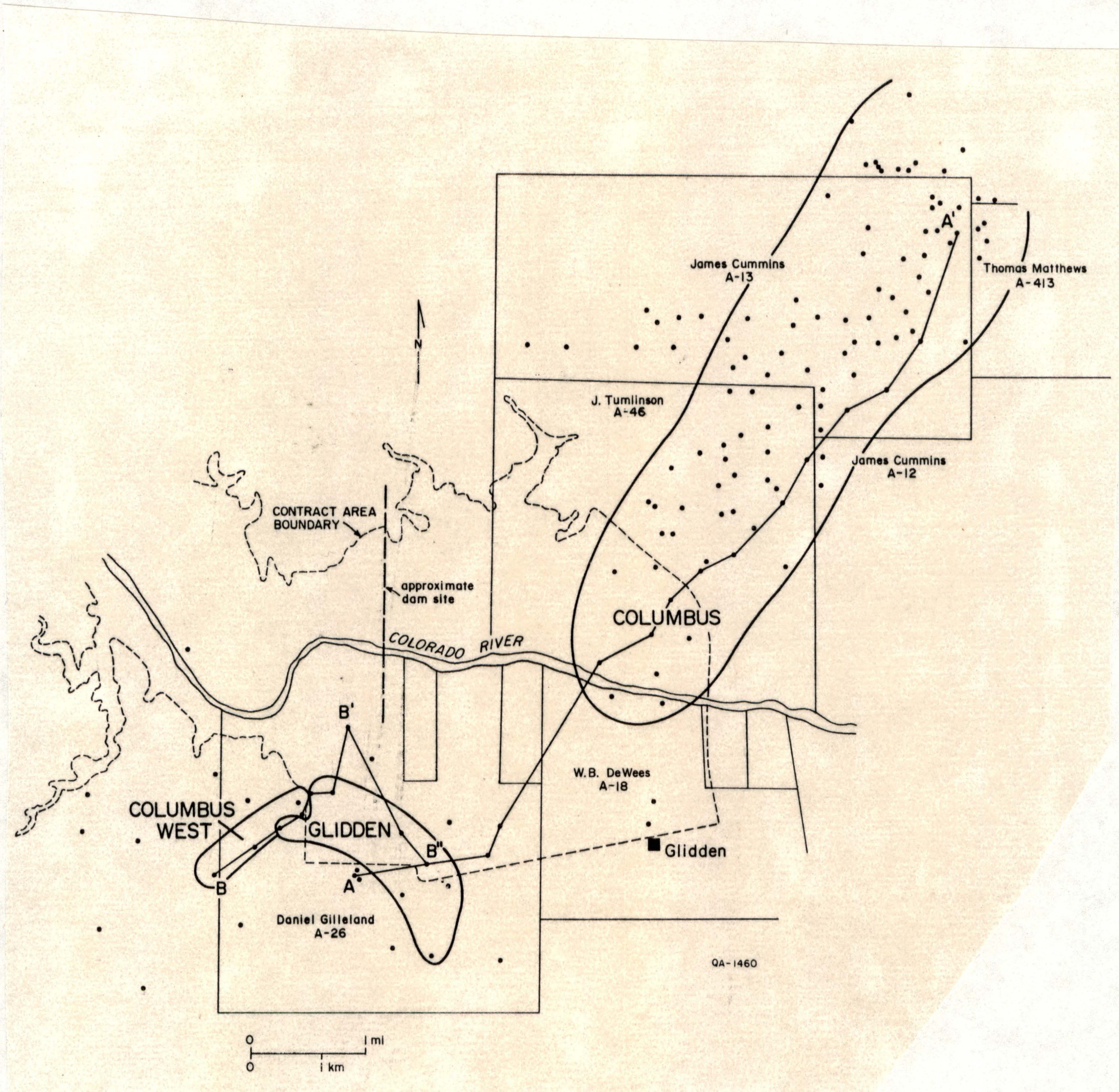


Figure 6. Columbus, Columbus West, and Glidden fields, Wilcox trend, Colorado County. Cross-section lines shown (A-A' and B-B'') are for figures 7 and 8.

See separate file for Figure 7

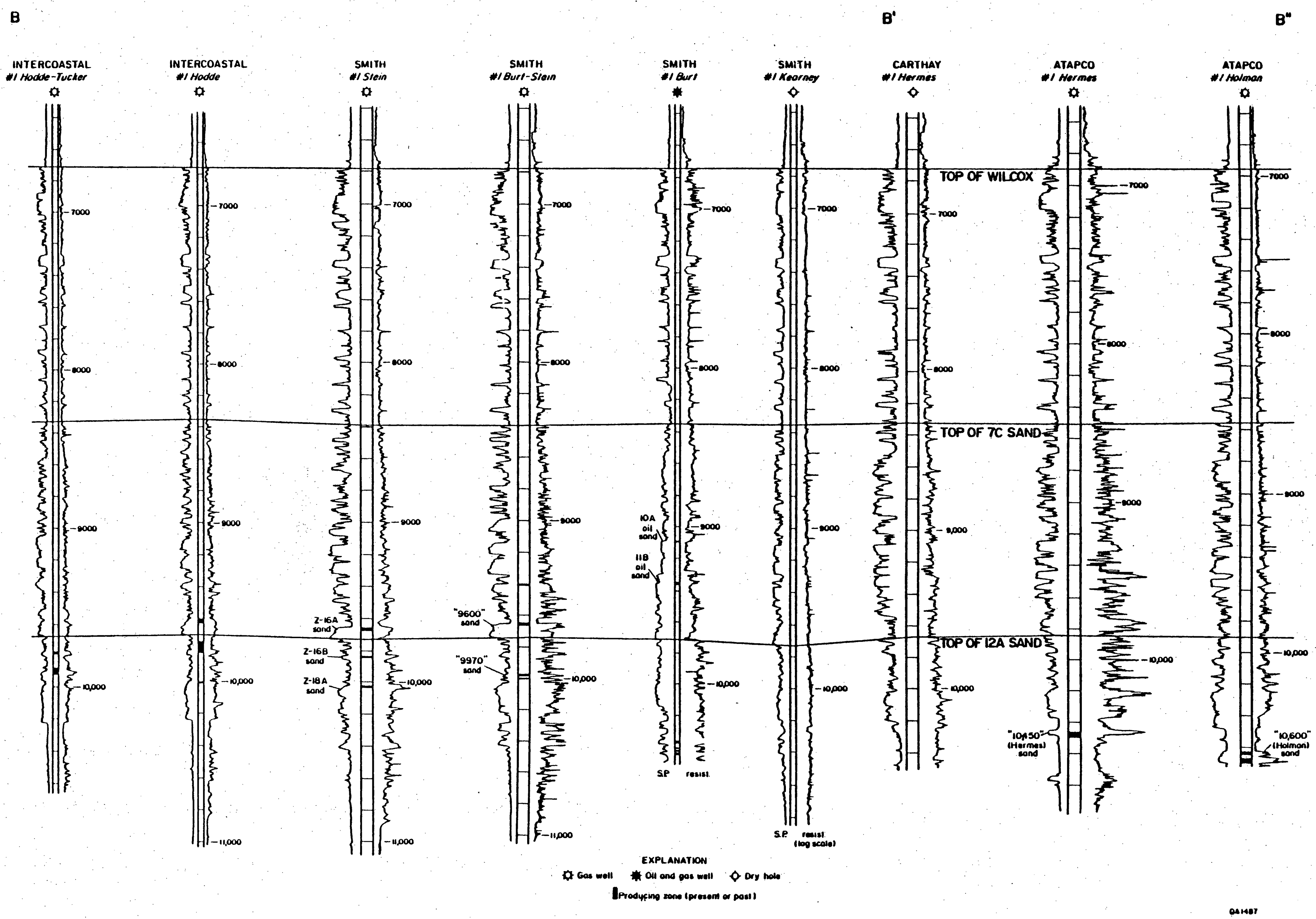


Figure 8. Strike (B-B') and dip (B'-B") cross sections through the Columbus West and Glidden fields. Location of section shown on figure 6. Not to horizontal scale.

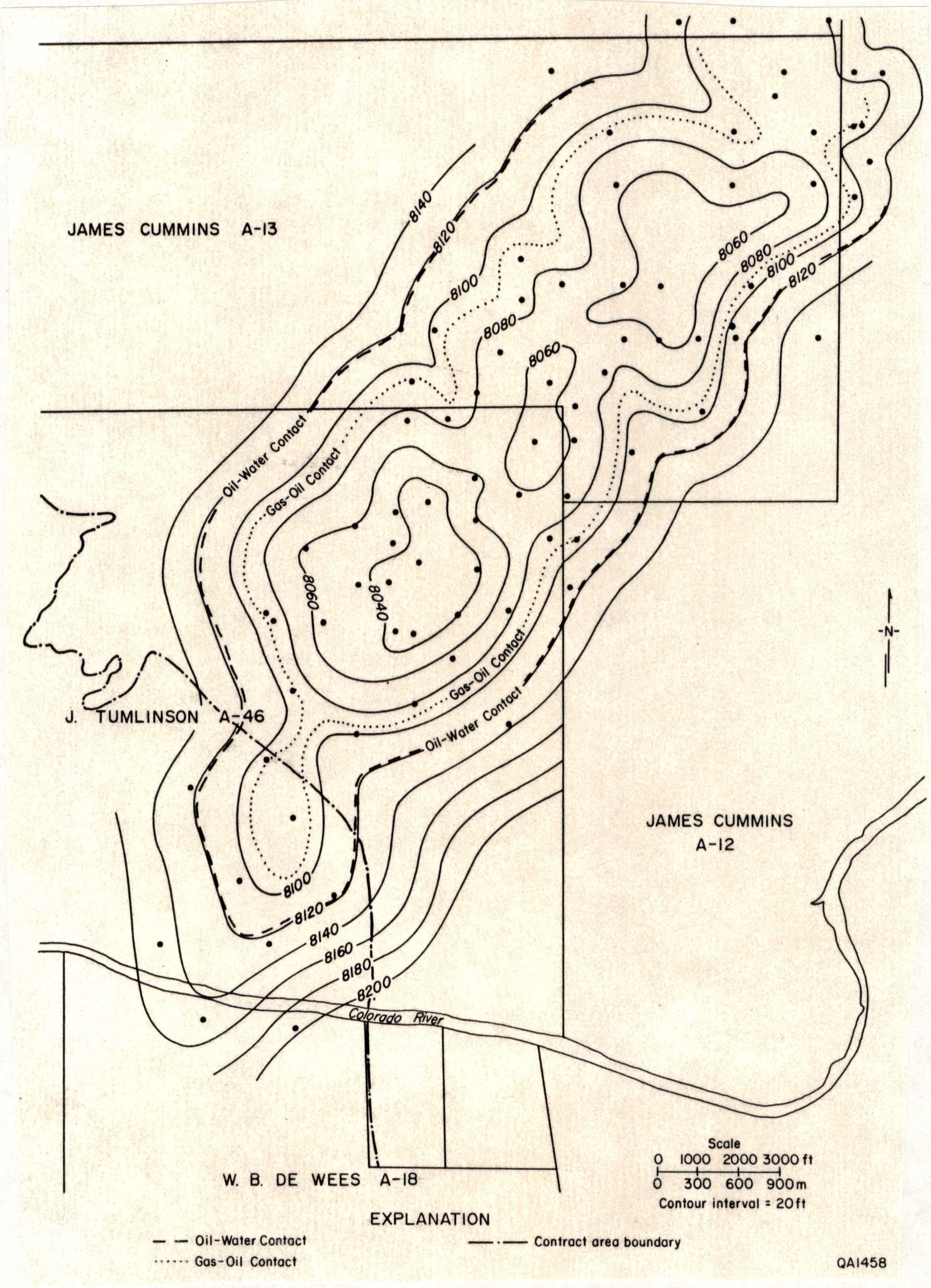


Figure 9. Structure map of the Columbus field, contoured on top of the Wilcox 7C sand at sub-sea level elevation, with elevations of original gas-oil and oil-water contacts (from Cities Service Oil Company, 1970). In 1970 the gas-oil contact was 8,111 ft below sea level.

