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DRILLING THE CITY: THE IMPACT OF OIL FIELD DEVELOPMENT IN OKLAHOMA CITY, 1928-2000

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DRILLING THE CITY: THE IMPACT OF OIL FIELD DEVELOPMENT IN OKLAHOMA CITY, 1928 - 2000

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Thanks to those who introduced me to Geography and especially to those who showed me this big, beautiful world and all of its wonders. Thank you for teaching me to love Geography. I thank my committee members who helped me create something worth reading and guiding me to create something worth remembering. Most of all, I thank my love and my family. Without you I would never have made it through this tiresome journey to this triumphant finish.

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1. Introduction

The structure and spatial evolution of urban areas are well-established topics in urban geography. Townscapes and morphological regions (Knox and Pinch, 2000) are a common focus of research, while environmental responses to urban development are analyzed in impact studies. Frequently, research focuses on social and economic inequalities within cities; one example is examining the relationship between zoning and socio-economic heterogeneity (Allen 1969). While urban geography provides insight to the economic and social forces shaping urban functions and morphology, the field has rarely considered resource extraction alongside activities such as trade, commerce and production. The experience of oil field development in the Oklahoma City metropolitan area provides an opportunity to examine the challenges of resource extraction in an urban area. The major contribution of this thesis to existing knowledge in urban and environmental geography is its examination of the influence of oil field development on the Oklahoma City metropolitan area.

Oklahoma City was established in 1889. Its founding, thus pre-dates by about forty years the discovery of petroleum in the Oklahoma City Field in 1928. Many towns associated with petroleum production have been labeled "boom" towns (Rister, 1949). Yet, Oklahoma City is distinctive because of the way oil extraction *followed* rather than initiated urban development. In many regions of the United States, petroleum production has disrupted existing lifestyles and changed the rate and pattern of urban development. In California, for instance, many small communities protested against petroleum companies when a potentially lucrative petroleum field was discovered near what is now

Los Angeles (Quam-Wickham, 1998). While their struggles to control and regulate production preceded the Oklahoma City Field, the communities in California were not yet large, concentrated urban areas.

Prior to the development of the Oklahoma City Field, the economy of Oklahoma City was based on the processing and distribution of agricultural commodities - notably cotton, wheat and maize - grown in the surrounding area (Robertson, 1937). The petroleum invasion began following the drilling of the initial discovery well in 1928. Never before in the history of petroleum development in North America had such a large metropolitan area been "threatened" by the development of a giant oil field (Robertson, 1996). The derricks, storage tanks, roads and oil camps moved into the once rural farmland on the eastern and southern periphery of Oklahoma City. The oil derricks and building of storage tanks led to significant decreases in land values. The transformation of the area from semi-rural to urban oil field depreciated agricultural land values in the surrounding areas considerably. The distribution of costs and benefits associated with oil development was highly uneven and the regulation of oil field development tended to reflect and reproduce existing economic and social inequalities. To take one example, many farmers benefited from the sale of mineral rights and land leases, while residents suffered from the depreciation of property values, influx of population and an increase in pollution hazards (Robertson, 1937).

The development of the Oklahoma City Field had a significant impact on many aspects of petroleum regulation and urban planning that continue to this day. This study analyzes and interprets the influence of the development of the Oklahoma City Field on

the metropolitan area of Oklahoma City. Specifically, this study: 1) analyzes the production history of the Oklahoma City Field during the period 1928 – 2000, 2) maps the field's spatial evolution, 3) reviews the social and environmental challenges this created in the Oklahoma City urban area and, 4) identifies how individuals and state and local institutions responded to these challenges. Four chapters follow this introductory chapter. Chapter 2 presents the history of petroleum production in Oklahoma and the Oklahoma City Field. It reviews the geologic setting of the Oklahoma City Field, presents and analyzes production history data from the field and places the experience of the Oklahoma City field in the context of the oil booms at the Oklahoma and national scales. The chapter then examines the spatial evolution of the Oklahoma City Field and presents a series of maps illustrating the expansion of the field following the initial discovery of 1928. Chapter 3 describes the environmental impacts of petroleum production and outlines a typology of the challenges posed by oil field development in the Oklahoma metropolitan area. The typology identifies and summarizes four primary challenges from oil development: 1) resource conservation, 2) impact on property values, 3) environmental quality and, 4) health and safety issues. It identifies specific regulatory responses to each of these challenges in the Oklahoma City Field and evaluates the dominant spatial scale - local, state and federal - at which these challenges were met. Chapter 4 identifies how individuals and institutions responded to petroleum production through various strategies designed to regulate the impact of oil production including zoning, land use planning and legislative and regulatory action. A final chapter - Chapter 5 - summarizes the results of the analysis of the production history of the Oklahoma City

Field, the spatial mapping of drilling activity between 1928 and 2000, and interprets the social and environmental challenges that faced Oklahoma City residents given their proximity to oil field activities.

Data for this thesis was complied over a two-year period and was drawn from the resources of the Oklahoma Historical Society in Oklahoma City and the University of Oklahoma libraries in Norman. The literature available from the Oklahoma Historical Society included archived newspapers, photographs and folders of manuscripts. The University of Oklahoma Bizzell library archives, Western History Collection and the Youngblood (Geology) library provided a substantial amount of material including The Oil and Gas journal archives, American Petroleum Institute (API) reports and Oklahoma Geology publications which contained production data and well locations.

The NRIS archive from Geo-Information Systems was accessed through the Oil Law Corporation website. This data was sorted by oil field and then sorted by well spud date. The data was imported into ESRI's ArcGIS (ArcView 8.3) software, where symbols were assigned by well type in order to create a sequence of thematic historical maps of the spatial development of the Oklahoma City oil field.

2. Petroleum Production History

This chapter has four sections. The first describes the history of oil production in Oklahoma, while the second looks specifically at the Oklahoma City Field. The chapter then turns to the production history of the Oklahoma City Field before briefly examining its spatial evolution. Chapter 2 thus provides the context for the discussion of the environmental impacts of oil production in Chapter 3 and the responses to oil production in Chapter 4.

2.1 Petroleum Production History of Oklahoma

The abundance of natural resources in the area we know today as Oklahoma enticed many white settlers even before the official opening of Indian Territory to settlement in April 1889. Homesteaders, cattlemen and railroad companies advocated the opening of the "Unassigned Lands" in what is now the central areas of the state. The railroads could not continue rail lines through Indian Territory without government land grants, but the United States government could not grant these since the properties were controlled by the Native American Tribal governments. White businessmen associated with petroleum exploration arrived as early as the 1850s (Northcutt, 1985) although the first records of significant commercial discovery date to 1897 (Franks, 1980). During this initial period when Oklahoma was not yet open for settlement early explorers and businessmen negotiated and worked with the Native American tribes governments of "Indian Territory". These tribes included the Choctaw, Chickasaw, Cherokee and Osage (Franks, 1980). Access to Indian Territory was limited until the United States government allotted

territory to members of Native American tribes. The remaining lands were then opened for settlement by non-Native Americans in a land race. The first homesteaders and entrepreneurs of 1889 rushed to the area in pursuit of free land, resources and employment opportunities (Harlow, 1967).

Oklahoma was granted statehood following the resettlement of Native American tribes and the allotment of reservation lands (Franks, 1980). The creation of this fledgling state and its new capital city drove the search for natural resources for economic development. The first major resource required for the development of Oklahoma City was water (Franks, 1980). The meandering streams that crossed the rolling prairie of central Oklahoma could not provide an adequate supply for the rapidly increasing population (Table 1). Oklahoma City grew following the in-migration of pioneers during the "Land Run", which, in turn spawned a drive for sinking water wells along with an occasional test well for oil (Rister, 1949).

Table 1 - Oklahoma City Population, 1890 – 2000

Year	Population
1890	4,200
1900	10,000
1906	32,500
1910	64,200
1916	92,900
1920	91,300
1930	185,400
1940	204,400
1950	243,500
1960	324,300
1970	366,500
1980	404,000
1990	444,700
2000	506,100

Source: U.S. Census Bureau, 2002

Initial production of oil in Indian Territory centered on the Bartlesville-Dewey field, discovered in 1897, but was hampered by limited access to eastern markets. Early Oklahoma petroleum production was generally concentrated in the northeastern part of the state, contributing to the rapid growth of the city of Tulsa, which became known as the "Oil Capital of the World" (Northcutt, 1985). The first producing well in Bartlesville, the Nellie Johnstone 1 (Figure 1), was capped after initial discovery due to a lack of storage facilities, and the fact that the railroad for transporting oil to market was not yet complete (Franks, 1980).

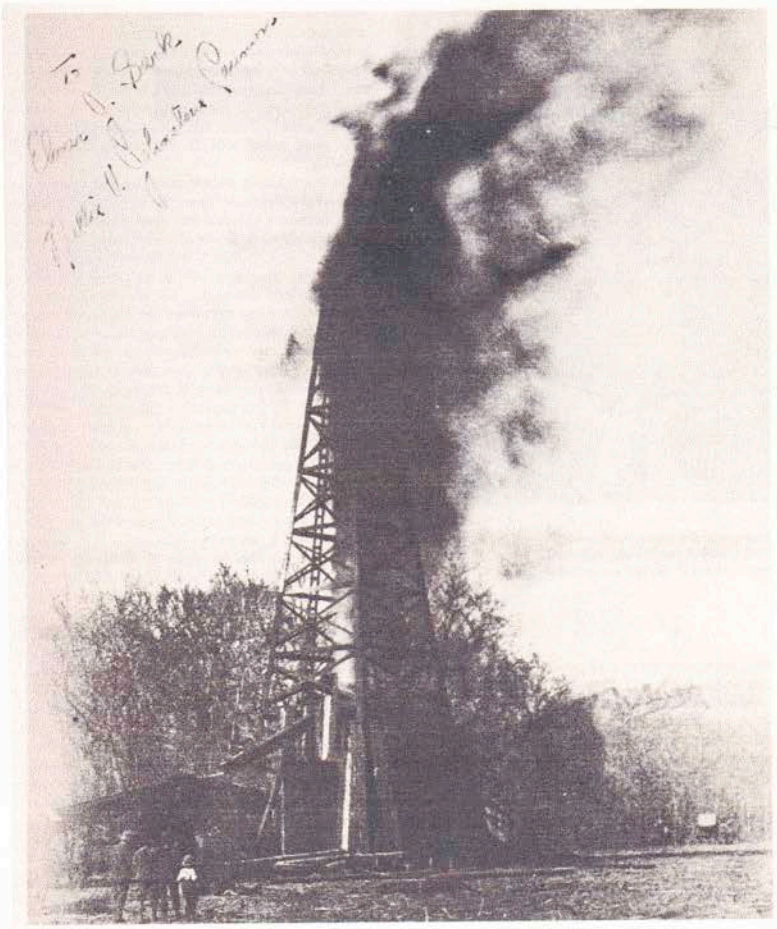


Figure 1 - The Nellie Johnston #1 in Bartlesville, Oklahoma, 1897

Source: Franks, 1980

With the development of an infrastructure for storing and transporting oil, production in Oklahoma grew rapidly. Initial discoveries in the northeast of the state, and the growing interest in other regions of the U.S. southwest (Table 2) created a thriving industry that by the 1920s permeated almost every aspect of business and politics in Oklahoma.

Table 2 - Southwestern United States First Petroleum Production Years

State	First Production
Kansas	1889
Texas	1896
Oklahoma	1897
Louisiana	1902
Arkansas	1921
New Mexico	1924

Source: Rister, 1949

Following the 1897 discovery other major oil fields in Oklahoma came on line with Oklahoma City Field proving to be a relative latecomer (Table 3).

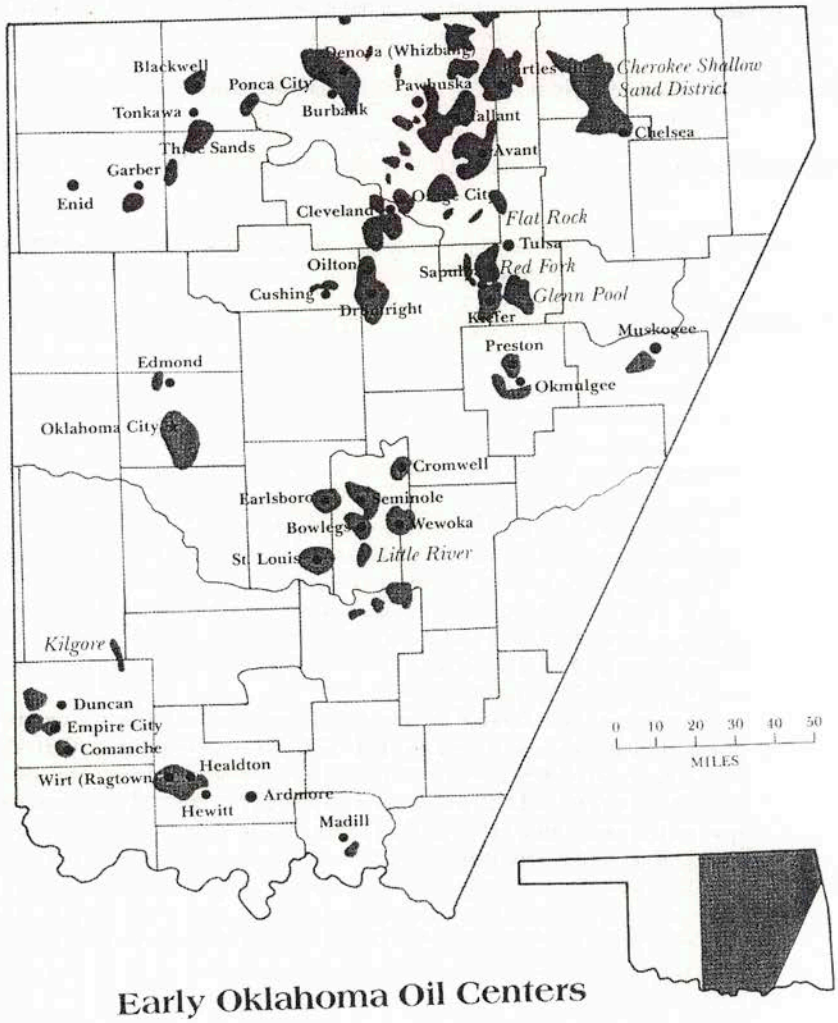
Table 3 - First Production Years of Early Oklahoma Oil Fields

Field	First Production
Glenn Pool	1907
Cushing	1914
Healdton (a)	1914
Burbank	1920
Hewitt	1920
Tonkawa	1922
Garber	1924
Seminole City (b)	1926
Earlsboro	1927
Little River	1927
St. Louis-Pearson (c)	1927
Oklahoma City	1928
Carr City	1929
Bowlegs	1931
Fitts	1934
West Edmond	1943

a-Includes Wheeler; b- Includes Earlsboro; c- Pearson Only

Source: Rister, 1949

Oil production was concentrated in the eastern part of the State with Map 1 illustrating the location of the major oil fields.



Map 1 - Early Oklahoma Oil Centers

Source: Franks, Lambert and Tyson 1981

With the growth of the automobile industry and the substitution of whale oil lamps with kerosene lanterns in the 1920s, the demand for petroleum markedly increased during the early part of the twentieth century. Several businessmen invested in petroleum

companies, such as Phillips Petroleum, Conoco, and the Indian Territory Illuminating Oil Company (I.T.I.O). These firms were to become influential in the economic development of the state. As early as 1900 large refining companies such as Standard Oil and Gulf Oil extended pipelines into Oklahoma (Franks, 1980) from major outlets such as Houston and Kansas City and began producing and refining large amounts of petroleum (Rister, 1949; Franks, 1980).

Indeed by 1907, Oklahoma ranked first in oil production in the United States (Northcutt, 1985) (Figure 2).

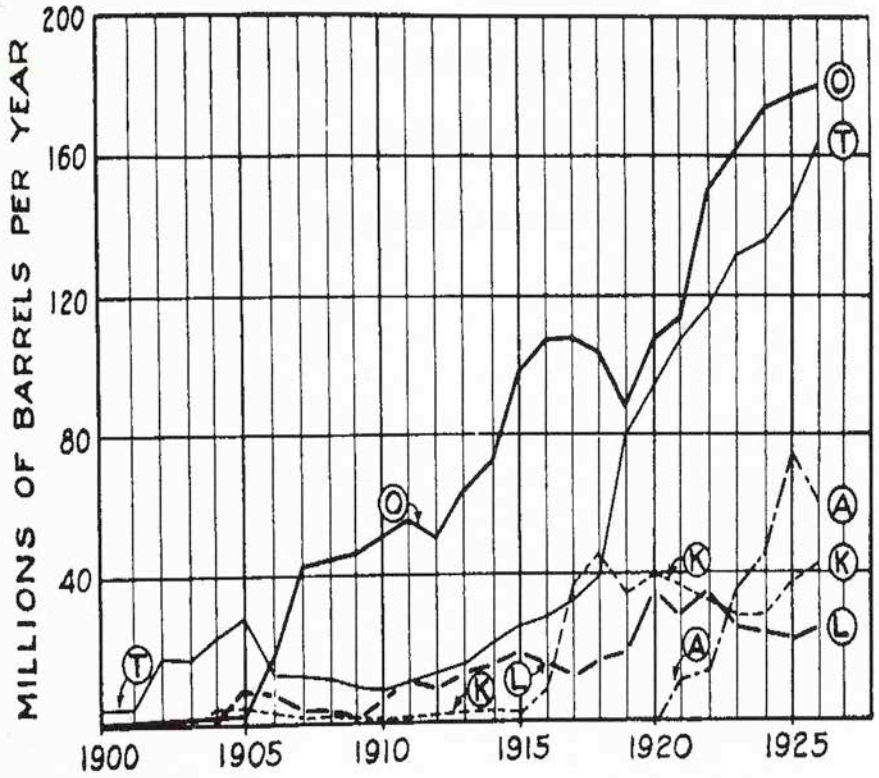


Figure 2 - Oil Production in major oil producing states, 1900-1925.