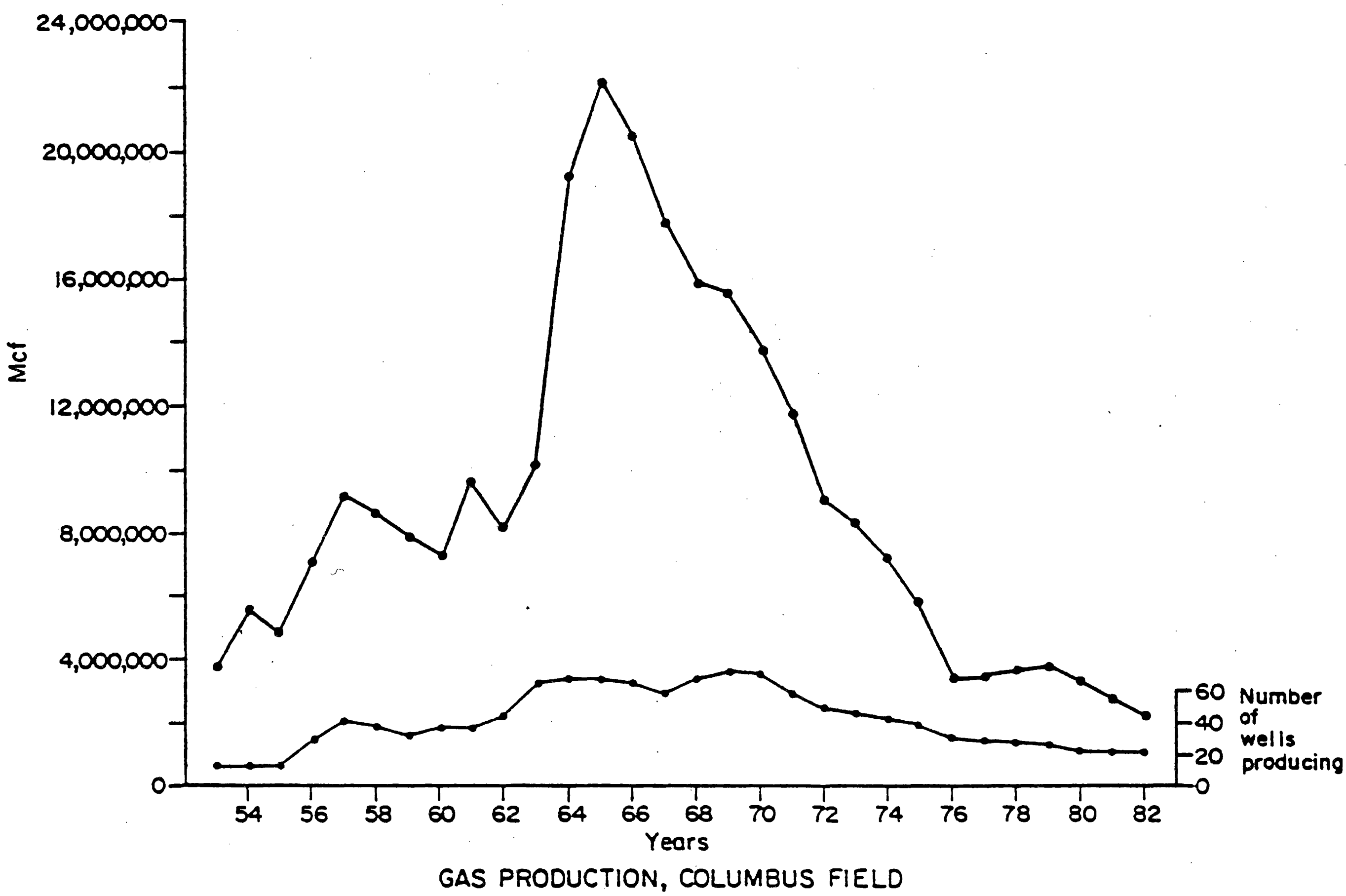


Figure 10. Annual Wilcox gas production and number of wells producing, 1953-1982, Columbus field, Colorado County.

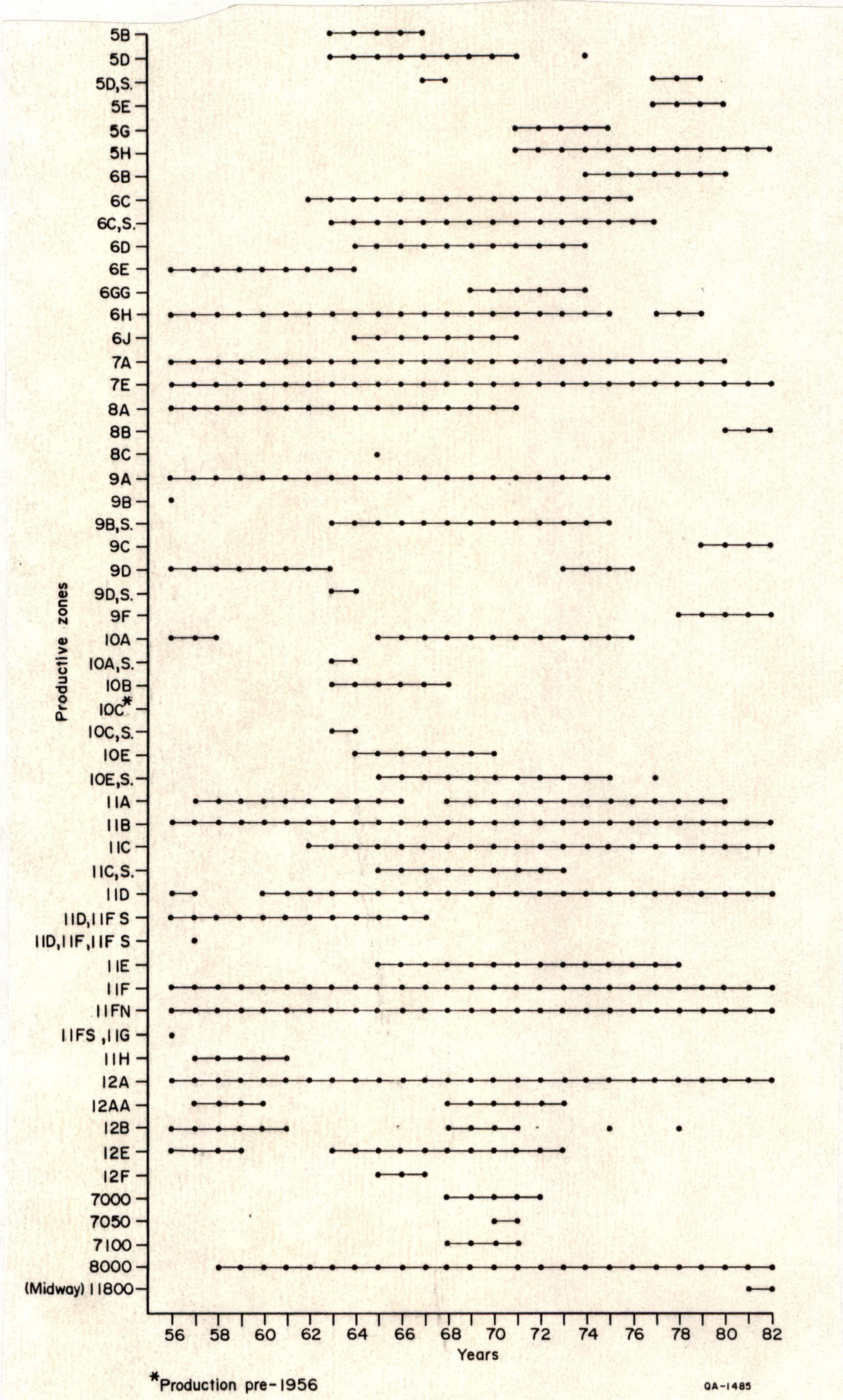
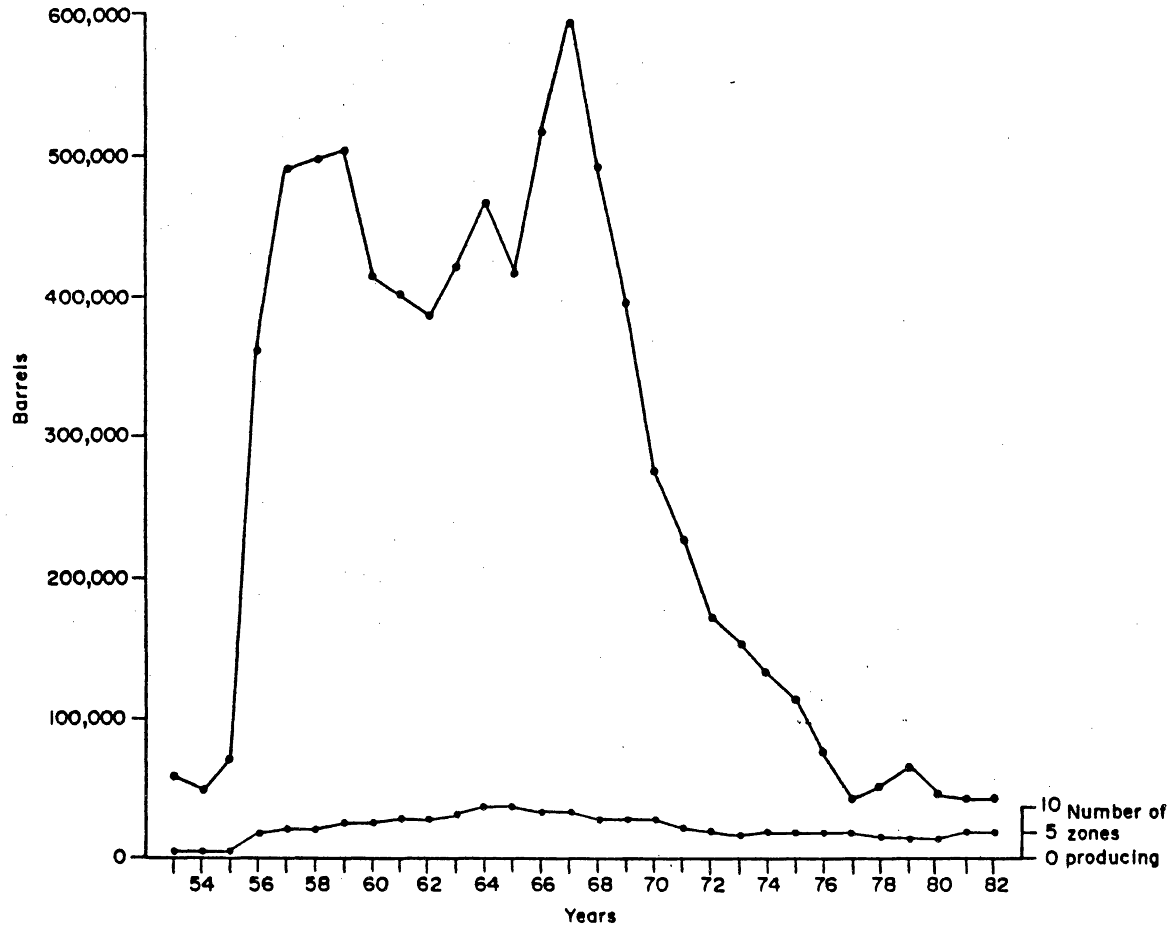
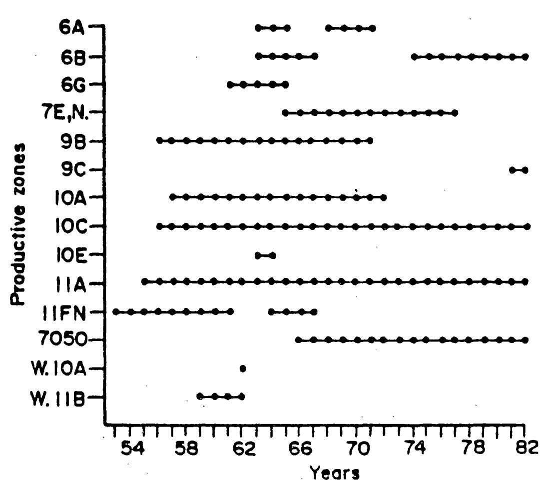


Figure 11. Wilcox productive gas zones, 1956-1982, Columbus field, Colorado County.



OIL PRODUCTION, COLUMBUS AND
COLUMBUS WEST FIELDS

A.



PRODUCTIVE OIL ZONES, COLUMBUS AND
COLUMBUS WEST FIELDS

B.

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Figure 12. Annual Wilcox oil production (A) and productive oil zones (B), Columbus and Columbus West fields, Colorado County.

heading in Railroad Commission of Texas production data. In 1970, gas injection was terminated (Cities Service Oil Company, 1970). Gas has invaded most of the oil column, and gas injection and workovers are no longer economically feasible (Cities Service Oil Company, 1970).

Present Status

Only one of the eight Columbus field wells within the contract area, the Smith #1 Reimers, is presently producing. In 1982 this well produced 22,549 Mcf of gas; in the first 11 months of 1983, 15,188 Mcf. It is at or rapidly approaching its economic limit of production (table 2). Currently there is some activity at the northern end of the field, in the Cummins A-13 survey (see fig. 9) and farther north; however, the Columbus field appears to be nearly depleted at today's economic conditions.

Glidden and Columbus West Fields

Located at the southwestern end of the contract area close to the proposed dam site, the Glidden gas field has been a small producer since its discovery in 1973 (fig. 6). The Columbus West field, discovered in 1959, is no longer producing within the contract area. The hydrocarbon trapping mechanism for these fields, like that of the Columbus field, is probably a combination of a rollover anticline bounded by an updip growth fault and lateral sand pinch-outs (fig. 13). A more detailed structure map shows small anticlines responsible for trapping the Wilcox 10,450 gas reservoir (fig. 14).

Production History

Production from the four gas zones in the Glidden field reached a peak of more than 1,600 MMcf/year in the three years after discovery (fig. 15A). Gas production in the Columbus West field likewise peaked at about 1,000 MMcf/year during the second year of production (fig. 15B).

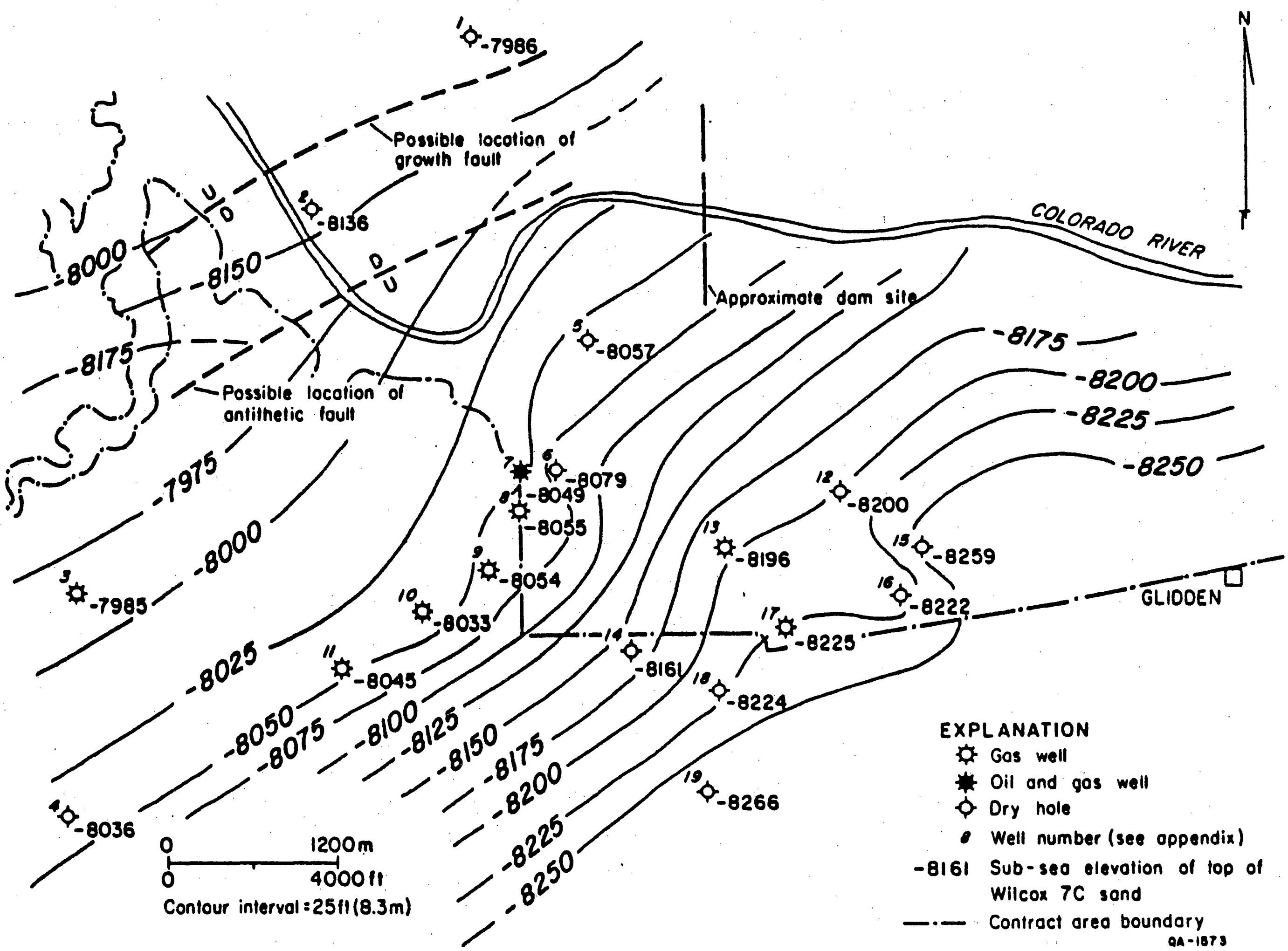


Figure 13. Structure map of the Glidden field area, contoured on top of the Wilcox 7C sand. Numbered wells are listed in appendix A.

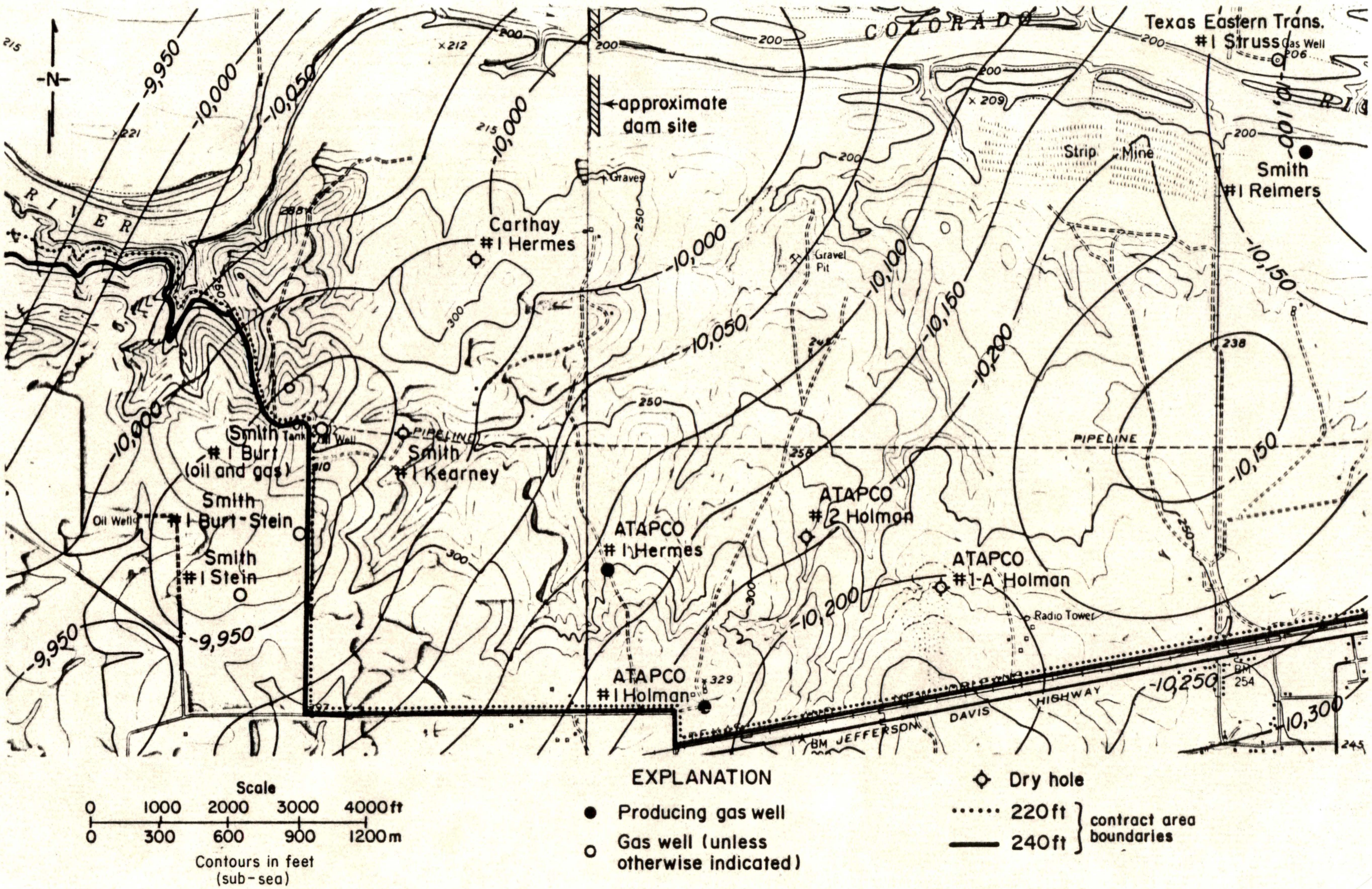


Figure 14. Structure map of the Glidden field area, contoured on top of the Wilcox 10,450 (Hermes) sand (from American Trading and Production Corp., 1975).