Letters represent Oklahoma, Texas, Arkansas, Kansas and Louisiana

Source: Franks, 1980

Advances in petroleum geology and petroleum production technology in the 1920s and 1930s in the booming areas of the southwest, including Texas and Oklahoma, increased the success of each prospect and greatly increased well completions throughout the industry's early history. Annual oil production in Oklahoma reached a record 278 million barrels in 1927 (Figure 3). Production fell with the Great Depression but reached a secondary peak of 229 million barrels in 1937 (Rister, 1949). Oil production fell again to only 125 million barrels in 1944 but following the end of World War II production steadily increased to reach 216 million barrels in 1956. 1967 saw the last recorded spike in production with an annual total of 231 million barrels. Production has declined from that point although production rebounded in the 1980s in response to the very rapid escalation of crude oil prices after 1973 (Figure 3). A steady decline after 1984 cut annual production from 168 million barrels to a mere seventy-eight million barrels by 1998 (Northcutt, 2000).

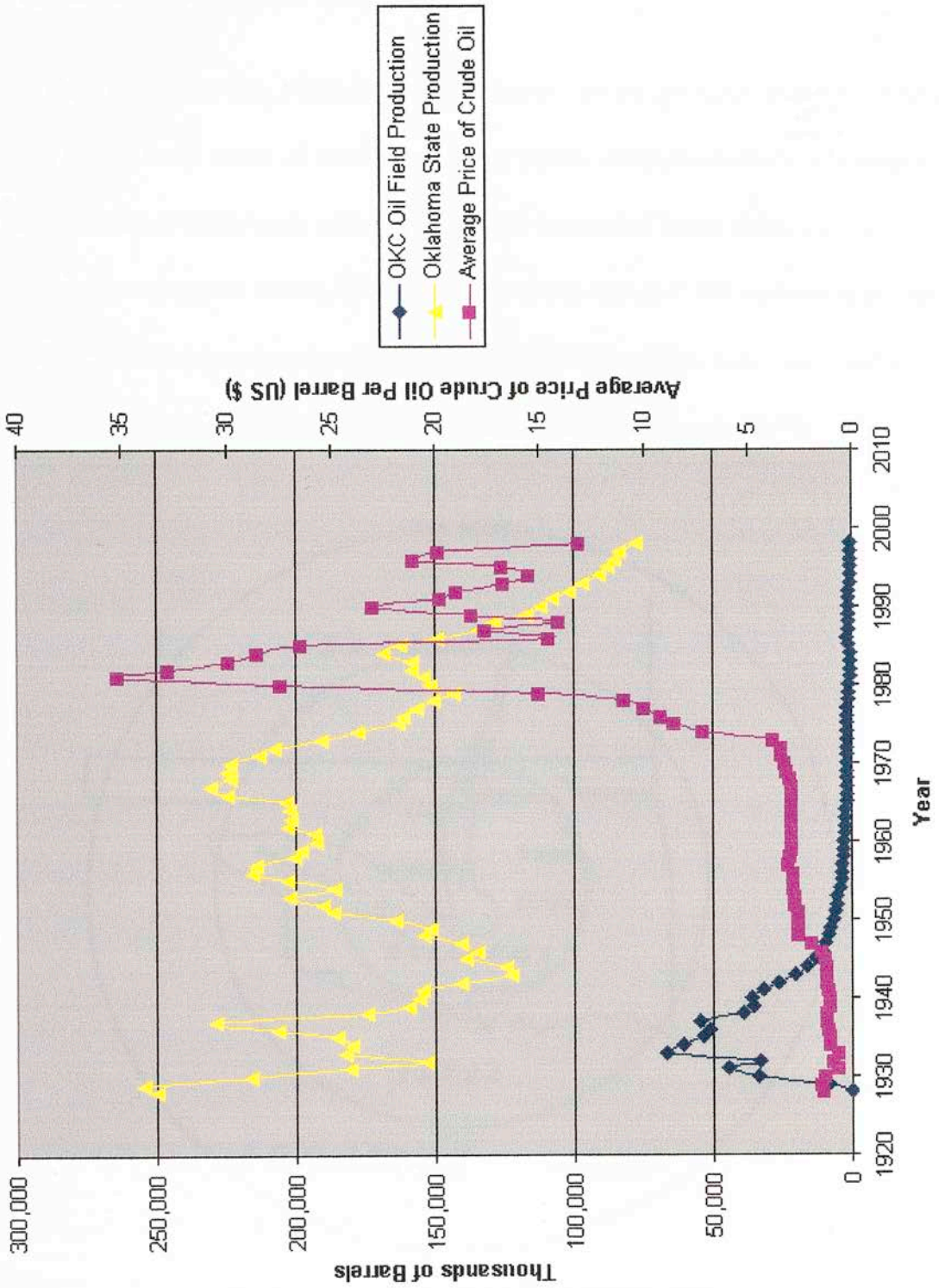
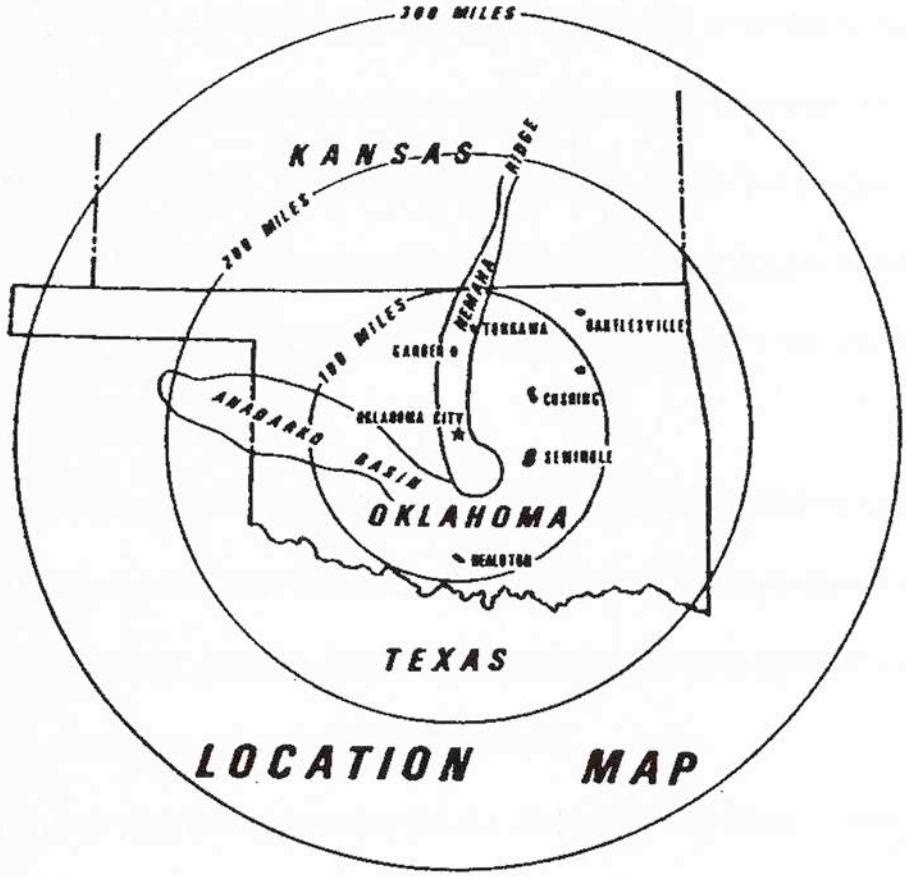


Figure 3 - Average Price of Crude Oil and Oklahoma Oil Production vs. Oklahoma City Oil Production

2.2 Geology of the Oklahoma City Field

The Oklahoma City Field structure is located on the southern tip of the Nemaha Ridge. This regional series of mobile basement uplifts extends south from Southeast Kansas into central Oklahoma where it meets the Anadarko Basin (Map 2). The growth of this anticline occurred during Ordovician (between 438 and 505 million years ago) through early Pennsylvanian time (between 286 and 320 million years ago) and is most likely related to the subsidence of the Anadarko Basin (Gatewood, 1970).



Map 2 - Geologic Location of the Oklahoma Region

Source: Gatewood, 1970.

The trap geometry of the Oklahoma City Field is a twelve-mile long by four and a half mile wide faulted anticlinal fold with vergence (or upfold) to the east. The front (eastern) limb is faulted through by a large, nearly vertical, reverse fault with up to 2,000 feet of throw (Gatewood, 1970) that juxtaposes early Ordovician units against early Pennsylvanian units. An uninterrupted sequence of strata that are involved in the folding include pre-Cambrian granite at the core of the structure to the late Ordovician Sylvan Shale in the upper most portion of the western limb of the anticline. Contemporaneously with fold development was a crestal truncation of late through early Ordovician units, due to erosion, of the upper 2,000 feet of original structural relief resulting in the later development of an angular unconformity as strata of the early Pennsylvanian were deposited (Gatewood, 1970). The producing sandstones of the Ordovician through Pennsylvanian are fluvial deltaic channels that were draining sediment into the Anadarko Basin. The early Pennsylvanian Oswego units most likely act as a top seal for the Oklahoma City Field.

Net producing closure is approximately 1,000 feet of cumulative column with at least thirty different productive reservoirs. From these reservoirs, over one billion barrels of oil and oil equivalent gas have been produced making the Oklahoma City Field a true "giant" of the petroleum industry (Gatewood, 1970).

The source rock and maturation for the Oklahoma City Field is most likely generating oil and gas that is being charged out of the Anadarko Basin and migrating vertically up-dip to the Oklahoma City Field anticline. This represents a large portion of the southeastern Anadarko Basin. Figure 4 illustrates the structure of the Oklahoma City

Field and Figure 5 displays the vertical profile of the Oklahoma City structure. The main reservoirs are located between 4,000 feet and 7,000 feet below the surface.

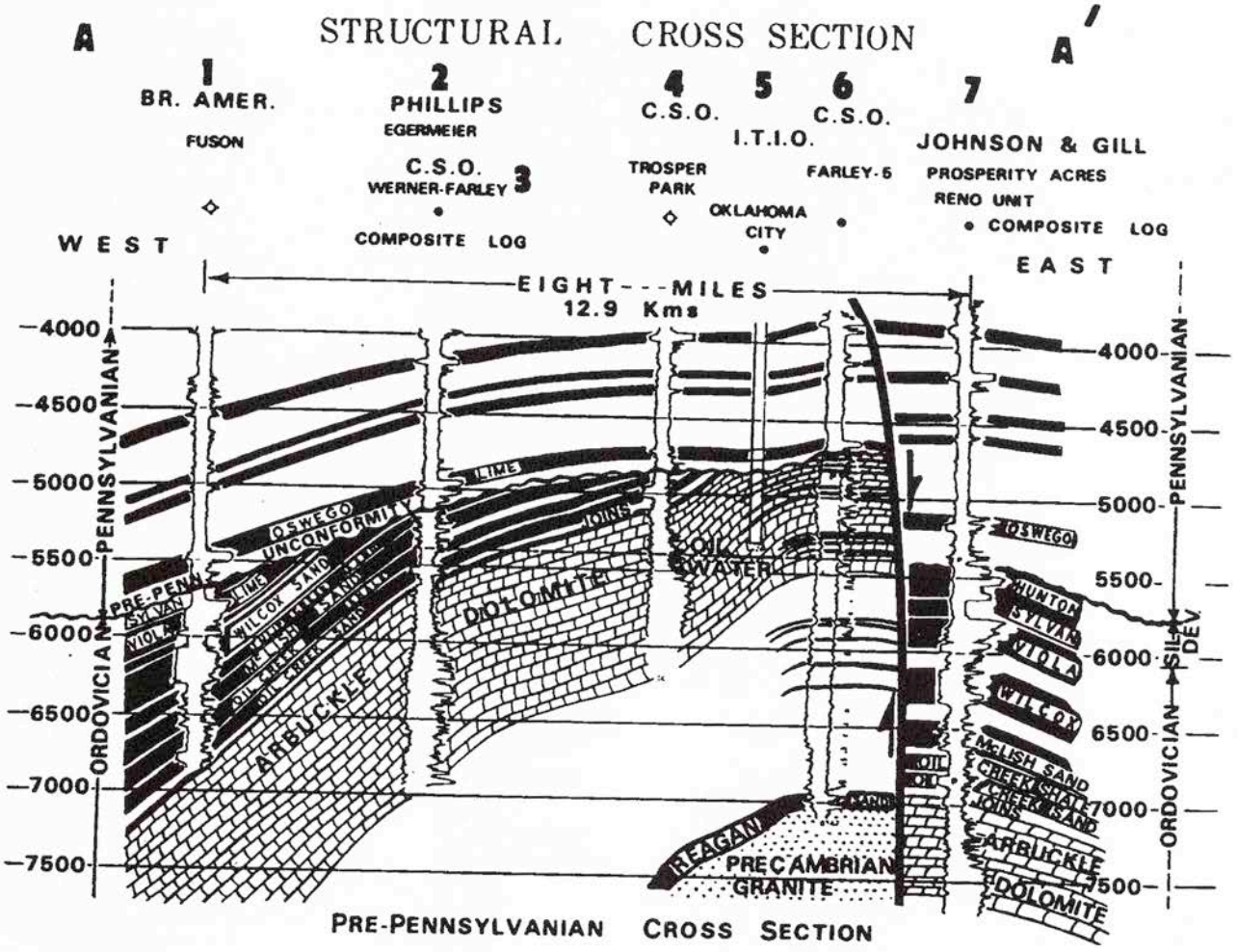


Figure 4 - Oklahoma City Field Structural Diagram

Source: Gatewood, 1970

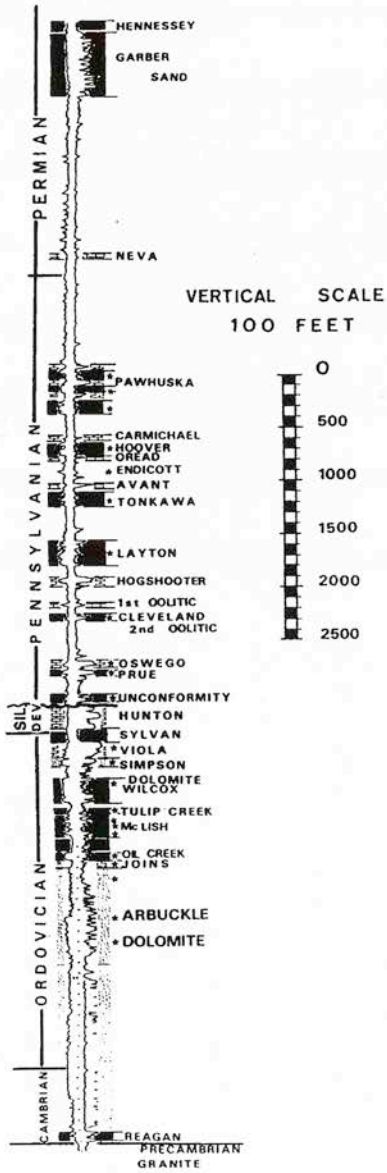
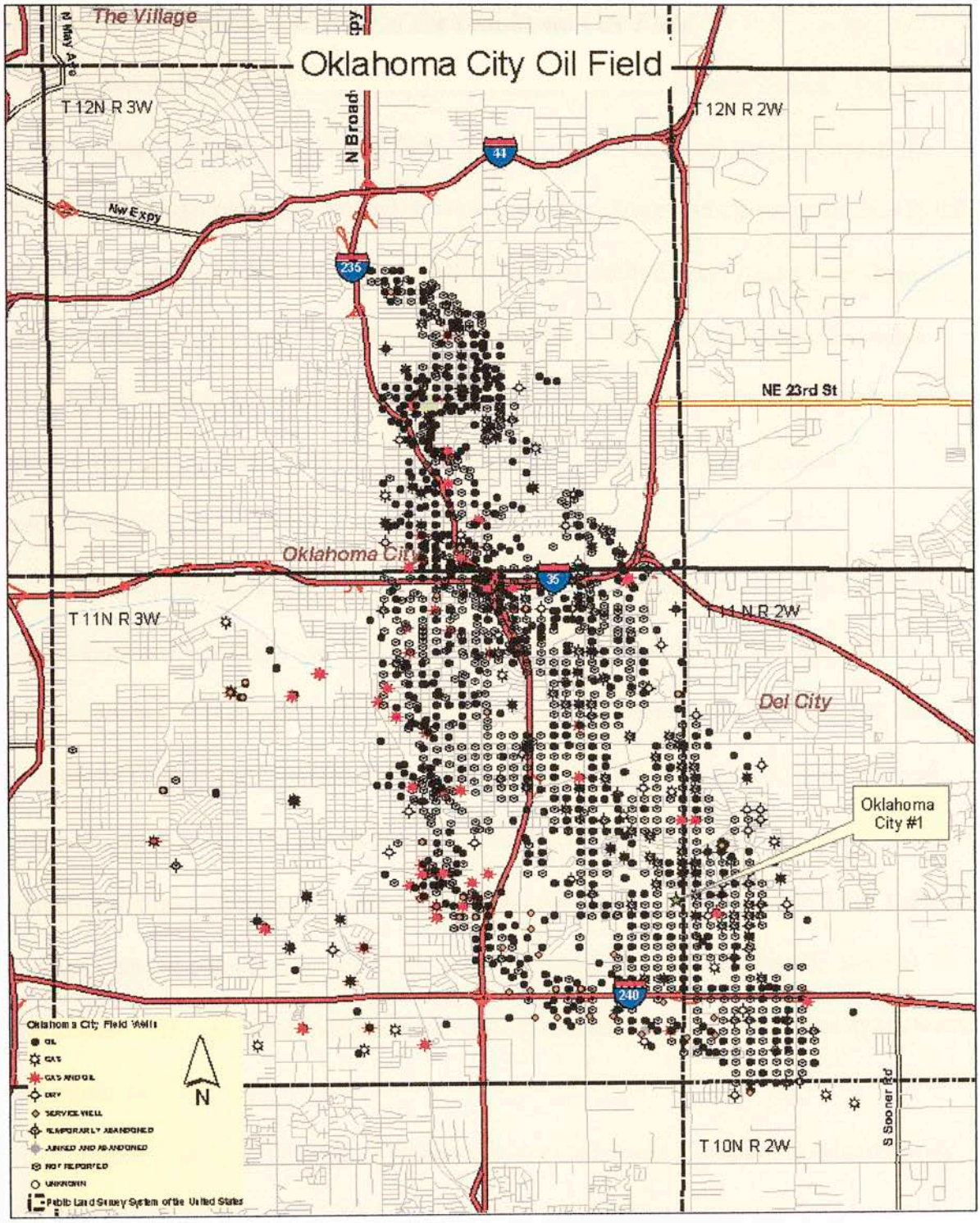


Figure 5 - Vertical Profile of OKC Field

Source: Gatewood, 1970

Geologists began mapping the region around Oklahoma City in 1917 (Franks, Lambert and Tyson, 1981). By 1925, geologists had mapped a surface high near the State Capitol. However, at this time sub-surface geological knowledge was limited.