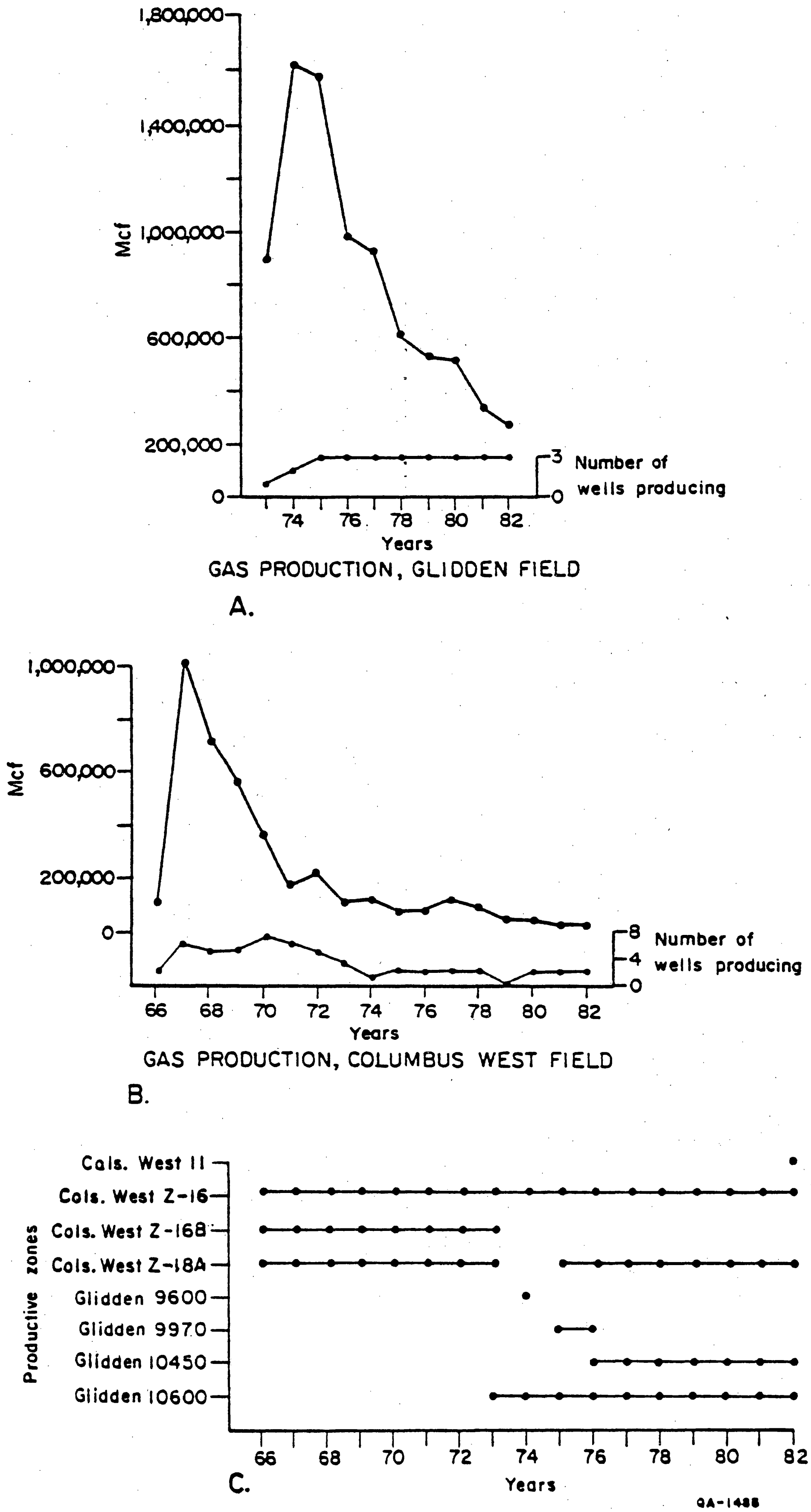


Figure 15. Annual Wilcox gas production, Glidden field (A) and Columbus West field (B), and productive gas zones (C).

Present Status, Glidden Field

Only four wells have ever produced from the Glidden field; two still produce within the contract area: American Trading and Production Corporation (ATAPCO) #1 Hermes (Wilcox 10,450) and ATAPCO #1 Holman (Wilcox 10,600) (fig. 14). Production has decreased since 1978 for ATAPCO #1 Hermes, the closest of the producing wells to the proposed dam site. The p/z versus cumulative production plot for this well indicates that its remaining productive life is relatively short (fig. 16 and table 3). In addition, when the slope of the plot of log q versus cumulative production (the decline curve) is carried to its intercept with log Q_{limit} (fig. 16 and table 2), the remaining life of the well can be estimated at approximately 15 years, holding the change/year in cumulative production constant at the 1981-1983 value. This estimate assumes the curve will not dip sharply, as for ATAPCO #1 Holman.

Production for ATAPCO #1 Holman has declined since 1975. This well also appears to be approaching the limit of economic production within a few years, barring a dramatic increase in gas price. Both the p/z versus cumulative production plot and the decline curve show a short remaining life (fig. 16). The high values of p/z shown in the figure may indicate a component of water drive in addition to the gas expansion drive. The abandonment of the two ATAPCO wells, which cannot be shut in without water damage to the reservoir, will spell the end of current production from the Glidden field in the contract area. Optimistic ATAPCO geologists have drawn a potentially gas-bearing anticline to the northwest of Carthay #1 Hermes (fig. 14), but this structure remains untested. Some potential still exists for the discovery of new Wilcox reservoirs in the Glidden field area.

Present Status, Columbus West Field

The Columbus West field has produced gas from three zones: Z-16A, Z-16B, and Z-18A (figs. 8 and 15). No wells in this field are producing within the contract area today. Oil was produced for four years from Sinclair #1 Burt (table 1), but all other production has been gas and condensate. Recent developments include the discovery in 1982 of the Wilcox 11-B gas zone in Smith #1 Burt-Stein (fig. 8), but the well produced only 26 Mcf in early 1983 and is

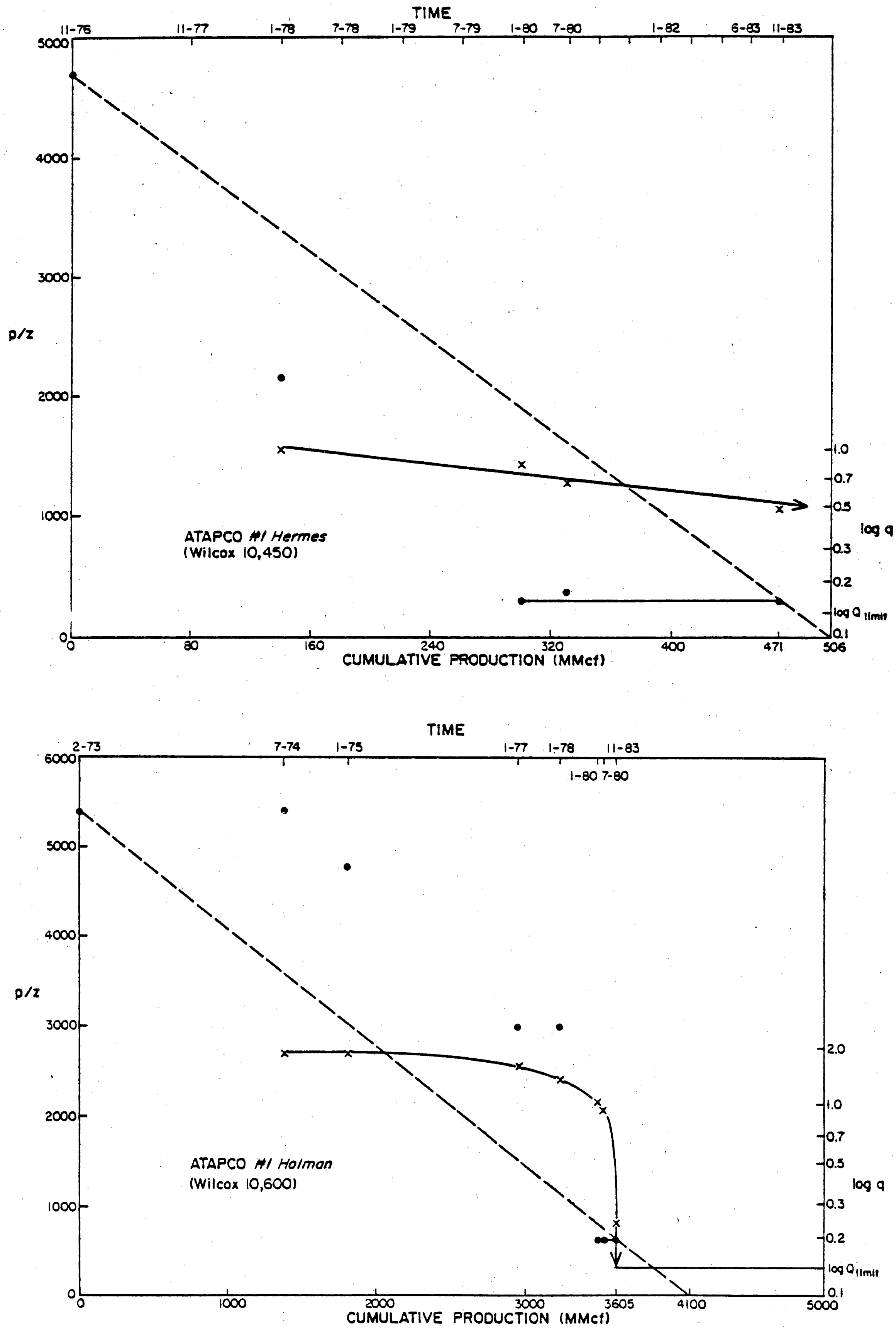


Figure 16. P/z versus cumulative production plots (solid circles) and decline curves (x's) for ATAPCO #1 Hermes and ATAPCO #1 Holman. See tables 2 and 3 for further explanation of data.

temporarily abandoned. Smith #2 Burt-Stein was permitted 625 ft northwest of Smith #1 Burt-Stein in August 1983. No production figures are available, and it is not known if this well was ever drilled. Future production potential in the Columbus West field lies to the south and west of the contract area.

Austin Chalk Trend

The Austin Chalk oil and gas trend crosses the contract area in a northeast-southwest direction, and the Austin Group underlies all of the project area (fig. 3). No wells produce from the Austin Chalk inside the contract area, but there are several within a few hundred feet of the contract area northwest of La Grange. Southeast of the La Grange area, the nearest production of both oil and gas is in Lavaca County a few miles southwest of Colorado County.

Geology

Outcrop thickness of the Austin Chalk is about 300 ft; it thickens into the subsurface in central Fayette County to about 800 ft and then thins to about 400 ft in northern Colorado County (Thornhill, 1982). The unit is composed predominantly of fine-grained, light-gray limestone that was deposited on a wide, deep marine shelf (Holditch and Lancaster, 1982). Oil and gas are contained in fractures in the limestone and perhaps to a smaller degree within intergranular pore spaces (Grabowski, 1981).

Production History

Information that follows concerning past and present Austin Chalk production is from Holditch and Lancaster (1982). Drilling first began in the Austin Chalk trend in the 1930's; the rising price of oil and improved technology spurred new development in the late 1970's. In recent years drilling has declined sharply because of falling oil prices and rising operating costs.

Present Status

Optimum production of oil from the Austin Chalk is encountered between 5,000 and 10,000 ft in depth, and gas is produced below 10,000 ft. Most of the potential production from the Austin Chalk within the contract area is therefore gas (fig. 3). Successful production depends to a large degree on the location of good fracture porosity. One dry hole, Artusy #1 Wegenhoff, has penetrated the Austin Chalk in the contract area (fig. 5, table 1); the Austin Chalk underlying most of the contract area has not been tested.

Stuart City - Edwards Formations

The Stuart City reef trend, originally called the Deep Edwards play, crosses the contract area on the southeast (fig. 3). The information given here concerning the Stuart City trend is primarily from Bebout and Loucks (1974). The reef limestone near the contract area is packstone and grainstone with minor boundstone. The reef sediments were deposited on an ancient shelf margin in water up to 15 ft deep, and they are greater than 400 ft thick under the contract area.

The Stuart City trend is marginally productive of gas throughout Texas. The nearest production to the contract area in the Stuart City trend was from one well in the East Hamel field, 3.3 mi to the south of well #19 in figure 13. This well, the Exxon #1 Wegenhoff (Edwards gas unit #1) was drilled in 1978, but no gas was produced until 1980. Gas produced during 1980 was 34,712 Mcf; since then the well has been shut in. Only one other well has penetrated the Stuart City trend near the contract area. It was drilled a few hundred yards southeast of #1 Wegenhoff by Exxon, and it was dry. At current prices, gas production potential for the Stuart City trend within the contract area is marginal at best.

Lease Values

Lease values for oil and gas lands were not available in the courthouse records. Private sources indicate a possible value of $50 per acre in the Columbus field area, but advance royalty and bonus payments could greatly increase this figure. Acreage at the southeast part of the contract area in the Wilcox trend constitutes about 6,300 acres, and at $100/acre the lease price comes to $630,000; this figure assumes an extra $50/acre for advance royalty or bonus payments.

Potential for Secondary or Tertiary Recovery

Gas recovery efficiency for ATAPCO #1 Hermes and ATAPCO #1 Holman is calculated in table 4. Such a high initial recovery rate, approximately 90 percent, precludes secondary and tertiary recovery from those wells at today's prices.

Standard procedure dictates that secondary or tertiary recovery is not economic at today's gas prices if the gas recovery rate is greater than 60 percent of the original gas in place, which is the case for most wells. Secondary and tertiary recovery from Wilcox reservoirs, the Austin Chalk, and the Stuart City reef trend probably are not feasible unless gas prices increase significantly.

Estimates for Slant and Raised Drilling

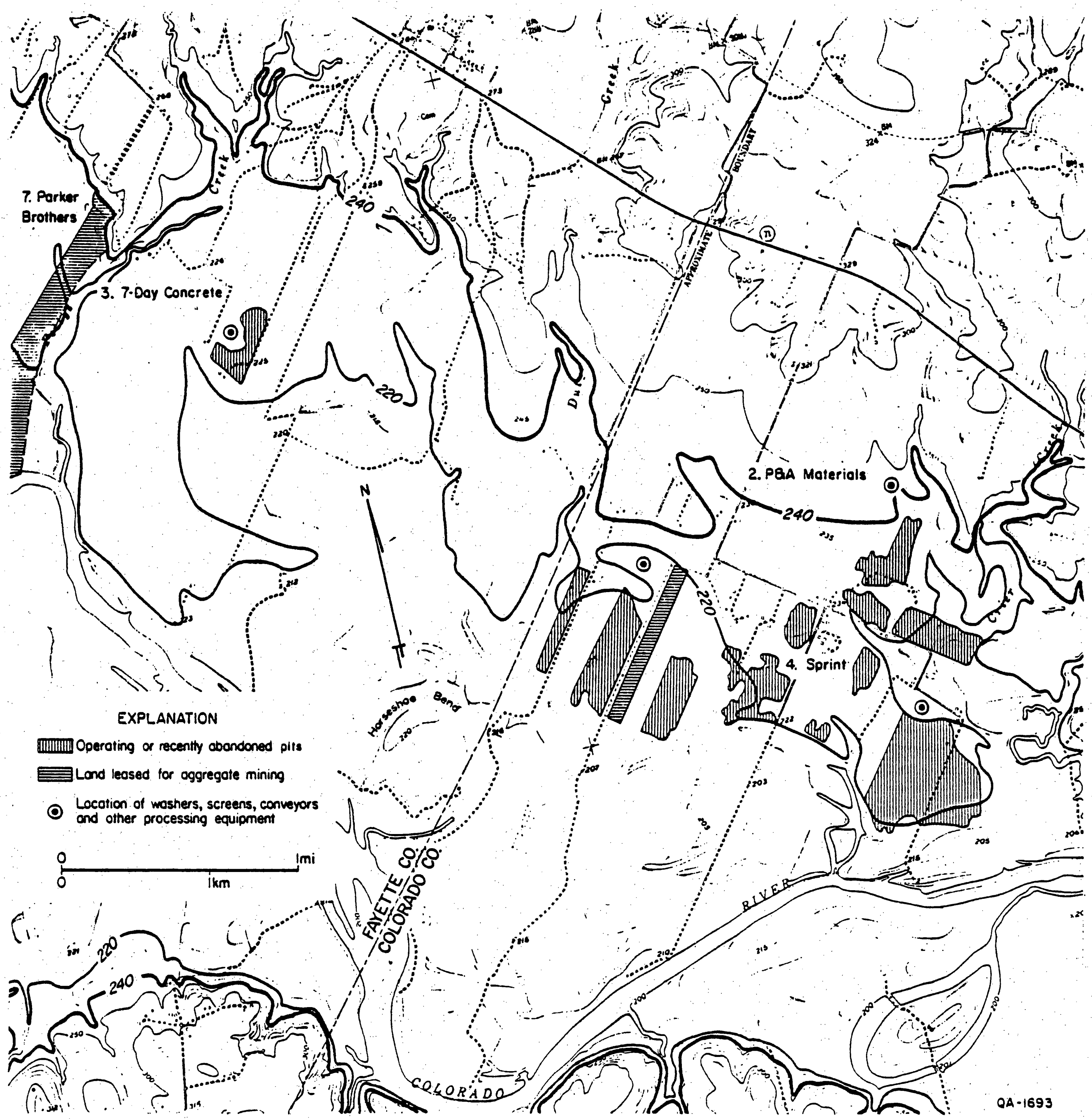
One cost estimate obtained for drilling a 9,000-ft well at regular pressure is $800,000 (Thornhill, 1982). No estimate was available for the cost of completion. Installation of a compressor system for low-volume producers was estimated at $300,000 or more. Slant hole drilling can cost up to twice as much per hole as vertical drilling, and the steeper the slant angle the higher the cost. All potential hydrocarbon reservoirs under the proposed reservoir site are accessible by slant drilling techniques available today. No estimates for the cost of raised drilling were available. Platforms built would be 50 to 60 ft tall at the most.

SAND AND GRAVEL

Sand and gravel resources lie predominantly in Quaternary fluviatile terrace and alluvial deposits (figs. 17 and 18); a small amount is present in the Pleistocene river deposits of the Willis Formation (fig. 1). The Quaternary units can be up to 50 ft thick. Six sand and gravel mining operations comprising 644 ± 10 acres exist within the contract area, and a seventh is adjacent to it (fig. 17, table 5). Leased lands in the contract area not currently mined represent at least 322 acres. All information on sand and gravel lease holdings was acquired from courthouse records only; a lease for one operation near Holman was not located in the records and the owner is listed as unknown. Most of the lease activity in the area occurred during the late 1970's; the only new lease activity on record post-1979 is by P&A Materials (table 5).

The lease and stockpile purchase value of remaining fluviatile and alluvial sand and gravel resources within the contract area is estimated at $63,000,000 (table 6). This estimate includes (1) land on fluviatile terraces, which has a high percentage of sand and gravel, (2) alluvial land, which is clayier and subject to periodic flooding, and (3) sand and gravel in stockpiles. Mined-out acreage is not included in the estimate, although small resources may remain at abandoned locations. The only significant mined-out acreage (area greater than 10 acres) is near the town of Columbus, downriver from the proposed dam site (fig. 4). Additional resources are present in the Willis Formation, which is composed predominantly of gravel and occurs at the southeast end of the contract area. The region covered by the Willis Formation, approximately 1,500 acres, is somewhat dissected and the thickness of the Willis is variable. Assuming a value of $1,645/ac (table 6), this additional resource has a lease value of $2,500,000, making the grand total lease and purchase value of remaining sand and gravel resources equal to $66,000,000, rounded to the nearest significant figure.

Figure 17. Locations of sand and gravel pits and leases.



7. Parker Brothers
3. 7-Day Concrete
2. P&A Materials
4. Sprint
Creek
240
220
N
Horseshoe Bend
FAYETTE CO.
COLORADO CO.
APPROXIMATE BOUNDARY
RIVER
COLORADO
EXPLANATION
Operating or recently abandoned pits
Land leased for aggregate mining
Location of washers, screens, conveyors and other processing equipment
0
1mi
0
1km
QA-1693