Only surface features, such as surface evidence of an anticline indicated a possible trap below ground where petroleum could be located. With the prospect of petroleum in the area, geologists and businessmen began sinking wells around the city. The Oklahoma City Field officially began producing in December 1928. This "giant" field (Gatewood, 1970) eventually produced from multiple producing zones (Northcutt, 1985). The Oklahoma City Field is unique in a number of different respects. Not only was it a major oil field located within city limits, but also there were at least thirty producing zones (Gatewood, 1970). The Oklahoma City Field is located in the central part of the state and more specifically the south-west-central area of Oklahoma County (Township 11, 12N, Range 2, 3W). The current extent (as of 2000) is shown in Map 3.



Map 3 - The Oklahoma City Oil Field 2000

Map created by Author 2002, Source Data – NRIS, 2002

2.3 Petroleum Production History of the Oklahoma City Field

Initial drilling in Oklahoma City was designed to find a water source. The first petroleum exploration wells were drilled on the northern and southern outskirts of the city limits although over time test wells were drilled in closer and closer proximity to the urban area itself. One of the first recorded wells to be drilled was located near Warr Acres (northwest Oklahoma County) in 1903 (Rister, 1949). Even as more test wells were drilled in opposite corners of the county exploration results from these early wells reported little more than traces of oil. Consequently production was deemed uneconomical (Franks, 1980).

Testing continued throughout the early part of the twentieth century. Geologists such as George D. Morgan and L.E. Trout studied the area and created maps of the surface geology of the region. These maps showed the outlines of a field located just north of the Garber and Hennessey formations. These formations were promising and companies such as the Oklahoma based Indian Territory Illuminating Company (I.T.I.O.) began to purchase leases in the area. Contemporaries made attempts to drill just north of the State Capitol complex, but these tests were unsuccessful (Rister, 1949). Several "wildcatters" also attempted to sink wells throughout Oklahoma County, but again found only minor traces of oil.

Finally, on June 12, 1928, ITIO and Foster Petroleum Company spudded a well - the Oklahoma City No.1 (Map 3). On December 4th drilling at this site found several pockets of over-pressured natural gas, and after dealing with casing difficulties and problems with borehole stability, the oil began to flow. The Oklahoma City No. 1 flowed

out of control for more than an hour (Franks, 1980). This well, near the southeastern edge of Oklahoma County, marked the beginning of a booming oil field.

The geology of the region was confusing to many oilmen. The first producing wells of the Oklahoma City Field were sunk directly into compartmentalized reservoirs of crude. Later, as wells were developed farther away from the producing formation, the productivity lessened. One of the first to figure out the field's complex geology was Dean A. McGee, of Phillips Petroleum Company who led his employer to significant reserves of oil in several areas of the Oklahoma City Field (Franks, 1980).

The history of the Oklahoma City Field demonstrates the close relationship between production, the changing market for oil and shifts in the local regulatory environment. Production rose quickly following the initial 1928 discovery and by 1931 had reached nearly 45,000 barrels (Table 4 and Figure 6). In 1931 and 1932 the Governor enforced regulation of production rates leading to a temporary fall in production volumes. Lifting of these regulations in 1933 allowed production for the Oklahoma City Field to peak at over 66 million barrels of crude extracted (Figures 6 and 7). From that point forward production declined at a relatively modest rate such that by 1954 annual production had fallen to under five million barrels. The two anomalies to that pattern in the post 1945 period are modest increases in 1973-1974 associated with the OPEC oil crisis and similar rises in 1984, 1985 and 1986 associated with the rising price of crude (Figure 3).

Table 4 - Oklahoma City Field Crude Oil Production

Year	Thousands of Barrels	Year	Thousands of Barrels	Year	Thousands of Barrels	Year	Thousands of Barrels	Year	Thousands of Barrels
1928	101	1942	26,484	1956	3,743	1970	1,802	1984	860
1929	8,637	1943	20,338	1957	3,482	1971	1,770	1985	1,229
1930	33,965	1944	16,295	1958	3,290	1972	1,858	1986	1,555
1931	44,823	1945	12,968	1959	3,050	1973	1,908	1987	1,397
1932	33,398	1946	10,693	1960	2,851	1974	2,026	1988	1,253
1933	66,985	1947	9,370	1961	2,617	1975	1,912	1989	1,153
1934	60,834	1948	8,543	1962	2,381	1976	1,760	1990	1,304
1935	53,386	1949	7,703	1963	2,300	1977	1,510	1991	1,160
1936	51,232	1950	6,785	1964	2,112	1978	1,253	1992	929
1937	54,776	1951	6,303	1965	1,978	1979	1,159	1993	741
1938	38,938	1952	5,513	1966	1,922	1980	1,050	1994	598
1939	35,728	1953	5,187	1967	1,941	1981	891	1995	541
1940	35,970	1954	4,148	1968	1,963	1982	783	1996	509
1941	32,184	1955	3,803	1969	1,892	1983	766	1997	465
								1998	525
								1999	874

Source: Oil and Gas Journal and API

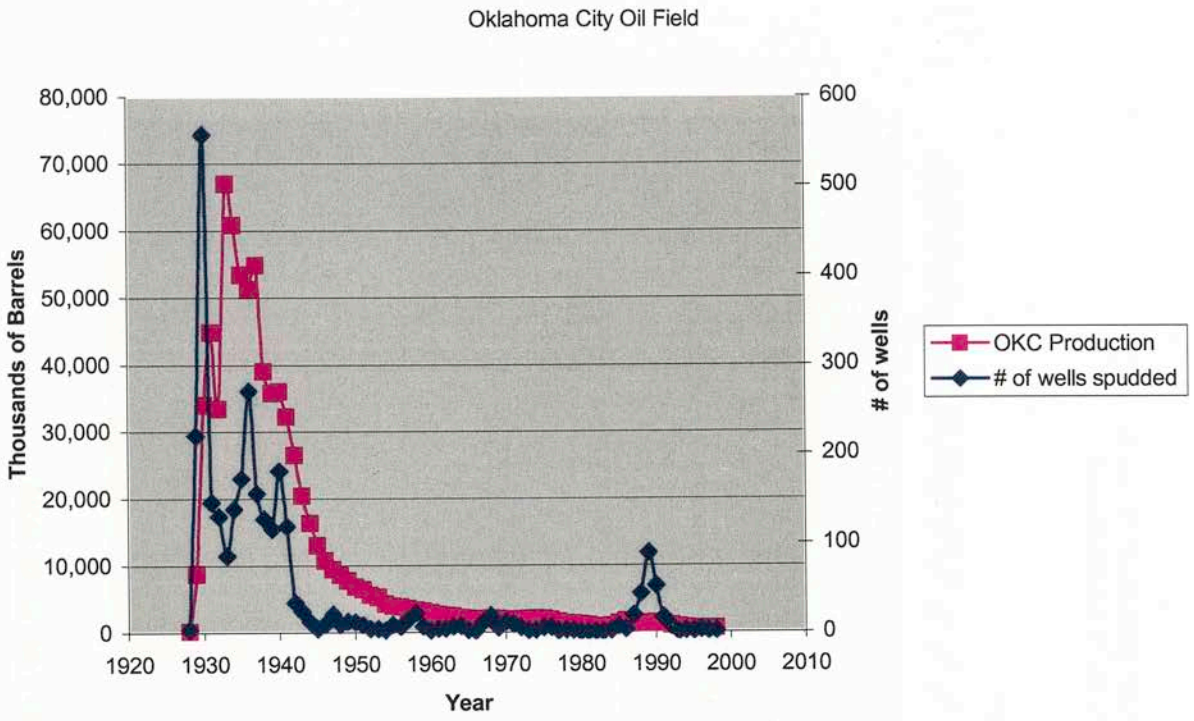


Figure 6 - Oklahoma City Field Production and Drilling Activity

Source: Oil and Gas Journal and API

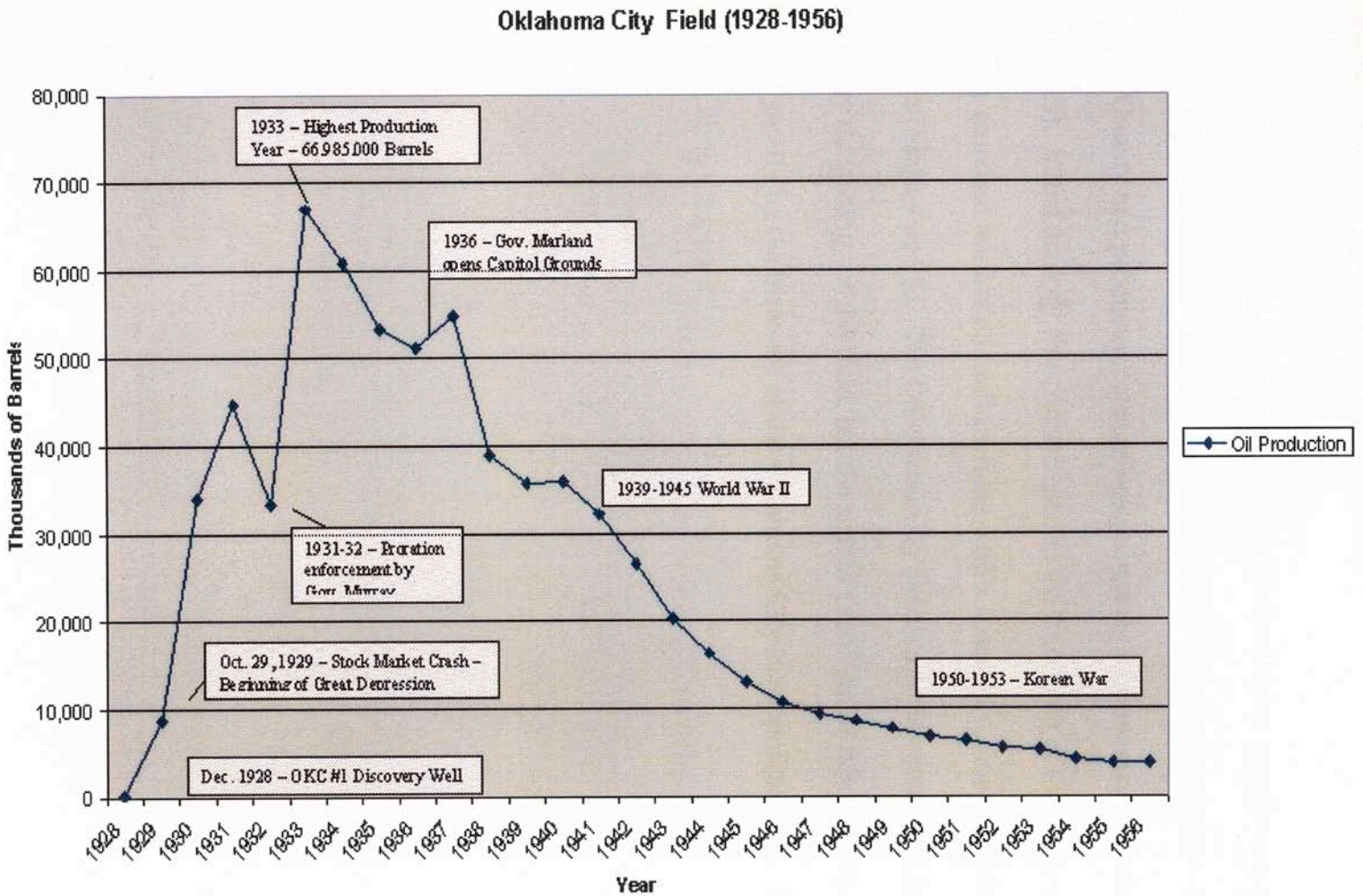
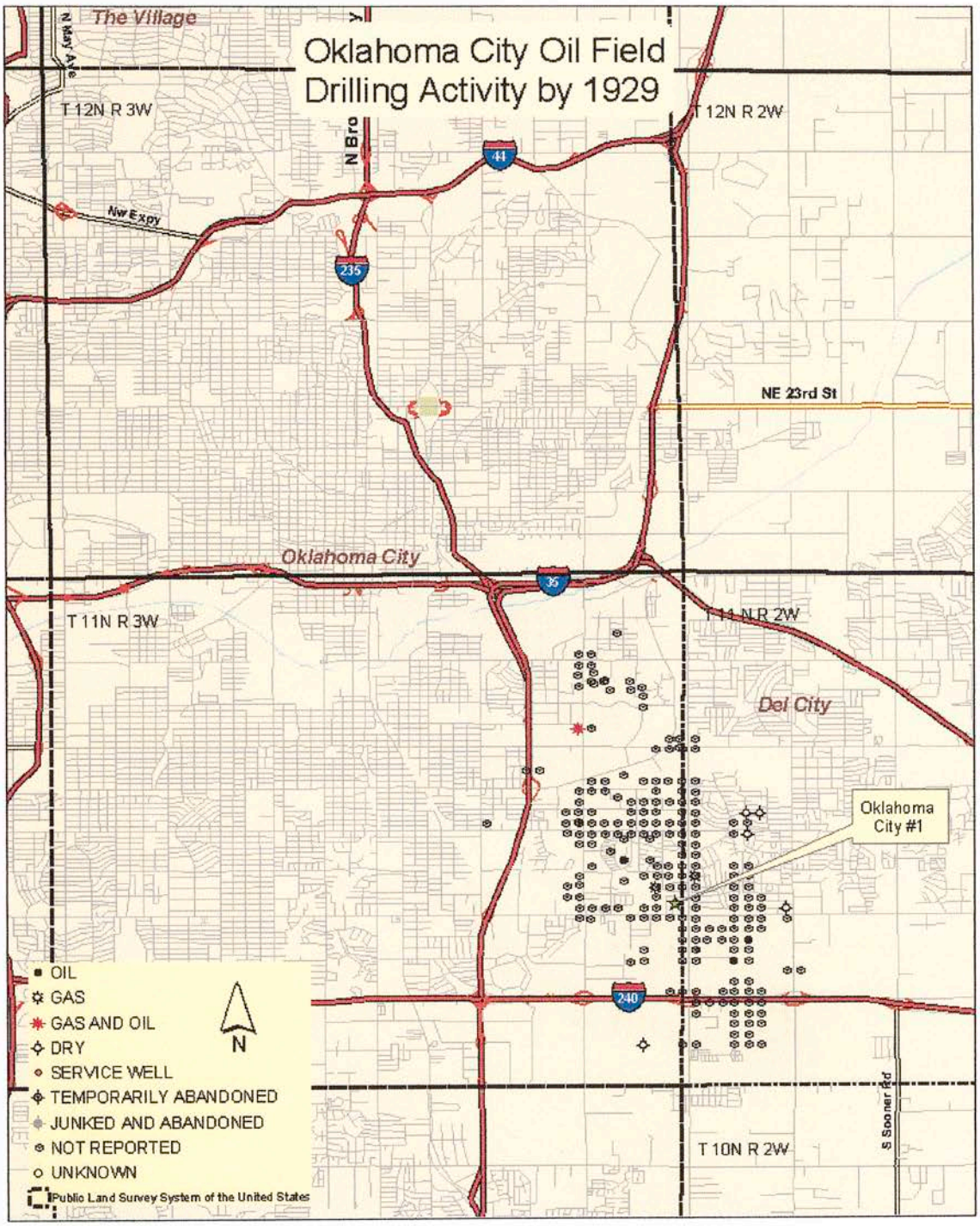


Figure 7 - Oklahoma City Production with Historical Markers

Data Collected from Various Sources to complete a historical profile of production rates.
Sources: Rister, API, Oil and Gas Journal, Vance Rowe/Petroleum Information, and NRIS

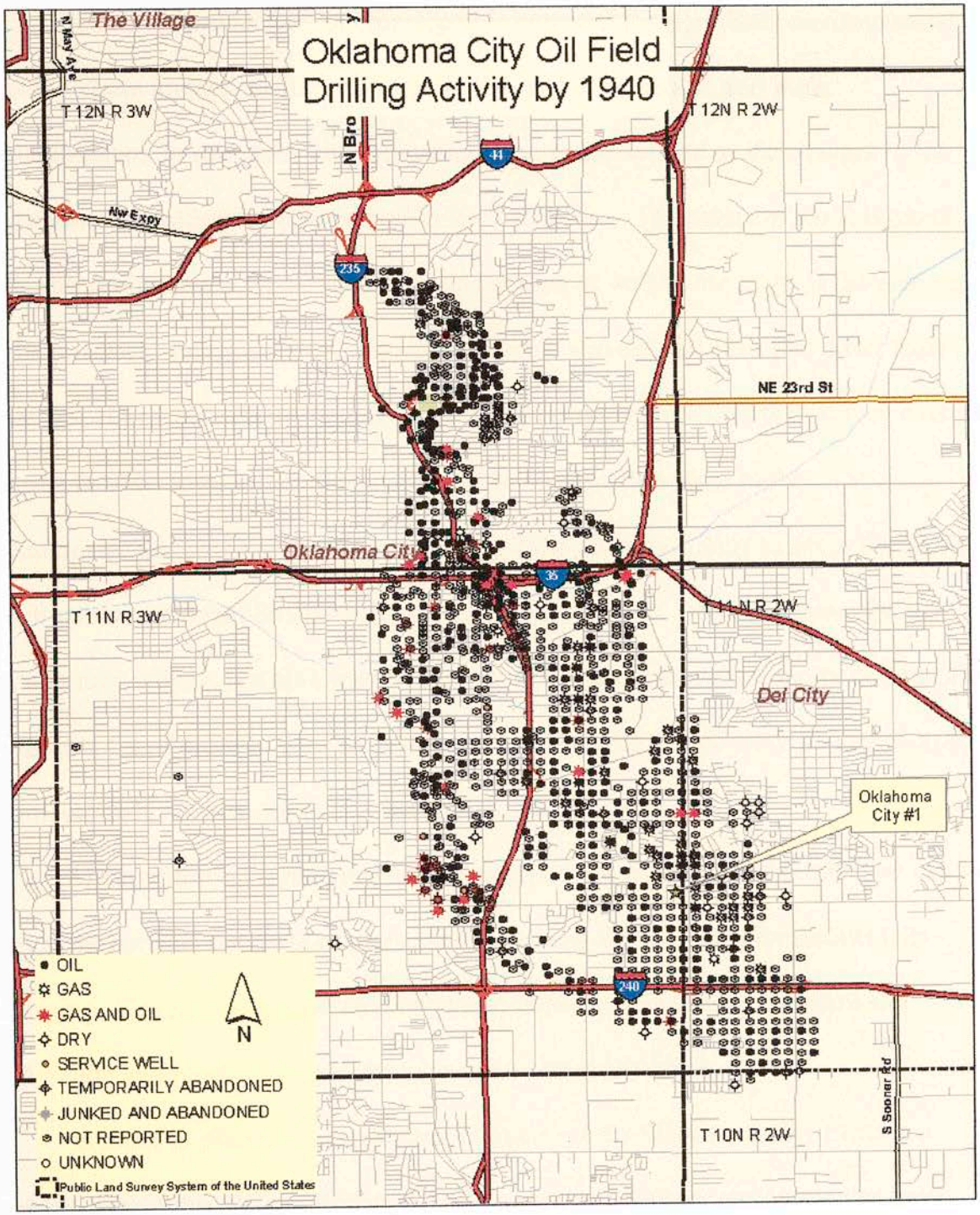
2.4 Spatial Evolution of the Oklahoma City Field

Appendix A provides a sequence of maps illustrating the spatial evolution of the Oklahoma City Field. The Oklahoma City Field grew from a single well on the edge of Oklahoma County to a production area of approximately fifty-two square miles (nearly 38,000 acres). Initial activity was concentrated in the south end of the field, and drill sites slowly marched northward until merging with a southward movement from the State Capitol area (Maps 4 and 5). The Oklahoma City field's spatial extent was limited primarily by the geology of the field, but the spatial evolution of field activity was also influenced greatly by the presence of the Oklahoma City metropolitan area. This is an issue taken up in Chapter 4.



Map 4 - Oklahoma City Field Well Map by 1929.

Map created by author, 2002. Source data NRIS, 2002



Map 5 - Oklahoma City Field Well site map by 1940

Map created by author, 2002. Source Data NRIS, 2002

3. Environmental Impacts of Petroleum Production

Petroleum production has considerable potential for significant environmental impact. These impacts include noise pollution, soil degradation, and water contamination. In this study environmental impacts are defined as the changes in the environment resulting from petroleum-related activities. The nature of these impacts varies according to the type of activities undertaken as well as the stage of development of the prospect. Environmental impacts of seismic surveys, for example, differ from those associated with production drilling. The environmental impacts thus vary over the life of a facility, from initial exploration, to the construction stage to the decommissioning stage of the project. Much of the impact is likely to occur during the construction of the facility and during the production phase. More occasionally, the impacts may only be felt after lengthy periods of hidden degradation and pollution. The Oklahoma City field was not absent of such incidents and indeed since its inception the petroleum industry has struggled with environmental issues.

Much of the environmental impact associated with petroleum production can be seen at the surface, but there can be unseen problems that are also environmentally damaging. The most common environmental impacts associated with petroleum exploration and production activities are summarized in table 5.

In order to place the environmental history of the Oklahoma City Field in a broader context this chapter first explores the general problems and issues that have arisen with the development of the petroleum industry. The production industry has quite humble beginnings. The exploration of early petroleum reserves began with finding

Table 5 - Environmental Impacts of Petroleum Production

Petroleum Production Activity	Equipment Transport	Hazardous Chemical and Fuel Transport and Handling	Construction of roads by clearing vegetation	Vegetation and Disease Treatment/Management	Acoustic Disturbance	Rehabilitation Activities - During and After	Cuttings and Drilling Fluids Containment/Management	Trenches	Hydrostatic Test Fluid Handling/Management	Formation Water Discharge (from production)	Gaseous Emissions	Flaring	Solid and Liquid Waste Disposal	Noise and Light Pollution	Continued Drilling	Petroleum transfer to tankers	Infrastructure Removal
Seismic Exploration	X	X	X	X	X	X											
Drilling (Exploration or Production)	X	X	X	X		X	X										
Facility Construction	X	X	X	X		X											
Pipeline Construction/Maintenance	X	X		X		X		X	X								
Facility Operation	X	X		X						X	X	X	X	X	X	X	
Decommissioning	X	X					X										X

seeps and near surface oil rich formations (Rister, 1949; Franks, 1980; Van Dyke, 1997). The impacts associated with this type of exploration were minimal compared to the intensive operations of modern petroleum exploration and production. The increase in petroleum dependant technologies and the resulting increases in demand initiated an intense and complicated struggle between man and nature.

3.1 Seismic Exploration

Surface mapping of regional geology alone cannot locate petroleum in lower strata formations (Van Dyke, 1997). Instead searching for reserves relies on seismic exploration, which consists of clearing tracts of land for taking seismic measurements using explosive charges along a defined track (Van Dyke, 1997). This, in turn, requires the transportation of seismic equipment to and from the exploration sites. Equipment transportation is arguably the most common source of environmental impacts associated with exploration and production activities with the transportation of heavy machinery and repeated visits to and from each site often causing considerable surface damage. This activity can impact the local vegetation and ecology adversely as can the transport of chemicals and fuel for machinery. The area is also impacted greatly by the construction of roads for access to and from the testing area as vegetation is removed and occasionally treated for disease management, e.g. adulticiding and larviciding for mosquitoes that may carry disease (Van Dyke, 1997).

Other impacts are associated with the seismic readings themselves. The seismic charges are received by geophones that map the geology of the area with the waves penetrating below ground formations and then reflecting back to the recorder (Van Dyke, 1997). This may cause some acoustic disturbance as well as explosive hazards. While this type of surveying is being conducted, rehabilitation of the local environment can impact the area. The uniqueness of each area's characteristics determines the amount of impact and the effort required to return the site to its previous condition. The timing of each survey is important to the rehabilitation effort given that seasonal phenomena such

as breeding and vegetation patterns can be significantly impacted by invasive exploration and production activities.

3.2 Drilling (Exploration and Production)

As with seismic exploration, equipment and machinery transport and the construction of roads for exploratory and production drilling are common activities that can have a significant environmental impact. Until pipelines are constructed, the raw crude oil has to be transported by tanker trucks (Van Dyke, 1997). Drilling is associated with the transport of significant amounts of equipment as well as the movement of hazardous chemicals such as those required for gamma ray logging and fueling equipment. Given the material and equipment requirements drilling activities can have a much more substantial impact on the local environment than seismic exploration. As with most petroleum production activities, the local vegetation, insects and animals may be adversely impacted by clearing and treatment with chemicals.

The actual drilling activities for exploration and production produce cuttings and drilling fluids that must be contained and monitored. Cuttings are pieces of rock from the drill hole (Van Dyke, 1997). These have significant potential to impact the environment in a number of ways. Many drilling fluids are poisonous and can cause damage to the surface ecology impacting vegetation and soil fertility. Historically, brine taken from formations was deposited at the surface and allowed to flow across the soil or sit in slush ponds (Robertson, 1937). This practice caused considerable damage to vegetation and rendered soil infertile for an extended period. This is now a prohibited activity and brine

is usually contained by injection into a closed formation or contained artificially.

In the Oklahoma City field, drilling techniques were developed for high-pressure wells that were capped with gas. Traditional drills could not control the pressure in the hole and the unstable natural gas would cause tremendous damage at the well site. Rotary drills and "mudding" techniques were developed to better control hole pressures and prevent "blow-outs" (Franks, 1980; Northcutt, 1985).

Due to the intense drilling that occurred after the initial discovery of oil, many oilmen discussed matters of proration drilling, well site spacing and plans of operation (Franks, 1980). Many of them preferred the limits set by the Oklahoma Corporation Commission of one well per forty acres. Even with this spacing in mind many of the more aggressive producers in the Oklahoma City Field placed wells in too close proximity to one another. Given similar increases in production from around the southwest, prices plummeted, causing a glut. This was a feature that occurred repeatedly over the course of the field's development. In 1929, the Oklahoma Corporation Commission ordered the first thirty-day shutdown of the Oklahoma City Field to help stabilize the production and address the glut problem (Rister, 1949).

The development and expansion of the Oklahoma City Field generated a number of environmental problems and issues. With the number of leases for petroleum production on the rise, the drilling activity began to encroach into the residential areas of the city. This combination of urbanization and oil field development was a problem that Oklahoma oilmen had never previously encountered. Many new zoning laws were enacted to protect the community, but allow for continued petroleum production (Allen,

1969).

Despite the innovations in technology that occurred during development of the Oklahoma City Field, the field was the site of well disasters. As previously noted the Indian Territory Illuminating Oil Company drilled the discovery well, the Oklahoma City #1 in 1928. This well was located on the southeast edge of Oklahoma County (Map 4). This well was a "gasser" (Robertson, 1937), meaning that drilling hit a pocket of natural gas just before it hit oil causing oil to explode out of the well with tremendous force. These types of hazardous blowouts became a common occurrence in the Oklahoma City Field and in many others across the southwest United States (Rister, 1949; Knowles, 1959). The most famous "gasser" was the "Wild" Mary Sudik well (Robertson, 1937; Knowles, 1959; Franks, 1980). This well (Figure 8) blew out of control for 11 days in March 1930 with oil streaming out of the well and spewing over the surrounding prairie, falling as far south as Norman, seventeen miles away (Robertson, 1937; Franks, 1980).

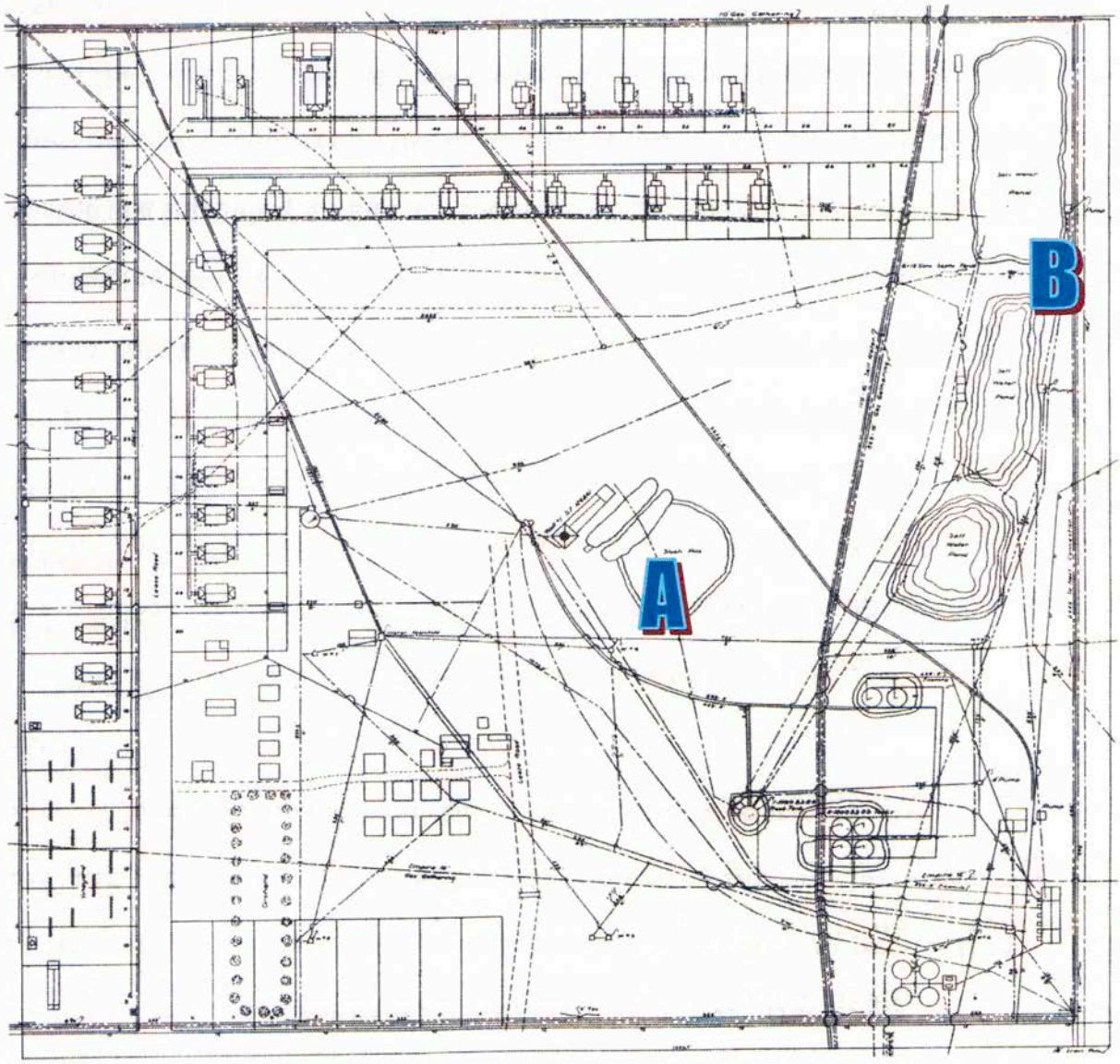
Figure 8 - The "Wild" Mary Sudik flowing out of control in March 1930.

Source: Oklahoma Historical Society.

3.3 Facility Construction

Following exploration, and the discovery of petroleum the construction of a facility is initiated. All of the impacts associated with exploration are now concentrated in one area. Equipment, machinery and hazardous chemicals (including petroleum products) are transported to and from the facility site on roads constructed as part of the exploration phase. Where necessary vegetation is cleared and the area treated for disease prevention or control. Buildings are constructed to house the products and equipment required to service the production facility (Van Dyke, 1997). The size, impact and timing of the activities have a significant bearing on environmental impacts.

In the Oklahoma City Field, the settlement of workers around the wells took the form of "Oil Field Camps" owned by the drilling company that was leasing property, from local landowners (Allen, 1969). Each camp was self-sustaining with a "farm boss" and a typical oil field camp included a gasoline plant, water supply, natural gas supply and a sewage disposal system (Allen, 1969). Roads were constructed, derricks were built, and prefabricated "shotgun" huts were rented to employees. Map 6 illustrates the Oklahoma City ITIO discovery well oil field camp (Allen, 1969). This map shows several common features of typical oil field camps, such as the slush pit labeled "A" and the salt-water ponds labeled "B".



Map 6 - The Oklahoma City discovery well oil field camp

Source: Allen, 1969

3.4 Pipeline Construction and Maintenance

As wells and facilities are established, the next step involves the transportation of petroleum through pipelines to collection facilities, such as refineries. Equipment, chemicals and fuel are transported to and from the facility and to pipeline location sites.

Again vegetation is usually cleared and the local areas are treated for disease prevention.

One specific impact pipeline construction can have on the local environment arises from the digging of trenches or ditches (Van Dyke, 1997) which can lead to erosion and gullying of the topsoil. In most cases, the pipeline is buried to prevent rupture of the casing by human or natural accidents. In some cases this can have a negative affect on the local environment where the trench influences vegetation or creates soil loss. With the construction of pipelines, hydrostatic test fluids, if used improperly, can have adverse impacts on the local environment most notably in the form of watershed pollution. With the completion and periodic maintenance of the pipeline, the areas may be rehabilitated to re-establish local vegetation or animal populations.