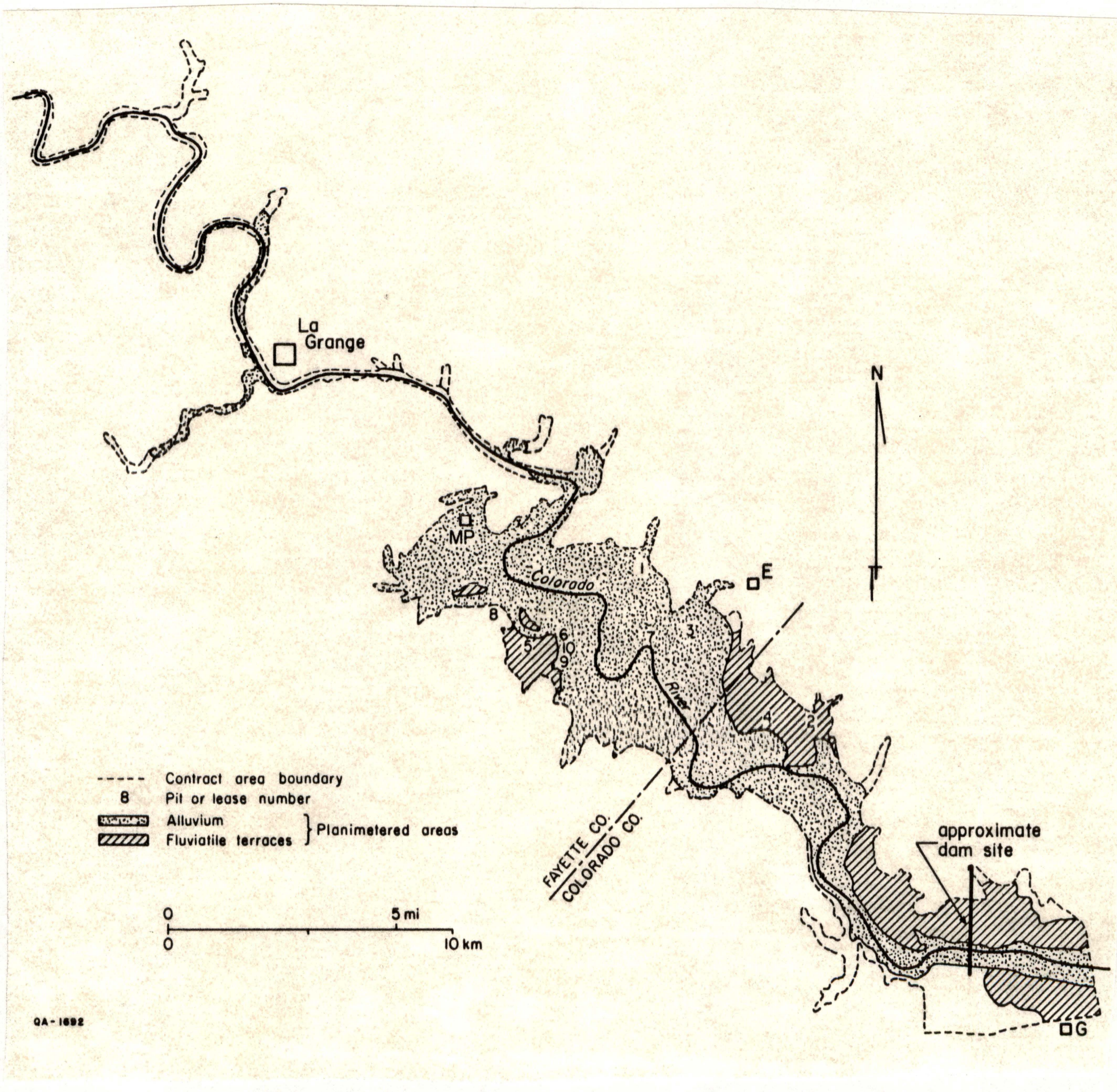


Figure 18. Planimetered areas of alluvium and fluviatile terraces for calculation of remaining sand and gravel resources (geology from Barnes, 1974). Pit and lease numbers correspond to table 5.

LIGNITE

Geology

The lignite-bearing strata underlying the contract area are the Eocene Yegua Formation and Jackson Group and the Eocene-Paleocene Wilcox Group (figs. 1 and 2). Strike of these units is nearly parallel to the Texas coast, and dip is from 0.25 to 4 degrees to the southeast.

Near-Surface Resources

Most of the lignite in the Jackson Group occurs in the Manning Formation, and it is shallow enough to be reached by surface mining in the region upriver from La Grange. Resources in this area have been studied in detail by Ward (1980); figure 19 is a summary of the thicknesses of the three major lignite seams underlying the Colorado River. Seam B, underlying seam A, is the thickest of the three having a maximum of 15 ft. Other thin and less continuous seams also exist in the area (Ward, 1980), but these will not be economically mineable unless lignite prices rise dramatically.

Leases and Lease Values

Confidential information indicates that lignite lands have been leased adjacent to the Colorado River. Courthouse records show no lease activity since the mid- to late-1970's. Most of the lease terms on record are for 10 or 25 years. Leases to Phillips Petroleum Company are for $35 and $25 per acre, and two of these are for land in the John Castleman survey, which adjoins the Colorado River on the south from the entrance of Jordan Creek to the entrance of Buckners Creek. Exact locations of the leases are not readily available. Experience shows that lignite leases can sell for as much as $0.50 per ton, which, at 1,750 tons per acre-foot, equals $875/ac for a 1-foot-thick seam. This assumes 100-percent recovery of the seam; average recovery in surface mining is 85 percent. Alternatively, the land could be leased for 5 percent of the market price, which is about $12 to $14 per ton, mine-mouth, in 1983 dollars. Five

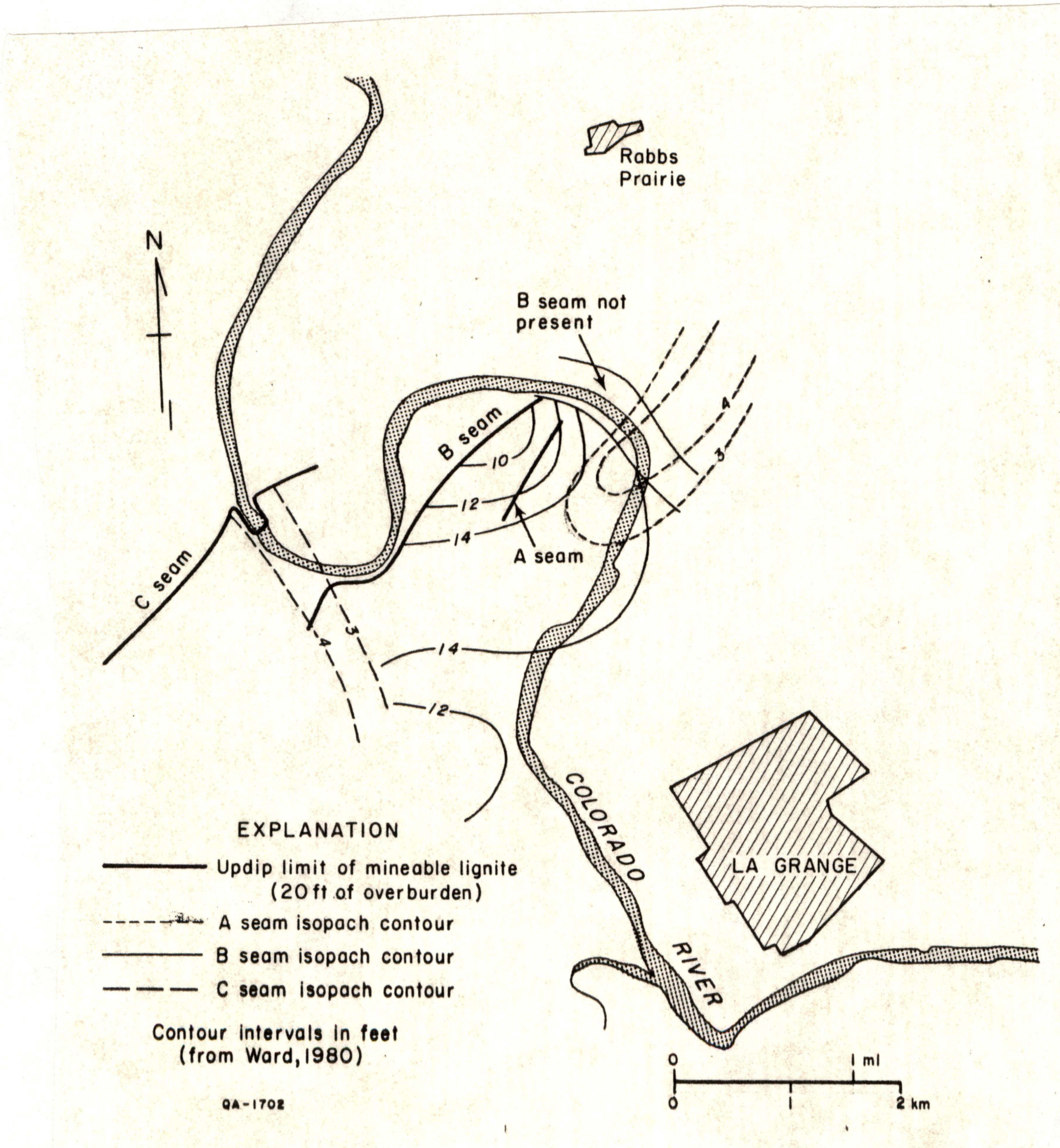


Figure 19. Isopach map of mineable lignite (Manning Formation) along the Colorado River immediately northwest of La Grange. See figure 18 for contract area boundary.

percent of that figure is \$0.60 to \$0.70 per ton. Actual lease values on record appear to be much lower than this, but it is important to note that bonuses or advance royalty payments are not included in the \$35/ac price.

Deep-Basin Resources

At today's prices, lignite in the Yegua Formation is too thin to be economical (less than 3 ft, Kaiser and others, 1980) in the downdip regions that underlie the contract area. The top of the Yegua Formation is about 1,000 ft deep at La Grange and depth increases toward the coast according to dip.

Lignite in the Manning Formation occurs downdip southeast of La Grange and could be mined with deep-mining methods (Kaiser and others, 1980). The seams shown in figure 19 may extend downdip or, more probably, other thick seams may be present. Depth to the top of the Manning Formation 5 mi southeast of La Grange, where the contract area widens abruptly, is also about 1,000 ft. This is a probable maximum depth for which in situ gasification can be economic. It is important to note that water influx from surrounding aquifers, such as alluvium, is a serious detriment to in situ mining at the present state of technology. Lignite in the other formations in the Jackson Group within the contract area is not of economic thickness at today's prices.

The Wilcox Group has numerous lignite seams, some up to 5 ft or greater in thickness. The top of Wilcox strata is about 3,500 ft deep at La Grange and more than 6,000 ft deep near Columbus. These values indicate that Wilcox lignite is beyond the reach of economic mining by any known method, and it is likely to remain that way in the foreseeable future.

URANIUM

The major uranium-bearing strata that underlie the contract area are the Miocene Catahoula and Oakville Formations (figs. 1 and 2). The Manning and Whitsett Formations also contain uranium, but in small amounts.

Manning and Whitsett Formations

Kaiser and Galloway (1983) indicate that concentrations greater than or equal to 10 ppm U_3O_8 are anomalous and of potential exploration interest. They have calculated the modal value of uranium in the Manning and Whitsett Formations for the Cummins Creek lignite mine area, 5 mi northeast of the contract area, to be 2 to 5 ppm U_3O_8. The Manning and Whitsett Formations probably do not contain economic deposits of uranium in the contract area at today's price of \$22/lb U_3O_8. Deposits that might be commercial at \$40/lb exist in these formations south of Plum (Kaiser and Galloway, 1983).

Catahoula and Oakville Formations

In the Catahoula Formation the nearest uranium anomalies in outcrop are more than 10 mi away, and potential for small- to medium-size (less than 10^6 lb U_3O_8) ore-grade deposits exists in the contract area (Galloway, 1977). Estimates of deposit size made by Galloway (1977) were based on stratigraphic, facies, structural, and hydrologic interpretations.

A similar study of the Oakville Formation (Galloway and others, 1982) indicates the potential for existence in the contract area of small ore-grade deposits, less than 10^5 lb U_3O_8 in size. Typical deposits of less than or equal to 10^6 lb U_3O_8 cover 10 to 20 acres (Kaiser and Galloway, 1983).

Confidential information indicates that even during the peak uranium-leasing years of the 1970's, no leases were held closer than 1 mi from the contract area. Lease price per acre of uranium ore is estimated at less than the lease price per acre of lignite-bearing strata, discounting bonuses and advance royalties.

SUMMARY

The mineral resource evaluation of the proposed Shaws Bend reservoir site includes oil and gas, sand and gravel, lignite, and uranium resources. Only three gas wells produce within the contract area; all are marginal producers and near the economic limit of production. Some potential for new discovery exists in the Wilcox Group and in the untapped Austin Chalk. Hydrocarbon potential in Stuart City strata is small.

The lease and stockpile purchase value of remaining Quaternary sand and gravel resources, located in fluviatile terraces, alluvium, and the Willis Formation, is estimated at $66,000,000. Thick (greater than 5 ft) near-surface lignite resources underlie the contract area north of La Grange; deep-basin resources extend south of La Grange but have low value because they underlie alluvium within the contract area. Estimates of uranium resources that may be present are small. No uranium leases are known to be held within the contract area.

REFERENCES

American Trading and Production Corporation, 1975, Material submitted for hearing on Wilcox 10,450 reservoir: Railroad Commission of Texas Glidden field hearings file, Wilcox 10,450 reservoir.

Barnes, V. E., 1974, Seguin sheet: The University of Texas at Austin, Bureau of Economic Geology, Geologic Atlas of Texas, scale 1:250,000.

Bebout, D. G., and Loucks, R. G., 1974, Stuart City trend, Lower Cretaceous South Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 78, 80 p.

Cities Service Oil Company, 1970, Exhibits and engineering data for amendment to the net GOR rule Columbus field 7-C reservoir, Colorado County, Texas: Oil and gas docket no. 3-59997 prepared for Railroad Commission of Texas hearing, hearing file no. 59997, 12 p.

Dwight's, 1980a, Natural gas well production histories, production versus pressure: computer printout, gas report 4P16, active wells, Railroad Commission of Texas District 3, Richardson, Texas, 890 p.

Dwight's, 1980b, Natural gas well production histories: computer printout, gas report $-16, inactive wells, Railroad Commission of Texas District 3, Richardson, Texas, 612 p.

Fisher, W. L., and McGowen, J. H., 1967, Depositional systems in the Wilcox Group of Texas and their relationship to occurrence of oil and gas: The University of Texas at Austin, Bureau of Economic Geology Geological Circular 67-4, 26 p.

Funk, V. T., 1981, Costs and indexes for domestic oil and gas field equipment and production operations, 1980: Washington, D.C., U.S. Department of Energy, Energy Information Administration, 179 p.

Galloway, W. E., 1977, Catahoula Formation of the Texas Coastal Plain: Depositional systems, composition, structural development, ground-water flow history, and uranium distribution:

The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 87, 50 p.

Galloway, W. E., Henry, C. D., and Smith, G. E., 1982, Depositional framework, hydrostratigraphy, and uranium mineralization of the Oakville sandstone (Miocene), Texas Coastal Plain: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 113, 51 p.

Grabowski, G. J., Jr., 1981, Origin, distribution, and alteration of organic matter and generation and migration of hydrocarbons in Austin Chalk, Upper Cretaceous, southeastern Texas: Baylor University, Ph.D. dissertation, 161 p.

Holditch, S. A., and Lancaster, D. E., 1982, Economics of Austin Chalk production: Oil and Gas Journal, v. 80, no. 32, p. 183-189.

Kaiser, W. R., Ayers, W. B., Jr., and LaBrie, L. W., 1980, Lignite resources in Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 104, 52 p.

Kaiser, W. R., and Galloway, W. E., 1983, Cummins Creek mine geologic and hydrologic setting: document presented to the Electric Utility Commission of the City of Austin, Texas, 2 p.

Thornhill, S. A., 1982, The Austin Chalk and its petroleum potential: south-central Texas: Baylor University, Master's thesis, 161 p.

Ward, A. E., 1980, Evaluation of lignite resources at proposed La Grange and Columbus Bend reservoir sites, Fayette, Bastrop, Lee, and Colorado Counties, Texas: U.S. Department of the Interior, Bureau of Mines, 35 p.

APPENDIX A

Names of wells used in figure 19

Well No.	Well Name
1	Sinclair #1 Foster
2	Millican #1 Fowler
3	Hamill #1 Richter
4	Mosbacher #1 Helcamp
5	Carthay #1 Hermes
6	Smith #1 Kearney
7	Smith #1 Burt
8	Smith #1 Burt-Stein
9	Smith #1 Stein
10	Intercoastal #1 Hodde
11	Intercoastal #1 Hodde-Tucker
12	ATAPCO #2 Holman
13	ATAPCO #1 Hermes
14	Export Petr. #1 Snokhous
15	ATAPCO #1-A Holman
16	Aikman #1 Holman
17	ATAPCO #1 Holman
18	Exxon #1 Richter
19	Exxon #2 Richter

Table 1. Well statistics for all wells in contract area.

Operator	Well no.	Lease/Date§	Type	Status*	Ground elevation (ft)	Location: Field/Co.	Location: Survey	Legal description	Prod. zones	Misc.	T.D. (ft)
Aikman Oil Corp.	1	Holman 7-14-78	Dry	Aband.	303	Glidden Colorado Co.	D. Gilleland A-26	467' FWL and 467' FSL of 93.72 acre lease	--		10,815
American Trading and Production Corp. (ATAPCO)	1	G.W. Hermes 9-07-73	Gas	Prod.	296.8	Glidden Colorado Co.	D. Gilleland A-26	2,000' FSL and 467' FWL of G.W. Hermes lease	10,450 (Hermes) sand	Reentered for current prod. 9-27-76, compressor added 10-77	10,953
ATAPCO	1	P. Holman 10-15-72	Gas	Prod.	319	Glidden Colorado Co.	D. Gilleland A-26	467' FSWL and NEL and 472.6' FWL of the P. Holman tract	10,600 (Holman) sand	Compressor added 2-72	10,804
ATAPCO	1-A	Holman 8-08-73	Dry	Aband.	277	Glidden Colorado Co.	D. Gilleland A-26	467' from Superior lease and 1,800' from Highway 90	--		11,000
ATAPCO	2	Holman 7-05-74	Dry	Aband.	262.1	W. Glidden Colorado Co.	D. Gilleland A-26	1,500' FWL, 3,450' from Holman #1 and 2,287' from Holman #1-A	--		10,848
G.D. Artusy III, formerly Amoco Production Co.	1	R. Wegenhoff	Dry	Aband.	KB 246	Wildcat NE of Holman Fayette Co.	S.A. Pugh A-85	623' FSEL and 2,023' FEL (Colorado River) of lease	--	In max. pool area only	13,947
J.F. Burdette, formerly H.L. Edwards Drilling Co.	1	W. Hermes, Jr. 5-24-49	Dry	Aband.	DF 252	Wildcat at La Grange Fayette Co.	J. Moore A-71	Not available, see fig. 5	--		4,118
Carthay Land Co.	1	G.W. Hermes 12-23-65	Dry	Aband.	251.3	W. Columbus Colorado Co.	D. Gilleland A-26	56' FWL and 13,600' FSL of survey	--		10,500
Cities Service Oil Co.	6	Tract 17 C.K. Gay 5-08-56	Gas	Aband.	approx. 216	Columbus Colorado Co.	J. Tumlinson A-46	6,616' FEL and 10,200' FNL of survey	--	Worked over 5-63 to 9,983'	10,220
Cities Service Oil Co.	8	Tract 17 C.K. Gay 10-21-56	Gas	Aband. Plugged 7-20-71	204	Columbus Colorado Co.	J. Tumlinson A-46	12,200' FNL and 5,716' FEL of survey	--	Worked over 8-06-63	10,115

§Date of completion
*Aband. = abandoned; Prod. = producing

Table 1. (continued)

Operator	Well no.	Lease/Date§	Type	Status*	Ground elevation (ft)	Location Field/Co.	Location Survey	Legal description	Prod. zones	Misc.	T.D. (ft)
Cities Service Oil Co.	1	Tract 16 L.H. Hastedt 2-18-51	Gas	Aband. Plugged 3-30-72	228	Columbus Colorado Co.	J. Tumlinson A-46	7,050' FWL and 8,960' FNL of survey; 1,200' FNL and 330' FEL of lease	9A, 11 F	Worked over 3-51	9,815
Cities Service Oil Co.	1	W. Struss 2-24-45	Dry	Aband. Plugged 4-07-45	approx. 250	Columbus Colorado Co.	J. Tumlinson A-46	600' S and 330' W of most easterly N corner of lease	--		10,001
Cities Service Oil Co.	2	Tract 16 G.E. Worthy 7-30-56	Gas	Aband. Plugged 7-02-76	205	Columbus Colorado Co.	J. Tumlinson A-46	1,700' FWL and 2,450' FSL of Tract 16; 11,750' FNL and 7,966' FEL of survey	--		10,000
Cities Service Oil Co.	3	Tract 16 G.E. Worthy 12-14-56	Gas	Aband. Plugged 7-12-71	208	Columbus Colorado Co.	J. Tumlinson A-46	1,750' S and 600' E of well #2 in Tract 16; 13,500' S of NL and 7,366.2' FEL of survey	--	Plugged back to 9,830'	10,500
Colorado Corp. and Gulf, formerly Colorado Oil Co.	1	N. Evans, formerly G. Turner est. 11-33	Dry	Aband.	#	Wildcat S of Ellinger Fayette Co.	John Petty A-80	Not available, see fig. 5	--		4,517
Fidelity Oil and Royalty Co.	1	R. Wegenhoff 1-27-53	Dry	Aband.	233.1	Wildcat SE of Ellinger Fayette Co.	S. A. Pugh A-85	990' FNWL and 990' FSL of lease	--	In max. pool area only	9,325
C.A. Milentz	1	G. Hodde et al.	Dry	Aband.	#	W. Columbus Colorado Co.	D. Gilleland A-26	Not available; location uncertain, may not be in contract area	--		585
Mayan Oil Co. et al.	1	Mayan Oil Co., formerly C.W. Ehlingers est.	#	Aband.	#	Wildcat S of Ellinger Fayette Co.	John Petty A-80	Not available, see fig. 5	N.A.†		N.A.†
Millican Oil Co.	1	R. Fowler 7-04-77	Dry	Aband. Plugged 7-19-77	215.5	Wildcat W of Columbus field Colorado Co.	W.R. Hunt A-29	470' FSWL and 3,550' FEL of survey	--		11,513

§Date of completion
*Aband. = abandoned; Prod. = producing
#Uncertain
†N.A. = not available

Table 1. (continued)

Operator	Well no.	Lease/Date§	Type	Status*	Ground elevation (ft)	Location: Field/Co.	Location: Survey	Legal description	Prod. zones	Misc.	T.D. (ft)
R. Mosbacher	1	A. Schulenburg 10-23-57	Gas	Aband. Plugged 2-06-69	194.8	Columbus Colorado Co.	W.B. Dewees A-18	330' FNL and 467' FWL of lease	11 H		10,500
Joe E. Smith, formerly Sinclair, formerly Trice Production Co.	1	L.J. Burt 1-20-55	Gas and oil	Aband.	303	W. Columbus Colorado Co.	D. Gilleland A-26	660' FEL and 3,960' FSL of survey	10 A, 11 B, oil; 10,360 10,410, 10,420, 10,440, gas	Worked over 12-59 and 3-62 for oil	10,495
Joe E. Smith, formerly Shell Oil Co. and Trice Production Co.	1	C.W. Kearney 2-01-66	Dry	Aband.	286	W. Columbus Colorado Co.	D. Gilleland A-26	656.4' FWL and 489.2' from northerly north line of the 300 ac Kearney lease; 4,950' FWL and 10,400' FSL of survey	--	‡	10,850
Joe Smith	1	Massey Unit	Dry	Aband.	approx. 231	near Glidden Colorado Co.	W.B. Dewees A-18	Approx. 4,350' FWL of survey and 2,200' N from Highway 90	--		N.A.†
Joe Smith(?), formerly Masterson	1	F. Auerbach, Jr.	Dry	Aband.	#	W. Columbus Colorado Co.	D. Gilleland A-26	Not available; location uncertain, may not be in contract area	--		N.A.†
Joe E. Smith, formerly Jefferson Lake Sulphur Co.	1	J.W. Reimers 9-24-61	Gas	Prod.	204	Columbus Colorado Co.	W.B. Dewees A-18	3,200' FWL and 500' FNL of survey	11 F		10,350
Joe Smith	1	Southern Pacific Trans. Co. Unit	Dry	Aband.	approx. 236	near Glidden Colorado Co.	W.B. Dewees A-18	Approx. 4,200' FWL of survey and 800' N from Highway 90	--		N.A.†
Texas Eastern Transmission Corp.	1	W.A. Struss 2-28-57	Gas	Aband.	205	Columbus Colorado Co.	J. Tumlinson A-46	330' from most southerly EL of lease and 600' N of N bank of Colorado River; 4,250' FWL and 13,100' FNL of survey	11 F		10,385
Trice Production Co.	1	Hermes	Oil	Aband. 8-59	approx. 288	Glidden Colorado Co.	D. Gilleland A-26	Approx. 6,950' FWL of survey and 6,500' N from Highway 90	--		N.A.†