In the Oklahoma City field, pipeline construction significantly affected the land development patterns. Since the lessee, usually the producer, had the right-of-way for pipeline construction and maintenance, proper subdivision of properties could not be conducted. As Allen (1969) points out, "pipeline crossing an undeveloped tract may obstruct planned development of the entire acreage". Oddly shaped lots are present throughout the city as much petroleum development led to irregular development and depreciation of property values (Robertson, 1937; Allen, 1969).

3.5 Facility Operation

Once the facility is established and production is initiated, the potential environmental impacts of petroleum production increase significantly. Several impacts are associated with removing materials such as petroleum from the ground. Formations

may produce salt water that must be reinjected into the ground. Gaseous emissions and flaring must be controlled and properly managed in order to prevent blowouts and well fires. As with other activities, vehicle, equipment and machinery transport has an impact on the local environment, while hazardous chemical and fuel transport as well as routine handling of products can impact the environment through spills and leakages (Van Dyke, 1997).

As production progresses, solid and liquid wastes are produced and the process of disposal begins to play an important role in determining local environmental effects. If disposed of improperly these wastes can cause permanent damage to surface vegetation and the surface or subsurface water supply. One of the most common criticisms associated with petroleum production is the creation of the "slush-pit" (Robertson, 1937) or "mud pit" (Van Dyke, 1997). Also known as "reserve pits" (Van Dyke, 1997), the "mud pit" can store the mud used in rotary drilling. This mud contains chemicals and cuttings from the borehole. Alternatives to chemically treated mud storage in pits have now been developed. "Closed-loop drilling" for example, involves the recirculation of drilling mud, making the reserve pit unnecessary (Van Dyke, 1997).

During production of petroleum at a well site, noise and light pollution can negatively effect the local environment. Drilling may continue for an indefinite amount of time while contributing to the degradation of the environment throughout. Meanwhile, the transfer of petroleum from the site by pipeline or tankers threatens serious damage in cases of leakage or fire.

The Oklahoma City Field suffered from many of the environmental impacts

associated with petroleum facility operations. The "slush pits" and oil storage tanks were a common issue of public debate and overflow from oil storage tanks was commonplace (Figure 9). Incidents such as that shown in Figure 9 contributed to the waste of oil and led to the further degradation of the environment through to the pollution of local soils and water supply. These dangerous areas around "slush pits" proved to be major environmental and public safety issues not least through the threat of pollution events and fire hazards.

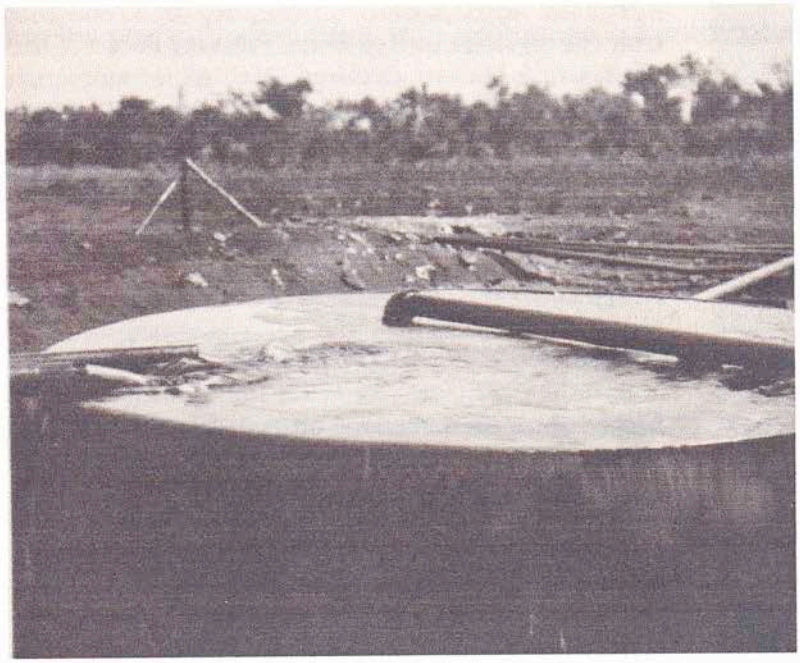


Figure 9 - Overflowing Oil Storage Tank during the 1930s

Source: Franks, 1981

3.6 Decommissioning

The decommissioning of production sites generates impacts associated with the removal of infrastructure and the remaining chemicals, cuttings and fluids. Even though the most invasive procedures have been completed, the remaining chores must be managed properly in order to prevent further environmental damage.

A number of problems are likely to arise from the abandonment of structures at the well site. In Oklahoma City structures that remained on the site served to devalue the property and make re-development difficult. As Allen (1969) indicates, "A lessor who wishes to develop his property after extraction operations are terminated may become entrapped in litigation concerning the abandonment of structures and equipment". This can, in turn, lead to the abandonment of monitoring and clean up duties.

The environmental impacts associated with petroleum production are thus numerous and commonly present significant dangers. Regulations now govern many of the procedures associated with production, and many companies have found that the increased cost of meeting regulatory standards drives innovation and better operating practice. With the increasing value of petroleum as a commodity, the need for protecting the resources and production facilities increases. The price and value of oil has pushed an innovative drive for better technologies to help protect the environment from many of the historically significant impacts.

4. Responses to Petroleum Production

Petroleum production has always been an intrusive process that can affect the local environment of those living near production sites. The responses of citizens or their representative agencies to the environmental effects of petroleum development divide broadly into four categories; (a) behavioral responses of individuals living in or near the oil fields, (b) civic protest and social movements, (c) land use planning, and (d) regulations and laws.

From early in its development the Oklahoma City Field was recognized as a unique set of circumstances. "Aside from being a determining factor in the growth of a unique metropolitan area this field has been a veritable laboratory in problems of state and municipal control and has made an epic in petroleum engineering" (page 1, WPA, 1938). While this unique situation generated "civic and technological gains" the WPA claimed that it is an "open question whether the profligate waste involved is (was) too high a price to pay for the good accomplished" (page 1, WPA, 1938). In this chapter I document the various citizen and regulatory responses to oil production and examine the distribution of environmental and related costs across different social groups. I argue that the nature and impact of social regulation reflected prevailing patterns of power and inequality within the Oklahoma City metropolitan area. In short those with significant economic and political resources were best able to effectively mitigate the environmental costs of drilling the city.

As noted in Chapter 2 the increase in drilling activity in the state oftentimes generated an oversupply of oil and hence declining prices. The oil fields of the early

twentieth century were not conducive to long-term storage of oil and the "Rule of Capture" ruled production ethics. The Rule of Capture encourages overproduction of limited resources, such as oil, that can be "captured" or "tapped" by those in adjoining properties (Van Dyke, 1997). At various times, regulations were enacted to help reduce waste, limit overproduction and thus help control the oil market.

Although zoning was used to protect the public from the hazards of petroleum production, there were actually very few restrictions on oil development. The dangers of petroleum production were ubiquitous and the citizens of Oklahoma City responded accordingly. During the 1930s, groups of citizens formed in opposition to the extension of oil field activities within the Oklahoma City limits (Robertson, 1996). Their concerns included noise pollution, fire hazards (Figure 10) and oil well blowouts.

Figure 10 - Oil Well Fire in Oklahoma City Field, Approximate Date 1932

Source: Oklahoma Historical Society

One of the most famous oil well blowouts in the Oklahoma City Field occurred during the drilling of the "Wild Mary Sudik" well on the southeastern edge of the field in 1930 (Rister, 1949; Knowles, 1959). As noted in Chapter 2 this well penetrated an over pressured gas cap above the targeted oil producing formation and when the gas depressurized and erupted from the well the oil spewed and was drawn out and blown over a wide area of the surrounding prairie (Rister, 1949).

4.1 Behavioral Responses

While the early development of the Oklahoma City Field was recognized as creating a unique juxtaposition "a sensational affair to stake a location within a few feet of a farmer's kitchen door" the WPA report of 1938 claims that this, "created no difficult problem" (WPA, 1938). Normally the producer moved the residence (Figure 11) to a relatively safe distance and from the original home site and "generally with considerable improvement" (WPA, 1938).

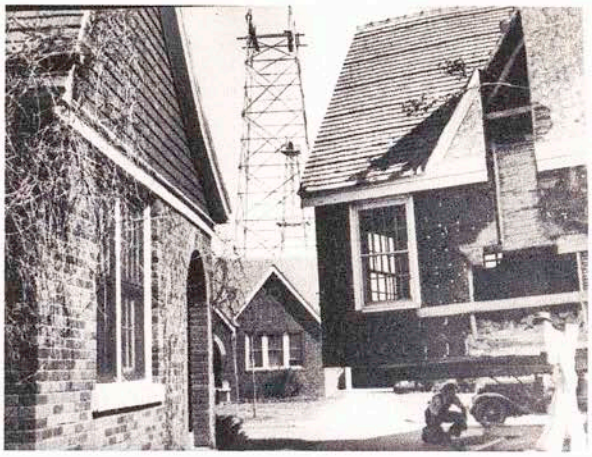


Figure 11 - House being moved for oil production site, 1930s

Source: Franks, 1980

More contentious was the slow northward and westward movement of the Oklahoma City field's activities. Many property owners demanded the right to share in the wealth of petroleum by sinking wells in their own backyard. Others argued that field activities depreciated the value of their property considerably and that this loss could not be balanced by income from petroleum production (Robertson, 1937). The depreciation values described by Leo Robertson (1937) are shown in Table 6.

Table 6 - Depreciation of Oklahoma City Property Values, 1937

INITIAL IMPACT OF DRILLING ACTIVITY ON PROPERTY VALUES IN OKLAHOMA CITY

Addition	Per Cent Devaluation
Hows State Capitol	15
Lincoln Terrace	15-20
Capitol Court	20
Fairfax	20
Harmony Hill (no houses)	10

Source: Robertson, 1937

4.2 Civic Protest and Social Movements

The transformation of the urban landscape via petroleum production sites affected citizens in a variety of ways. The "cultural landscape" (Robertson, 1937) of Oklahoma City was subject to an intense period of drilling activity and groups of citizens reacted differently to the changes. Arguably the most significant result of the impacts of petroleum production was the depreciation of property values. Others, however,

welcomed the oil boom given that the petroleum industry provided a major source of employment through the Great Depression. Figure 12 shows a typical family photo of a driller (second from left) in Oklahoma City taken around 1942. This family's home was loaded on the back of a flat bed truck and taken to the various towns where the driller worked.

Figure 12 - Family Photo of Oklahoma Driller W.B. Hickman Sr.

(Great-Grandfather of Author)

Photo Courtesy Dorothy Hickman Cole Smith, Daughter of W.B. Hickman Sr.

Rural areas also tended to welcome oil development given that this activity proved more profitable than farming. In contrast, residents and residential areas located on or proximate to the field were much more resentful given that the profits of oil were usually insufficient to offset the depreciation of their property. Oil development also led to, what many considered to be an influx of an "undesirable population element" (Robertson, 1937).

But not all residents and residential groups were negatively impacted by oil production. The Lincoln Terrace neighborhood, just southeast of the State Capitol building, was the only neighborhood to successfully block and restrict oil development

from encroaching on the neighborhood. The African American and white middle and lower middle class neighborhoods just south of the Capitol were quickly invaded in the absence of significant organized resistance. While the primary concern of the wealthy Lincoln Terrace residents was the depreciation of their (high) property values, the surrounding neighborhoods were rather more welcoming to the work and income generated by the field's development.

The Tulsa Daily World and the Daily Oklahoman were two of the first periodicals in the state and have long been associated with oil interests. Yet in this instance these newspapers defied the petroleum companies and carried advertisements placed by Lincoln Terrace citizens that sought protection of their property and neighborhood from the invasion of derricks. Figure 13 displays the Tulsa Daily World headline describing the invasion of oil derricks in Oklahoma City.

TULSA DAILY WORLD, WEDNESDAY, APRIL 29, 1936

Orgy of Drilling Despoils Beauty of Oklahoma City

OKLAHOMA CITY FIELD
NORTH END EXTENSION.

EILL
'O RACE
Files for
the Sixth
strict

Derrick Forest Invades State Capitol District

Green Lawns of Mansion Residential District Sink Beneath Slushponds

Taken from the top of the state capitol, this panorama of the new Mansion area of the Oklahoma City

earache, toothache, headache, or even heartache.
"Symptoms of the dread malady

PRESIDENT LEADS IN PENNSYLVANIA

Gets Huge Majority Over Breckinridge in Preference Poll

Tulsa County Has 400 Beer Dispensaries

Court Records Show Variety of Names Used by Dealers

If you want a drink of beer in

FAROUK IS
EGYPT'S
Boy Prince
Death of
Regency

Figure 13 - Tulsa Daily World Headlines. April 29, 1936

Source: Oklahoma Historical Society Archives

4.3 Land Use Planning

In May 1929, the Oklahoma City Council established an urban oil development zone termed the "U-7". The land uses granted to this zone included any uses permitted prior to the U-7 designation, as well as the placement of oil and gas wells, derricks, machinery, boilers, tool houses, storage tanks, and other petroleum structures. According to the ordinances, the zoning was devised to protect health, safety, welfare and property in the Oklahoma City area (Allen, 1969). This was certainly one of the most important achievements by the City and remains in virtually its original form as Chapter 22 of the Oklahoma City Revised Ordinances (McClure, 2001).

This zoning framework established three types of regulation. First, it provided

that drilling not take place within city limits except in designated U-7 areas. Second, it provided restrictions on the spacing of wells within each U-7 district of no more than one well per platted block or one well per five acres in areas that were not platted. Third, it defined standard methods for drilling operations and the closing or decommissioning of wells (McClure, 2001).

While zoning regulations sought to protect the public from the dangers of drilling and petroleum production, there were few other restrictions on oil development at the citywide scale. Options were available, however, to allow residential districts to have some measure of control over oil field production. A referendum of residents living in the areas affected was one mechanism by which a company could gain permission to drill in a particular neighborhood. In these cases royalties had to be divided with the residents of the area. With the approval of the referendum, the drilling zone could also be extended. Over the course of the field's development petroleum structures, such as steel derricks, continued to be wedged between houses, located in riverbeds, on golf courses, city parks, and even school grounds and church yards (Franks, 1979).

The dangers prevalent in these development zones included those noted in Chapter 3 - well blowouts, gas leakages, explosions and even oil fires. In this sense, the U-7 zones failed to fully protect the citizens of Oklahoma City from invading oil producers. Instead economic forces played a major role in driving the development of the U-7 zones. The City Council leased municipal lands to producers and was the first organization to profit from the petroleum production.

Problems also arose with the U-7 zones designations. When the ordinance was

first defined in 1929 the zoned area was confined to a small area on the outskirts of the city. Between 1929 and 1947 the City Council expanded the area on twelve occasions to include areas encompassing neighborhoods and city property. In response to this type of activity, the authority to expand the U-7 areas was taken from the Council by an amendment to the City charter (McClure, 2001). With this amendment, any further changes required a majority vote by the citizens of the City. Since the amendment was enacted, the U-7 districts have been expanded albeit at a much-reduced rate. In 1947, complications developed with the addition of new zoning ordinances resulting in the deletion or suspension of the U-7 district.

In 1959 and 1960 Oklahoma City began to annex large amounts of land. Eventually the incorporated area of the city grew from about twenty-eight square miles in 1936 to more than 640 square miles in 1970. However, the U-7 boundary designations did not accompany these annexations, such that even today the U-7 boundaries conform to the city limits as of 1936. Figure 14 illustrates the efforts of the City Council to restrict activities to certain areas of the city with the concentration of industrial areas in an area now known as Bricktown.

Figure 14 - Aerial Photograph looking northwest across Bricktown to Downtown Oklahoma City. Date Unknown

Source: Oklahoma Historical Society.

Annexation had the effect of incorporating several previously existing oil fields within the new city limits. These included the southern half of the Oklahoma City field, the Short Junction and the Northeast Moore fields in south Oklahoma City, the Witcher field in the northeast, and the Britton, Edmond and West Edmond fields in the northwest. As existing fields they were not included in the U-7 districts although this failure to expand the U-7 district posed little threat to the developers for quite some time (McClure,

2001).

Not until 1960 did exploration resume in the Oklahoma City urban area. By this time the ordinance appears to have been either forgotten or ignored. In November of 1960, for example, the Municipal Board of Adjustments began hearing requests for drilling permission outside of the designated U-7 districts. According to the minutes of the meeting two of the three wells had already been drilled and the third was in the process of development when the application was finally submitted to the Board.

Consultation with the Department of Planning and the Municipal Counselor's office generated a memo from the Planning Director and the Municipal Counselor's office asserting the right of the Board of Adjustment to permit a U-7 designation outside of the zoning district if recommended by the Planning Director. Some saw this decision as hasty and erroneous since it had no certain or clear terms of restriction. The only power granted to the Board of Adjustment in the oil and gas-drilling ordinance was that of allocating interests in certain wells drilled within the U-7 district (McClure, 2001). In Oklahoma, Boards usually only deal with zoning regulations in limited ways. In the Oklahoma City Code, however, the Zoning Ordinance is a different chapter from the oil and gas regulations. This haphazard method of granting permits for drilling within city limits compromised any protection that residents and the city had against oil field development. The precedent was set for the granting of hundreds of 'variances'.

Between 1960 and 1972 the Board granted over 1,400 variances to Chapter 22 of the Revised Ordinances of 1970 (McClure, 2001). The procedure became sufficiently routine for all involved to now assume that such variances are right and proper.

4.4 Regulations and Laws

As noted in Chapter 3 the production of petroleum is fraught with hazards to human health and the environment. Producing, transporting and processing petroleum products risks hazards such as fire, explosions and general polluting of the air, water and soil. For these reasons, the petroleum industry is subject to federal, state and municipal laws and regulations.

The settlement history of Oklahoma has created a complicated web of government response and regulation. The Tribal governments initially granted regulatory freedom by the Federal government were taken over by Oklahoma with statehood. Historically the Federal government has regulated the petroleum industry due to its interstate and international aspects. In this context state level regulation efforts represent local regulations focused on state level problems such as well spacing and property value issues. The local or municipal government has little effect on actual production rates, but is more focused again on limiting public exposure to drilling activities.

There are two principal areas of regulation that impact oil production and its environmental effects. The first concerns resource conservation, including activities that seek to prevent overproduction. This area of responsibility is usually lodged at the state level. The second concerns the environmental and health impacts of oil production. These regulations are usually lodged at the federal level with enforcement left to the state, via agencies such as the Department of Environmental Quality (Table 7).

Table 7 - Government Responses to Oil Production Challenges

	Challenge	City/Local	State	Federal
Resource Conservation	Overproduction		Oklahoma Corporation Commission (1907) House Bill #168(1915) Interstate Oil Compact Commission (1935)	
	Well Spacing		Oklahoma Corporation Commission (1907) House Bill #187(1935)	
Property Values	Property Values	Zoning (U-7 districts) (1929)	Oklahoma Corporation Commission (1907) House Bill #78 (1907) Senate Bill 168 (1909)	
Health and Safety	Safety	Zoning (U-7 districts) (1929)	Oklahoma Corporation Commission (1907) House Bill #238 (1909)	Occupational Health and Safety Act (1970) Toxic Substances Control Act (1976) Resource Conservation and Recovery Act (1976)
	Health	Zoning (U-7 districts) (1929)	Oklahoma Corporation Commission (1907)	National Industrial Recovery Act (1933) EPA Oil Pollution Act (1990) Hazardous Waste Operations and Emergency Response Standard (1970)
Air and Water Quality	Water Quality		Department of Environmental Quality	Environmental Protection Agency (1970)- Clean Water Act (1970) Safe Drinking Water Act (1974)
	Air Quality		Department of Environmental Quality	Environmental Protection Agency (1970)- Clean Air Act (1970)

4.4.1 Federal Laws Concerning Environmental Health

For the protection of human life and safety, the Occupational Health and Safety Act of 1970 created the Occupational Safety and Health Administration (OSHA). The charge of the agency was to regulate safety and health standards in the workplace. In the petroleum industry, for instance, workers now have the "right to know" (Van Dyke, 1997) what kind of chemical hazards are on the job and how to protect themselves from them. Other legislation in this general area includes the Migratory Bird Treaty Act of 1918 (MBTA), which covers five treaties signed with other nations to protect migrating birds (Van Dyke, 1997) from hazards such as pits or open-topped tanks that contain hazardous chemicals.

In 1973 the Endangered Species Act (ESA) established a List of Endangered and Threatened Wildlife and Plants and mandated federal actions to protect these species. Petroleum companies drilling on Federal Land are commonly subject to the provisions of this act (Van Dyke, 1997). The most intense period of environmental legislation in United States history began in the 1970s with the Environmental Protection Act. This legislation created the Environmental Protection Agency (EPA) to oversee environmental laws and regulations.

The Clean Air Act of 1970 authorized the EPA to regulate and set standards for air quality issues and emissions of pollutants into the atmosphere (Van Dyke, 1997). The most visible of the EPA regulations of the Clean Air Act are those pertaining to emissions from motor vehicles. The change in standards for gasoline emissions has affected the operations of refineries and the type of energy used for motor vehicles.

The Clean Water Act authorizes the EPA to regulate discharges into surface waters, such as oceans, rivers, streams, and lakes. Discharges associated with the petroleum industry include oil, sewage, hot water, drilling fluids, drill cuttings and pollutants, which are often washed away into collection areas.

The Safe Drinking Water Act of 1974 protects the nations underground water supply. Under this law, the Underground Injection Control (UIC) program monitors and regulates injection wells such as those used for waste disposal by the petroleum industry (Van Dyke, 1997). Petroleum production can contaminate drinking supplies in cases where abandoned wells are improperly plugged, casings are faulty, or fluids are accidentally injected into an aquifer. The UIC program regulates specific construction of wells, casing and cementing, plugging and abandonment, and the types of substances and pressures associated with reinjection into a well.

Offshore drilling and transportation legislations are a more recent creation. The Outer Continental Shelf Lands Act of 1953, amended in 1978 and 1985 regulates oil and gas activities on the Outer Continental Shelf of the United States, while the Oil Pollution Act (OPA) of 1990 regulates and monitors oil tanker spills (Van Dyke, 1997).

A final piece of relevant Federal legislation is the Toxic Substances Control Act (TSCA), which regulates hazardous material and wastes, including the manufacture, processing and distribution of chemicals. The EPA maintains a list of such chemicals, while the Resource Conservation and Recovery Act (RCRA) regulates the disposal of hazardous wastes.

4.4.2 State Laws Concerning Resource Conservation

The Oklahoma City field was discovered at a time when many other fields were already in operation across the entire southwest region of the United States and at times production overwhelmed the market causing significant price volatility. The overproduction of the late 1920s coupled with the Great Depression of the early 1930s forced governments to take action to counter the apparent waste of resources and plummeting oil prices. By the end of its second year the Oklahoma City field had already produced over thirty-seven million barrels of crude oil (WPA, 1938). This was more than the local and regional market could sustain and the overproduction problem was so grave that producers agreed to the first 30-day shutdown of the field in 1929. A fifty percent proration on a time basis was recommended and agreed upon. This marked the beginning of a proration policy that was gradually extended to the point of limiting production to "2.7 percent of the potential of every well in the field" (WPA, 1938). The Oklahoma Corporation Commission was responsible for enforcement of these policies and in 1929 and again in 1931, Oklahoma governor Alfred Murray temporarily closed the Oklahoma City field to cope with the overproduction problems.

The Oklahoma City Field was the testing ground for a number of technological advances that allowed improved production. The proximity to the metropolitan area of Oklahoma City was important in affecting this and other aspects of the field operations. The state had conflicting interests in its relationship to the industry. On the one hand, greater production meant increased revenues via gross production tax. On the other, however, over-production led to waste and declining prices for oil. The Oklahoma

Corporation Commission went through several different leaders in the search to coordinate plans between producers and the State. There was, according to the WPA, "constant murmuring from royalty holders" (WPA, 1938) and several leaders of the Oklahoma Corporation Commission sought to hold higher office in order to implement oil related legislation.

In 1933, however, the United States Supreme Court declared unconstitutional the conservation law set by the Oklahoma Corporation Commission (WPA, 1938). Within three days of this declaration, the Oklahoma City Field was back to producing at almost the limit of its potential. Governor Alfred Murray declared a shutdown of the Oklahoma City Field in 1929 and again in 1931 to control the rampant drilling and ordered the military to monitor the field. Such shutdowns of the Oklahoma City Field occurred on more than one occasion although oil continued to be routed out of the field and sold (WPA, 1938).

In 1936 petroleum production threatened to extend onto the State Capitol grounds. Governor Marland, later founder of Conoco Oil Company, defied the City Council by drilling beneath the Capitol and used the militia to prevent interference by the city with the drilling on State Land. When the State decided to sink a well in the front of the capitol building, the governor proposed to hide some of the objectionable features of the drilling by planting petunias around the pits and roses to grow on the derricks. Thus, the nickname of Petunia was given to the derrick located on the south side of the State Capitol building. This derrick (Figure 15) remains a monument to the petroleum history of Oklahoma (Robertson, 1996).

Independent oil producers keen to help organize oil and gas production in Oklahoma formed the Oklahoma Energy Resources Board (OERB) in 1994. Oklahoma's oil and natural gas producers and royalty owners fund the organization and its mission is to remediate abandoned petroleum production sites and the OERB frequently advertises its commitment to the safety of the public and well being of the environment.

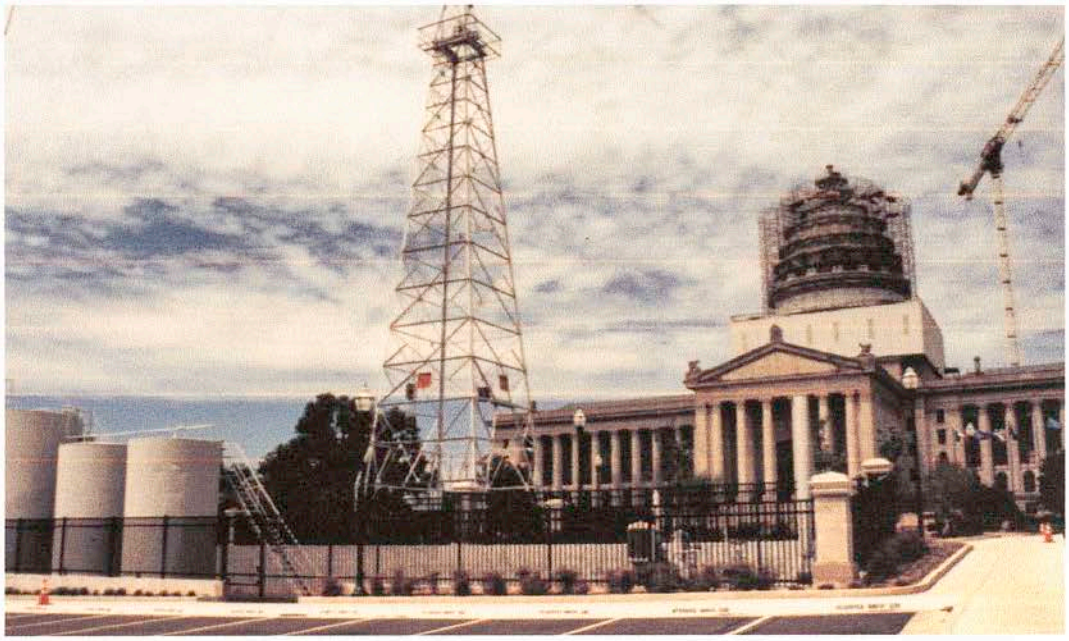


Figure 15 - 2002 Photo of Oklahoma State Capitol building with Petunia #1

Author Photo, 2002

4.4.3 City Laws

The City Council of Oklahoma City sought to please all sides involved in the drilling of the city. By 1930 the Wright Number 1 marked the northward progression of field activities while the Stout gusher sprayed the eastern portions of the city (WPA, 1938). These two incidents gave reason to the City Council to pass two ordinances, one establishing precise and rigid safety regulations and the other establishing drilling zones.

Slowly the city succumbed to the 'invasion of the derricks'. Wherever there was a prospect of oil every possible means of securing the right to drill was taken. Special elections were held to determine the extension of drilling. African American areas of the city were easily incorporated into the expanding field area. The exclusive residential neighborhood known as Lincoln Terrace sat just southeast of the State Capitol grounds. According to the WPA, "This constituted a last line of defense against the ugly monster of oil, which seemed willing to sacrifice any amount of beauty and home-life for oil money" (WPA, 1938).

A 1935 election almost allowed a popular vote to capture part of this neighborhood, but was later saved by a court ruling on the provisions of its original plat restrictions. This effort to control extension by plat restrictions failed in all instances, except Lincoln Terrace. This election, in turn, triggered a renewed effort by the extensionists and drilling spread rapidly. By the end of 1935 the derricks had reached the north to Twentieth Street (WPA, 1938) (Figure 16), although the Lincoln Terrace neighborhood remained intact and oil derricks never penetrated its boundary lines.

The City Council found that by using ordinances governing surface matters, such as the laying of water pipes and slush pits, partial control of field activities could be maintained. These efforts clearly helped to slow down the extension of the field onto more city property.

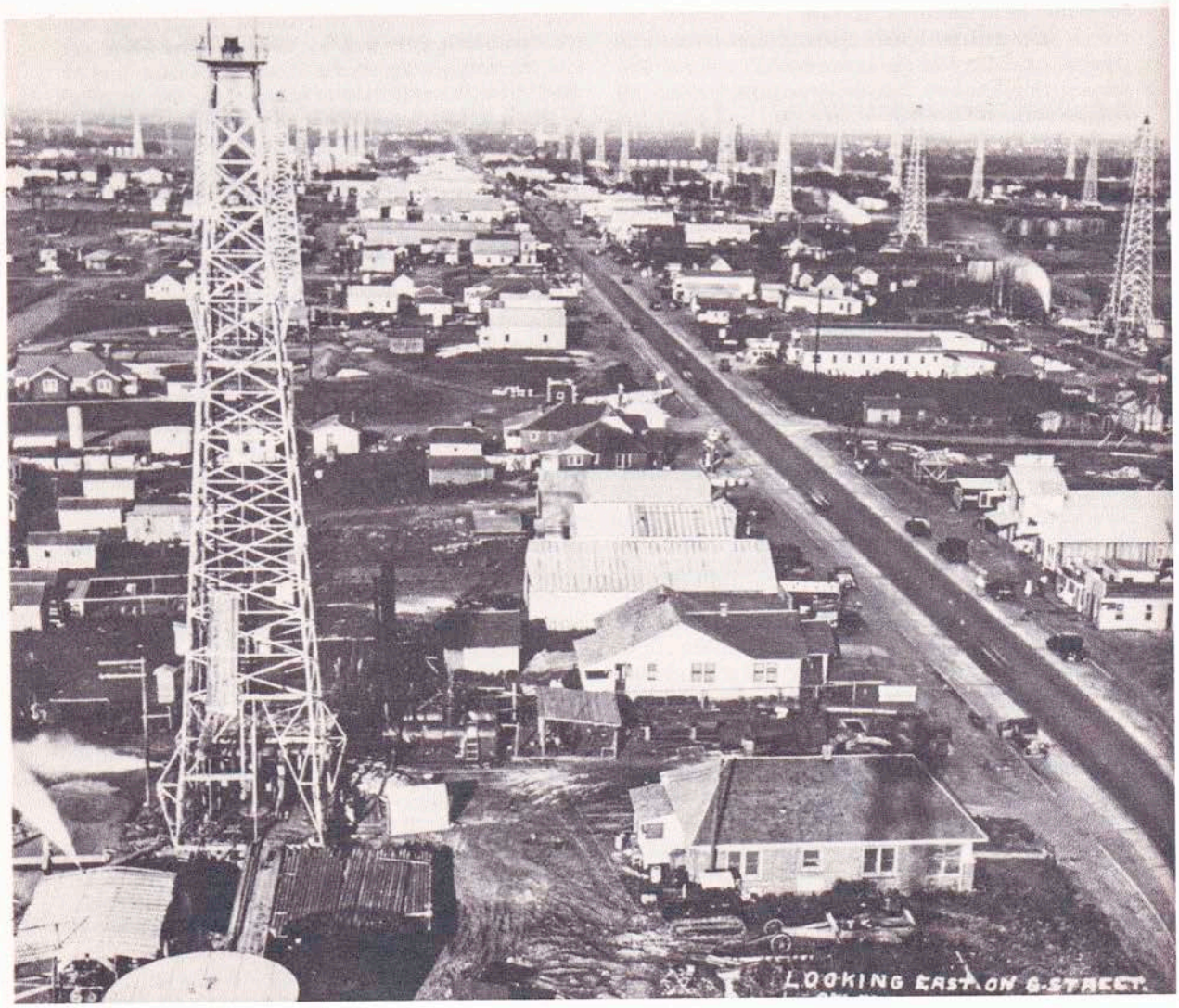


Figure 16 - Oklahoma City Field Wells encroaching into the City,

Approximate Date Late 1930s

Source: Franks, 1981.

5. Conclusions

The Oklahoma City Field provides a unique and intriguing story of the old "wildcatting" days of America's early petroleum history. The environmental challenges posed by petroleum production in an urban area generated a variety of responses from different interests and government bodies at a variety of scales. This chapter provides a summary of the objectives of the thesis, the research methods used to study the case, and the research findings. I shall argue that the environmental challenges posed by petroleum production in an urban area generated a variety of responses from different interests and government bodies at a variety of scales.

The four goals in this study were as follows, 1) to analyze the production history of the Oklahoma City Field during the period 1928-2000, 2) to interpret the spatial evolution of the field by creating a series of maps using well location data, 3) to review the social and environmental challenges this evolution created in the Oklahoma City urban area, 4) to identify how residents and government agencies responded to these challenges by, in some cases, initiating regulation. The following summarize the conclusions.

First, concerning production history, Oklahoma City was established in 1889 with the settlement of Indian Territory and initial economic activity in the area focused on agricultural commodities. With the influx of population and better technology for finding petroleum, the city became the first large metropolitan area to experience extensive petroleum development and production. Chapter 2 compared oil production history of Oklahoma City to the state level and placed the development of the field into its historical

context. The relationship between commodity price and production levels repeatedly surfaced as an important local and national issue. Economic factors significantly influenced the rate of production in the Oklahoma City field and throughout the southwest region.

In order to examine the geography of oil production and regulation a series of maps were produced designed to illustrate the spatial evolution of the Oklahoma City field between 1928 and 2000. Over this time, the field grew to be more than thirty-eight thousand acres in size. The gradual march of production activity from the southeast urban fringe of the city is shown to have eventually merged with a southward extension of activity from the State Capital area in the northeast of the city. Mapping spudded wells rather than completed wells emphasizes the true extent of oil related activity and its potential environmental effects.

The environmental impacts described in Chapter 3 illustrate the lifecycle of a drilling site and the potential impacts those activities can have on the surrounding ecology. The Oklahoma City Field experienced most of the environmental hazards and threats associated with oil production, including those relating to exploration and production drilling, facility construction, pipeline construction and maintenance, and decommissioning. Each of these activities was shown to create specific problems for producers and residents of the metropolitan area. These activities, in turn, were seen to generate a specific and complex set of responses on the part of individual residents, neighborhoods and governing institutions.