§Date of completion
*Aband. = abandoned; Prod. = producing
‡Worked over 1-66, plugged and abandoned 10-07-67, reentered to 10,670' on 10-25-82, no pressure 10-83
†N.A. = not available
#Uncertain

Table 2. Q_{limit} calculations for Smith #1 Reimers.

$$Q_{limit} = \frac{C}{12{,}000\ P\ W\ (1-T)} = \frac{\$17{,}150/yr}{12{,}000\ (\$2.50)\ (0.75)\ (1-0.45)} = 1.39\ \text{MMcf/mo}$$

where

Q_{limit} = value of MMcf/mo below which it is not economically feasible to operate a well

q = average MMcf produced per month, calculated by taking the difference between two values of cumulative production and dividing that number by the number of months elapsed between the two values

C = operating cost of the well per year, estimated at not less than $17,150/yr (Funk, 1981)

P = current gas price per Mcf, estimated at $2.50/Mcf

W = working interest, about 0.75

T = State tax rate, about 0.45

1/12,000 = conversion factor for changing Mcf/year to MMcf/month

log q
log Q_{limit} = logarithm to base 10 of q or Q_{limit} (see fig. 16)

Production for Smith #1 Reimers from 1-83 to 11-83 was 15.2 MMcf.

15.2 MMcf ÷ 11 mo = 1.38 MMcf/mo, on average

1.38 MMcf/mo is less than Q_{limit} calculated above.

According to this estimate, Smith #1 Reimers is near the end of its economic production.

Table 3. Interpretation of p/z versus cumulative production plots (figure 16).

p = bottom hole pressure

z = a factor calculated using bottom hole pressure and specific gas gravity

The p/z versus cumulative gas production plot is based on the material balance in gas reservoirs. For a reservoir with no water encroachment and no water production, the original gas in place (OGIP) may be estimated by extrapolating a straight line through the data points to the zero p/z value. The closer the cumulative production value is to OGIP, the shorter the remaining life of the well. Sources of error, especially applicable to the ATAPCO #1 Hermes plots, include possible incorrect measurement of p at the well site and the small number of p/z values available. Values of p/z used are from Dwight's (1980a). Since no p/z values were available in Dwight's (1980a) for 1983, p/z was held constant from the last available data and the p/z plot was drawn using that value.

Table 4. Recovery efficiencies for ATAPCO #1 Hermes and ATAPCO #1 Holman.

$$\text{Recovery efficiency} = (100)\,\frac{\text{Total gas produced}}{\text{Original gas in place}}$$

Well	TGP/OGIP	R.E. (%)
ATAPCO #1 Hermes	471/506	93.1
ATAPCO #1 Holman	3605/4100	87.9

Values of TGP and OGIP are from figure 16.

Table 5. Statistics on sand and gravel pits and leases in contract area.

Operator/Headquarters address*	Location/County	Lease/Year primary lease ends	Comments	Amount mined out	Lease price	Number on figures 17 and 18
Operating pits						
Ideal (This may be the Thorstenberg Minerals Co. division of Ideal: Highway 71 South Columbus, Texas 78934 ph. 409-732-2490)	2 mi W of Ellinger/Fayette	--#	--	89 ac.	--#	1
P&A Materials, Inc. Highway 71 North Columbus, Texas 78934 ph. 409-732-6876	2 mi south on S.R. 71 from Ellinger, then SW 1 mi/Colorado	19 ac. of D.T. Prause lease†/1988 or earlier	This company split off from Sprint	Property lines uncertain; 22-63 ac.	Not less than $60,000	2
7-Day Concrete Corp. FM Road 109 Columbus, Texas 78934 ph. 409-378-2885	1¼ mi SW of Ellinger/Fayette	--#	Dredge in use	35 ac.	--#	3
Sprint Sand and Gravel 1223 Witte Rd. Houston, Texas 77055 plant ph. 409-732-5949	3 mi SSE of Ellinger/Colorado	135 ac, in six leases†/1983	Two plants, three stockpiles. One 30 ac. lease on record appears not to have been mined	314 ac.	--#	4
Stratasource, Inc. 9898 Bissonnet, suite 260 Houston, Texas 77036 ph. 713-995-5343 plant ph. 409-263-5111	1 mi N of Holman on FM 155/Fayette	part of 200 ac. Henry Kana lease/1994	No overburden removal appears to be necessary. Segmented conveyor belt system used. Very large stockpile	90 ac.	Not less than $736,425	5
Unknown (possibly Starr)	2 mi NE of Holman/Fayette	--#	Processing plant and pits new in 1983	approx. 6 ac.	--#	6
Non-operating leases						
Parker Brothers P. O. Box 107 Houston, Texas 77001	2 mi SW of Ellinger/Fayette	180.2 ac. of J. Krenek lease/1988	Only 152 ac. lie within contract area	--	$180.20/mo advance royalty	7
South Texas Excavating and Mining Co.	2 mi NNW of Holman on FM 155/Fayette	63 ac. Henry Kana lease/1983	Mining underway adjacent to the south side of this lease	--	$250/yr rental	8
Southwest Materials, Inc.	1½ mi NE of Holman/Fayette	35 ac. of A. Seydler lease/1972	Lease probably no longer in effect	approx. 5 ac.	--#	9
Starr Aggregate Corp. Minnesota	1½ mi NE of Holman/Fayette	80 ac./1985	--	--	$5,000/mo rental	10

*as of lease date # information not available in courthouse records † lease information probably incomplete

Table 6. Calculations for lease and stockpile purchase value of remaining fluviatile and alluvial sand and gravel resources within the contract area.

A. Lease value of sand and gravel in the ground

1. For areas where lease value is known

   a. P&A Materials

      value of lease = not less than $60,000

      area leased = 19 ac.

      Some acreage may be mined already so these values were not used in calculations.

   b. Sprint

      royalty = not less than $30,000

      area leased = 30 ac.

      Tract may be mined already and actual value is probably greater, so these values were not used in calculations.

   c. Stratasource

      value of lease = not less than $736,425

      area leased = approximately 180 ac. (see table 5)

      remaining resource = 90 ac.

      $736,425 ÷ 180 ac. = $4,091/ac.

      $4,091/ac. x 90 ac. = $368,190

2. For all other areas (disregarding advance royalties or lease rental now paid; see table 5 for that information).

   a. Estimation of value per acre of sand and gravel in the ground. Sale values for only the total acreage of leases held by Stratasource and P&A were available. Acreage held by P&A is known for the price listed; acreage held by Stratasource is estimated. Royalty values per acre were available for the three other companies listed below.

Company	**Royalty or value ($)**	**Acres**	**Cost per acre ($)**
Stratasource	736,425	180	4,091
P&A	60,000	19	3,158
Sprint	1,000	1	1,000
Parker Bros.	2,500	1	2,500
Starr	5,000	1	5,000 (inactive)
	4,000	1	4,000 (active)

The average of these values is \$3,291/ac. The lease holdings are mostly on good-quality, fluviatile terrace land (fig. 17).

In the contract area, fluviatile terrace land = 6,642 ± 10 ac.

6,642 x \$3,291/ac. = \$21,858,822

Lesser quality alluvial land = 20,662 ± 100 ac. Value of this land is estimated at \$1,645/ac. (\$3,291 ÷ 2 = \$1,645).

20,662 ac. x \$1,645/ac. = \$33,988,990

Subtotal, lease value for sand and gravel in the ground = \$56,216,002

B. Purchase value of sand and gravel in stockpiles

1. Estimate of price per ton value

The following two price lists were obtained:

from P&A Materials		from Stratasource	
size (inches)	price per ton	size (inches)	price per ton
1.5	4.65	1.5	4.60
1	5.15	1	5.00
5/8	5.15	5/8	5.00
3/8	4.30	3/8	3.00
GS	3.45	Concrete Sand	1.00
Sand	2.45	Rd. Gravel	2.50
F. Sand	4.05		
without sand			
1.5	5.55		
1	5.55		
5/8	5.55		

Prices charged at Stratasource in December 1983 were 25 percent less than those listed above. In the following calculations, a value of \$4.60/ton was used.

2. Rough estimates of the surface covered by stockpiles:

Ideal	5 ac.	cone-shaped
7-Day	3 ac.	cone-shaped
Sprint	3.5 ac.	cone-shaped
	6 ac.	oblong
Stratasource	12 ac.	oblong

Stratasource stockpile was planimetered. Other stockpile areas were estimated, as it is difficult to get an accurate planimeter value for such small areas.

3. Volume computations

Assume: all stockpiles are 10 yd. high (except Stratasource)

Given: volume of a cone = 1/3 bh

a. cone-shaped piles

5 + 3 + 3.5 = 11.5 ac.

11.5 ac. x 4,840 sq. yd./ac. = 55,660 sq. yd.

1/3 x 55,660 sq. yd. x 10 yd. = 185,533 cu. yd.

b. oblong piles

<u>Sprint</u>: 6 ac. x 4,840 sq. yd./ac. = 29,040 sq. yd.

Given: The volume of a truncated cone with base diameter D, top diameter d, and height h = $(\pi/12)\, h\, (D^2 + d^2 + Dd)$.

diameter of a circle (D) of area 29,040 sq. yd. = 192.29 yd.

angle of repose of pile = 35 degrees; d = 163.73 yd.

volume of pile = 249,407 cu. yd.

<u>Stratasource</u>: 12 ac. x 4,840 sq. yd./ac. = 58,080 sq. yd.

D = 271.94 yd.; d = 224.36 yd.

h = 16.66 yd.

volume of pile = 808,206 cu. yd.

4. Value calculations

a. Three estimates of the number of pounds of sand and gravel per cu. yd. were available in the lease records:

Sprint	2,000 lbs/cu. yd.
Parker Bros.	2,800
STE&M	3,000

average = 2,600 lbs/cu. yd. (1.3 tons/cu. yd.)

b. Total yardage in stockpiles (except Sprint)

185,533 cu. yd. + 808,206 cu. yd. = 993,739 cu. yd.

c. Tonnage of stockpiles

Sprint: 249,407 tons[1]

All others: 993,739 cu. yd. x 1.3 tons/cu. yd. = 1,291,861 tons

[1]Not all of stockpile may be sellable. It does not appear to have been sieved.

d. Total purchase value

Total tons: 249,407 tons + 1,291,861 tons = 1,541,268 tons

1,541,268 tons x $4.60/ton = $7,089,833

Subtotal, purchase value for sand and gravel in stockpiles = $7,089,833

C. Total lease and stockpile purchase value for all remaining fluviatile and alluvial sand and gravel resources = $63,305,835, rounded to nearest significant figure = $63,000,000