In many ways the responses to petroleum production in the Oklahoma City Field

were unique among the oil towns in the southwest region. Oklahoma City was a thriving metropolitan area prior to the discovery of oil. The proximity of resource extraction and significant urban development magnified the environmental hazards and risks associated with oil exploration and production.

Initially, a majority of Oklahoma City residents were broadly supportive of the oil industry and the "sensational" nature of urban oil field development. Residents sought to realize short-term profits via the leasing or sale of mineral rights. Concerns over the long-term impacts of oil production on the neighborhood and environment were not immediately apparent. However, not all residents and residential neighborhoods responded in the same way. Oklahoma City, like U.S. urban areas more generally, was characterized by disparities in cultural values, races and economic and political power. The one neighborhood that successfully resisted the invasion of the oil derricks was Lincoln Terrace, a wealthy residential neighborhood proximate to the State Capitol building. Here residents mobilized their substantial economic and political power to resist and ultimately refuse production within the neighborhood's boundaries.

The "cultural landscape" of Oklahoma City was significantly impacted by the intensity with which the oil industry extended into urban areas. Residents were forced to face the realities of resource extraction, literally in their own backyards. The intrusion of production activities pushed municipal governments to create specific land use zoning regulations to mitigate and limit the impact of oil production. The U-7 zones created were intended to protect citizens from production activities. However, it is clear from the evidence presented in this thesis that these zoning codes were rarely enforced. It took the

influence of the Oklahoma Corporation Commission to enforce more substantial protection guidelines and laws than the city was seemingly capable or willing to implement.

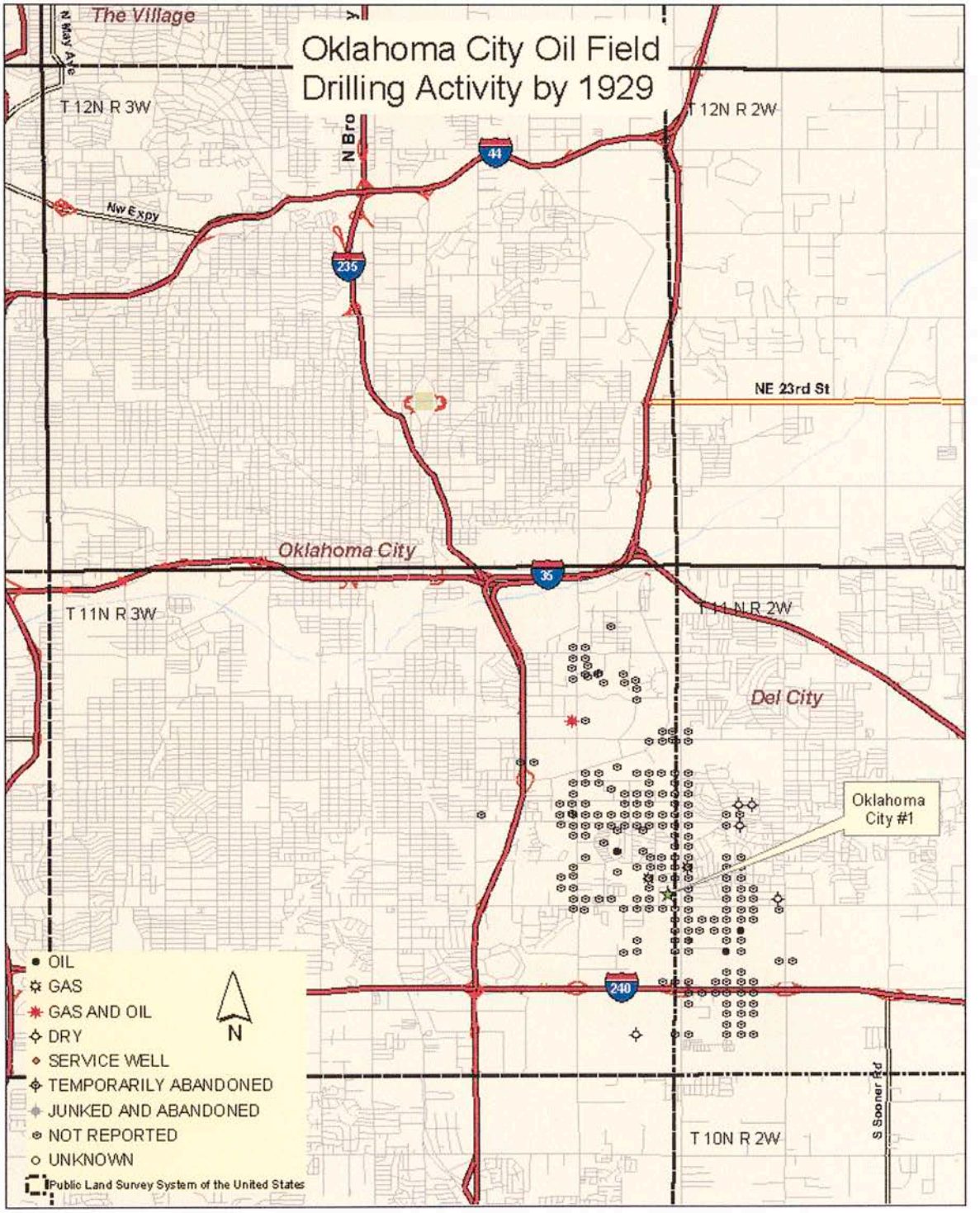
While federal laws are created on a broad scale it is the charge of the states to create smaller scale agencies and laws for area dependent activities. In this respect the state of Oklahoma has been a forerunner in establishing regulations for the oil industry. The formation of the Oklahoma Corporation Commission (OCC) with statehood provided the necessary foundations for regulating such an intrusive industry. The thesis has shown that at various times during the history of the Oklahoma City Field, the OCC has stepped in to control overproduction and waste.

The use of regulation to protect the residents of Oklahoma City was clearly influential in shaping the evolution of the field and its impacts on the local environment. Strict regulations on oil production have evolved from the exploitive history of oil in the southwest. As the price of crude oil has risen, operational regulations for production companies have become more stringent and effective.

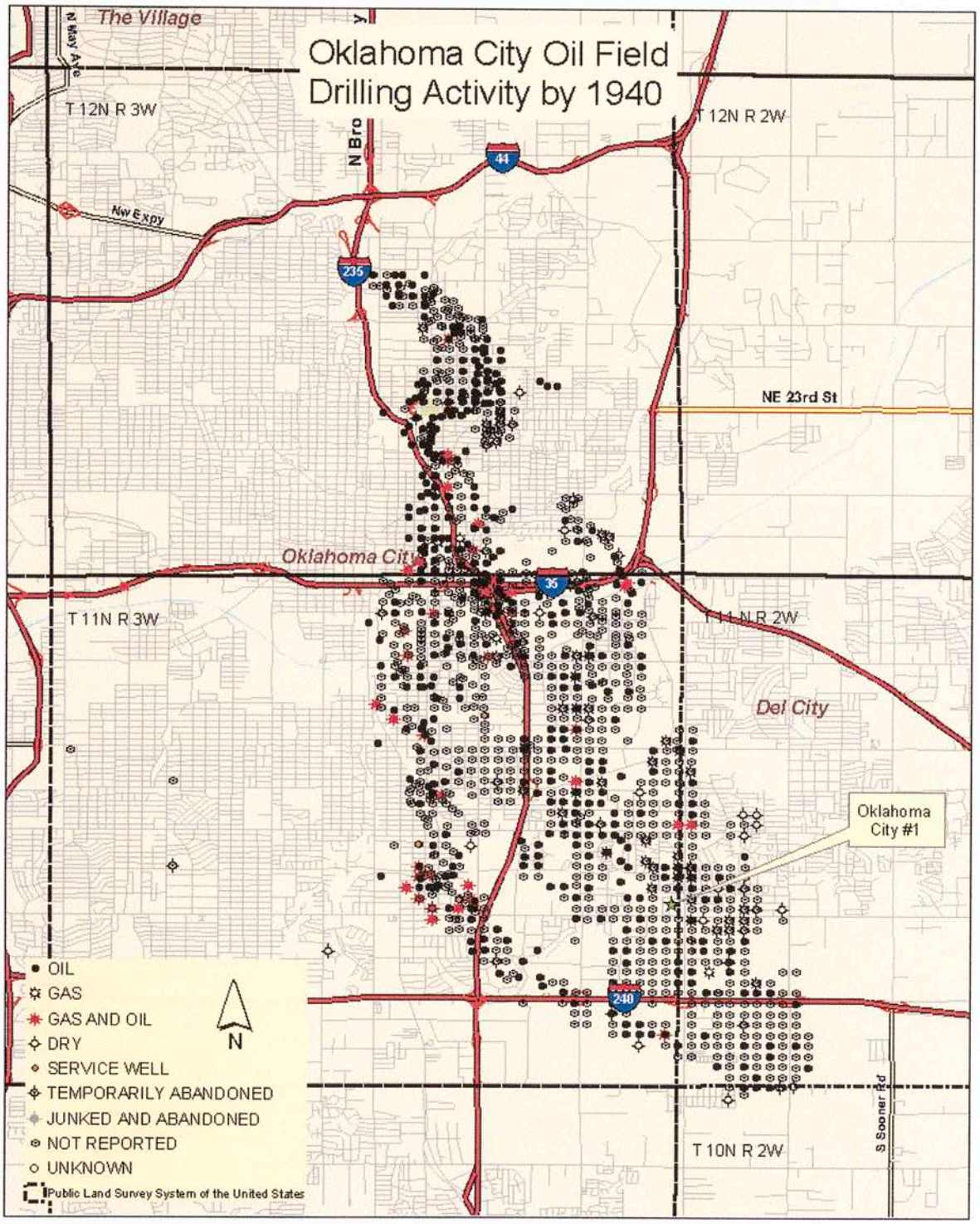
The residents of Oklahoma City were directly exposed to the hazards of oil production and the Oklahoma City metropolitan area was forever changed with the discovery of petroleum so proximate to the urban landscape. The morphology of the urban area was influenced greatly by the steel derricks, pipelines and relict equipment that remain today. Ideally, land use planning and regulation should protect the health, safety and welfare of the public. The experience of oil production in the Oklahoma City metropolitan area provided an early example of how civic organizations and governments

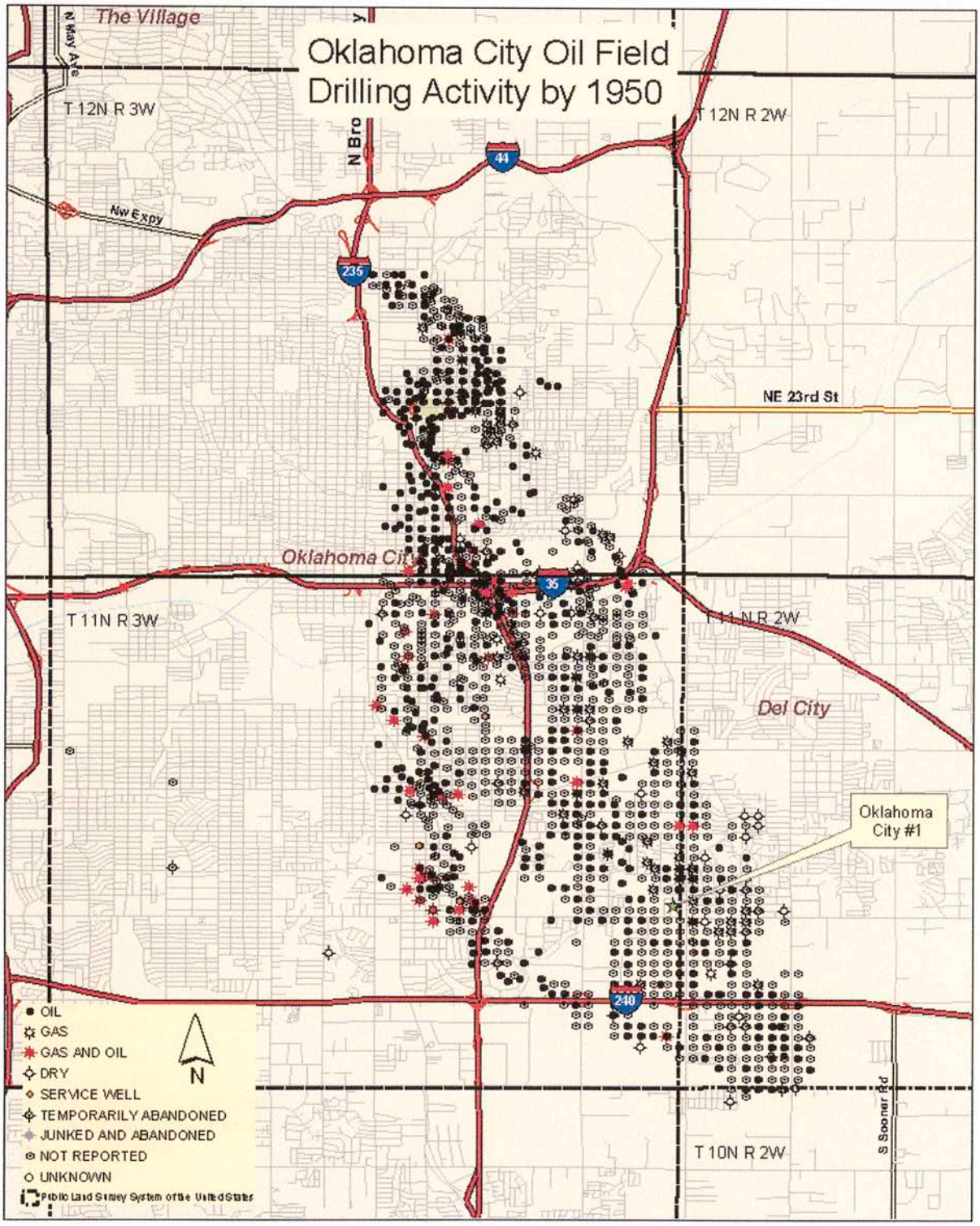
have sought to establish the necessary parameters for the future development of resources and their use.

Appendix



Maps Created by Author, 2002
Source: NRIS, 2002


Oklahoma City Oil Field
Drilling Activity by 1940
The Village
T 12N R 3W
T 12N R 2W
N Bro
NW Expy
44
235
NE 23rd St
Oklahoma City
35
T 11N R 3W
T 11N R 2W
Del City
Oklahoma City #1
240
S Sooner Rd
T 10N R 2W
OIL
GAS
GAS AND OIL
DRY
SERVICE WELL
TEMPORARILY ABANDONED
JUNKED AND ABANDONED
NOT REPORTED
UNKNOWN
Public Land Survey System of the United States
N


Oklahoma City Oil Field
Drilling Activity by 1950
The Village
N May Ave
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T 12N R 2W
N Bro
44
Nw Expy
235
NE 23rd St
Oklahoma Cit
35
T 11N R 3W
T 11N R 2W
Del City
Oklahoma City #1
240
T 10N R 2W
S Sooner Rd
OIL
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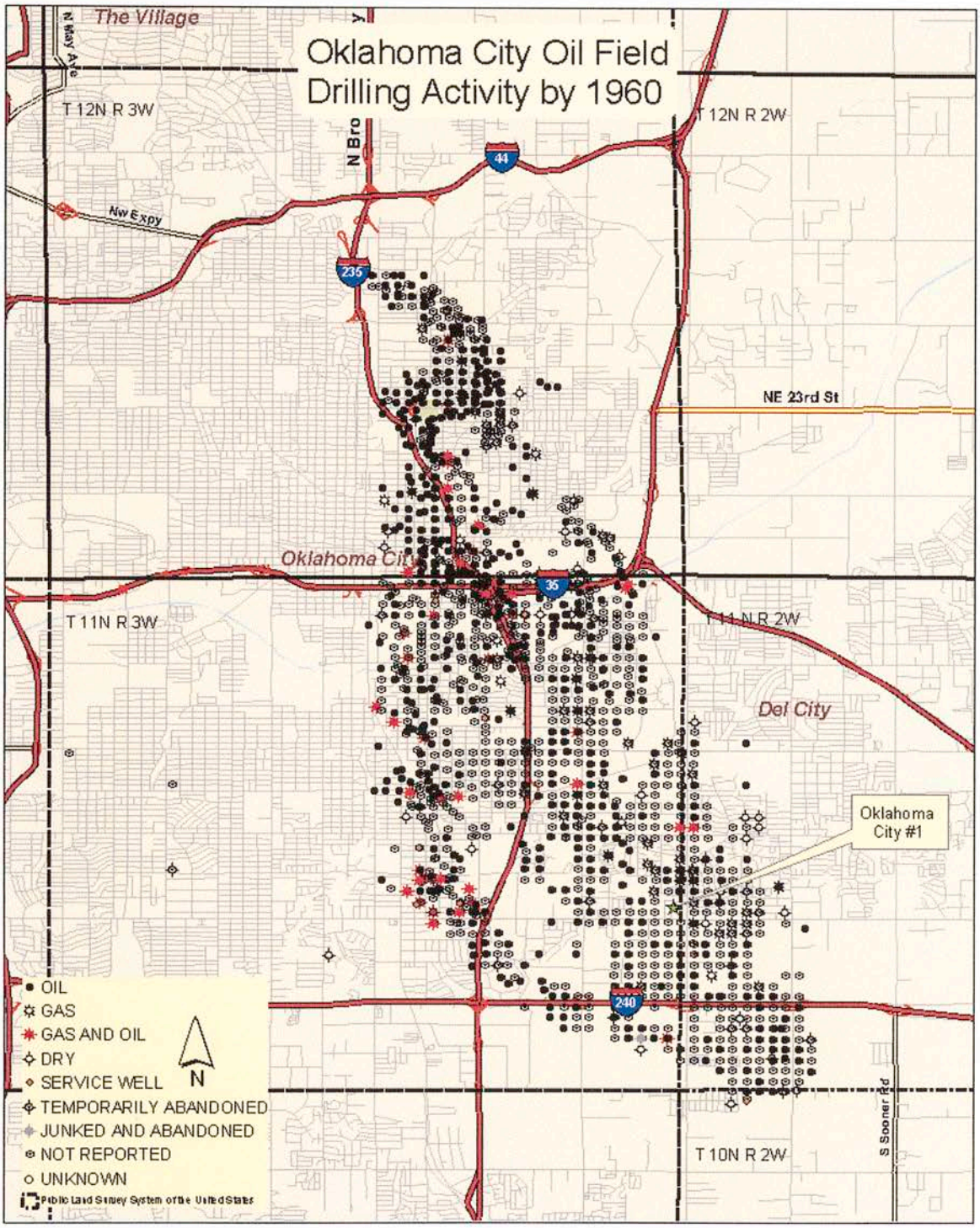
Oklahoma City Oil Field
Drilling Activity by 1960
The Village
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T 12N R 2W
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NE 23rd St
Oklahoma City
35
T 11N R 3W
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Del City
Oklahoma City #1
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S Sooner Rd
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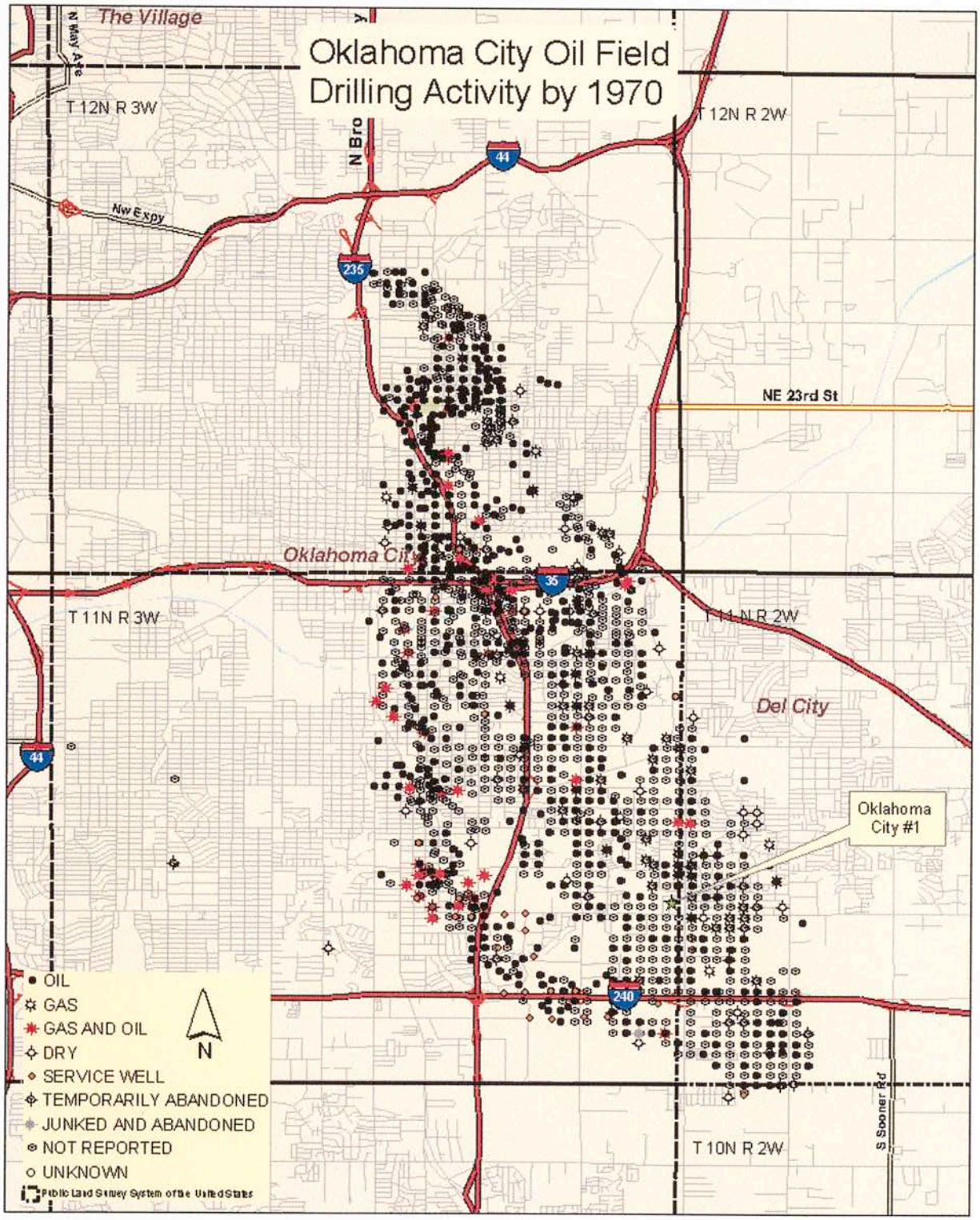
Oklahoma City Oil Field
Drilling Activity by 1970
The Village
N May Ave
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T 12N R 2W
N Bro
NW Expy
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NE 23rd St
Oklahoma City
35
T 11N R 3W
T 11N R 2W
Del City
44
Oklahoma City #1
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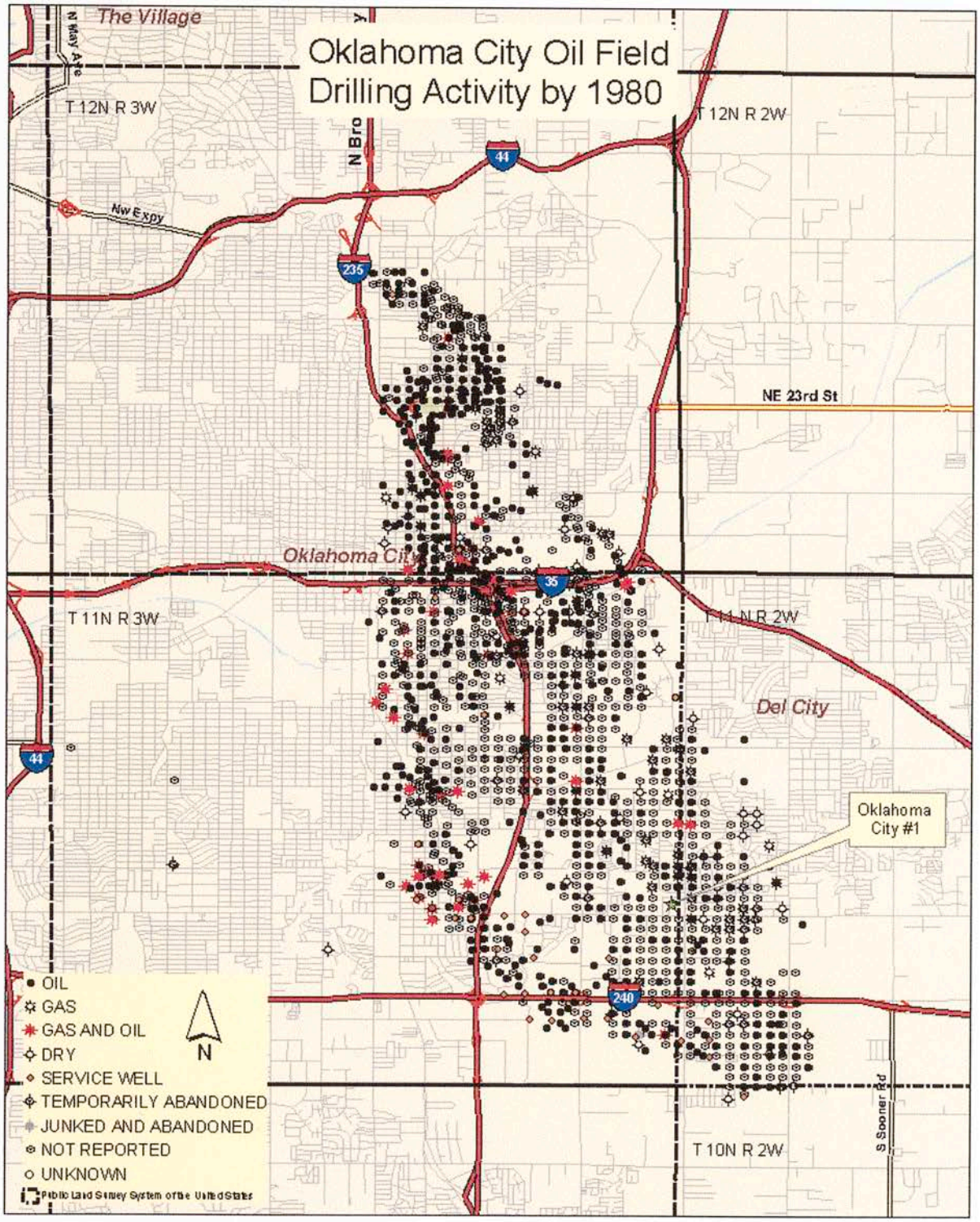
Oklahoma City Oil Field
Drilling Activity by 1980
The Village
N Kelley Ave
T 12N R 3W
T 12N R 2W
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T 11N R 3W
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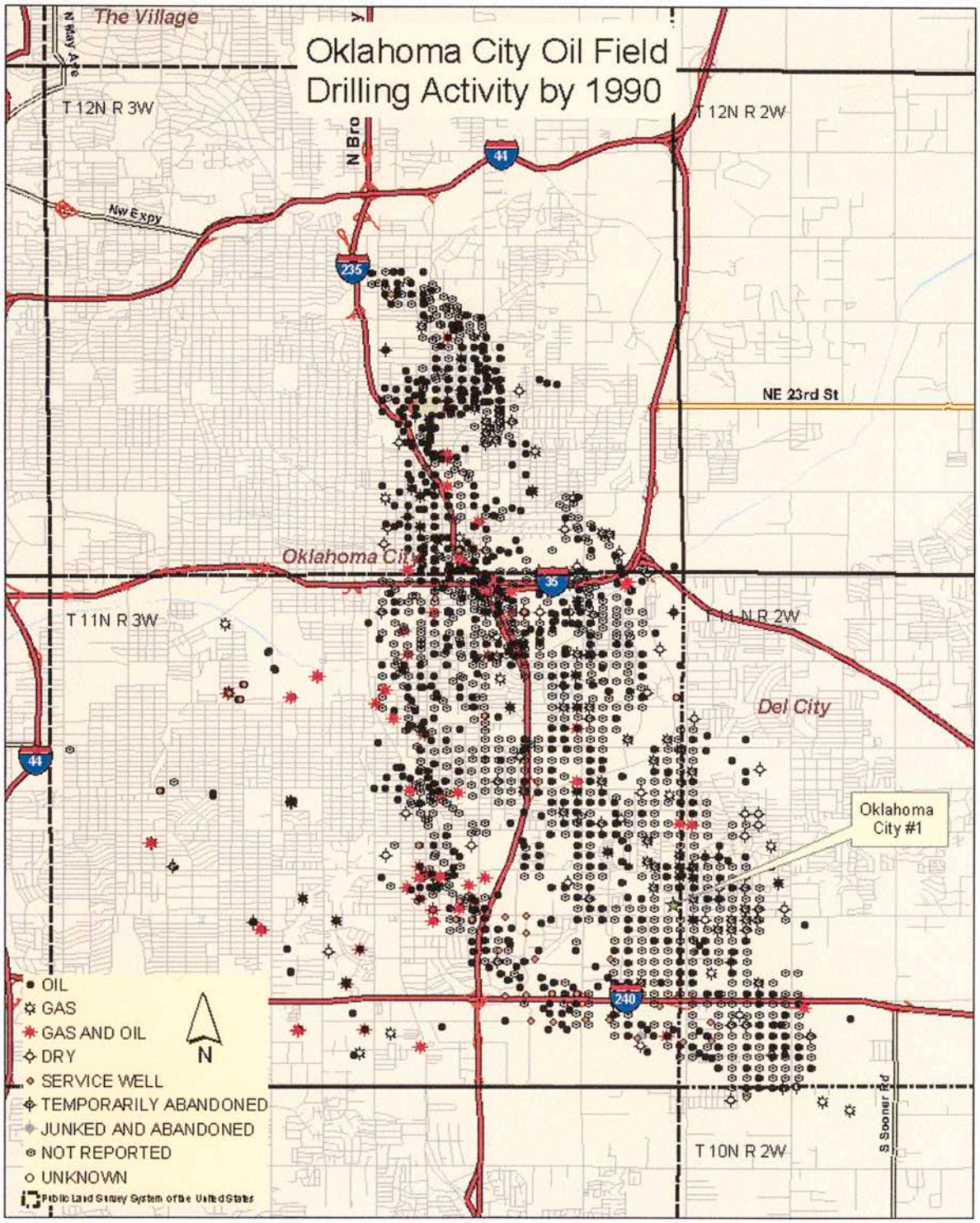
Oklahoma City Oil Field
Drilling Activity by 1990
The Village
N May Ave
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T 12N R 2W
N Bro
NW Expy
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235
NE 23rd St
Oklahoma City
35
T 11N R 3W
T 11N R 2W
Del City
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Oklahoma City #1
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OIL
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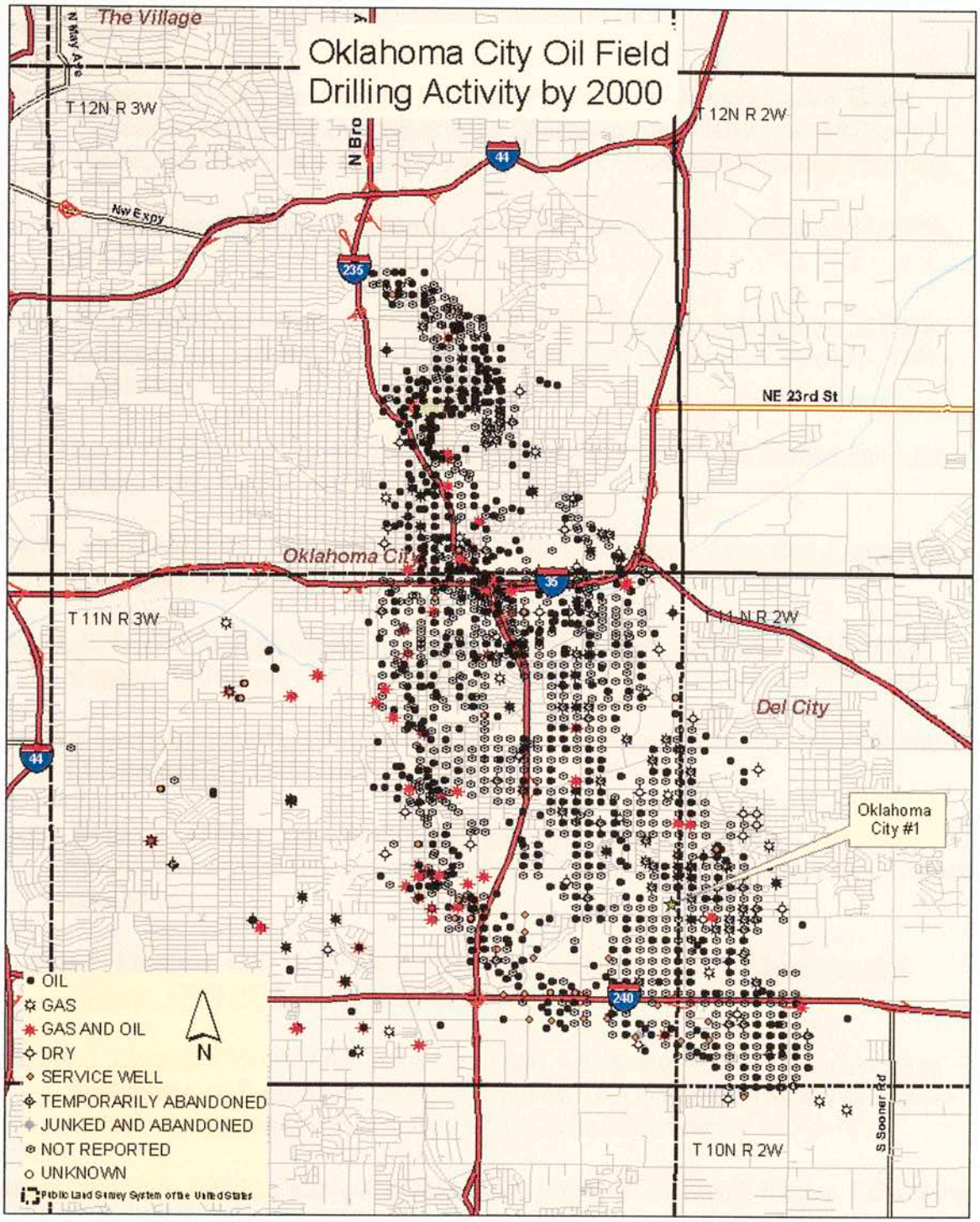
Oklahoma City Oil Field
Drilling Activity by 2000
The Village
N May Ave
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T 12N R 2W
N Bro
44
Nw Expy
235
NE 23rd St
Oklahoma City
35
T 11N R 3W
T 11N R 2W
Del City
44
Oklahoma City #1
240
T 10N R 2W
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TEMPORARILY ABANDONED
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Public Land Survey System of the United States

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