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EPA

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DRAFT

ENVIRONMENTAL IMPACT STATEMENT

FOR

PROJECT NUMBER WPC-OKLA-505

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NORMAN, OKLAHOMA

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ENVIRONMENTAL PROTECTION AGENCY

REGION VI

DALLAS, TEXAS

NEPA COLLECTION
Northwestern University
Evanston, IL 60201

APPROVED BY

John C. White

JOHN C. WHITE
REGIONAL ADMINISTRATOR

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SUMMARY

(X) Draft Environmental Impact Statement
( ) Final Environmental Impact Statement

Environmental Protection Agency
Region VI
Dallas, Texas

1. Name of Action

(X) Administrative
( ) Legislative

2. Brief Description of Proposed Action

The City of Norman, Cleveland County, Oklahoma has received Federal Grant Assistance for the enlargement and upgrading of the existing sewage treatment plant, enlargement of several existing lines that are overloaded and extension of sewage collection facilities into areas outside the presently urbanized sections of the city. All of the facilities have been completed with the exception of that portion of the grant which would extend service outside the urbanized area and would replace five oxidation ponds and two lift stations.

The Environmental Protection Agency (EPA) has evaluated the social, economic and environmental impacts of providing sewage collection facilities to the unurbanized area located within the Little River Watershed service area. Particular emphasis has been given to evaluating the environmental impact of the alternatives on Lake Thunderbird, the principal water supply source for Norman. It has been determined from this evaluation that the construction of sewage collection systems in this sparsely developed area of Norman could accelerate urbanization resulting in adverse secondary impacts which could degrade the quality of water in Lake Thunderbird. In light of this evaluation, the EPA has decided to pursue the "No Action" alternative and withdraw the remaining approved construction funds.

3. Summary of Environmental Impacts

Significant adverse secondary water quality effects (nutrient buildup, excessive algal growth, eutrophication, non-point source discharge of toxic pollutants) on Lake Thunderbird will be retarded. Impacts of construction (channel diversion and alteration of drainage patterns, relocation of utilities, destruction of vegetation and temporary degradation of water, air and noise quality) would be avoided. The no-action alternative will require the continued use by the City of Norman of the existing oxidation ponds and lift stations which had previously been scheduled for closing.

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4. Alternatives Considered

a. The City of Norman's Proposal

b. Oxidation Ponds

c. Treatment Plant Below the Dam

d. Diversion into Existing Collection System

e. No Action

f. Delay Action

5. All Federal, State, and Local Agencies and Other Sources from Which Comments Have Been Requested

Federal Agencies

Department of the Interior
U. S. Forest Service
Corps of Engineers
Department of Housing and Urban Development
Advisory Council on Historic Preservation
Department of Health, Education, and Welfare
Department of Agriculture
Federal Highway Administration
Economic Development Agency
Department of Commerce
Council on Environmental Quality
Soil Conservation Service

State Agencies

State Board of Agriculture
Environmental Health Service
Oklahoma Corporation Commission
Industrial Development and Park Development
Soil Conservation Commission
Oklahoma State Department of Health
Office of Community Affairs and Planning
Wildlife Conservation Commission
Oklahoma Department of Pollution Control
State Historic Preservation Officer
Association of Central Oklahoma Governments

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6. Date Draft Statement Made Available to Council on Environmental Quality and the Public _____.

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I. INTRODUCTION

A. THE GRANT APPLICATION

In anticipation of a continued high rate of growth, the City of Norman, Oklahoma in 1970 developed a comprehensive plan of improvements to its sanitary sewage system. The plan included an increase in capacity and a general upgrading of the existing sewage treatment plant, the enlargement of several existing lines that were overloaded, and the extension of sewage collection services into areas that outlie the presently urbanized sections of the city. In the same year, the city applied for Federal pollution control funds for these facilities under Public Law 660 (P.L.-660). The funding application, designated WPC-OKLA-505, was approved by the Environmental Protection Agency in mid-March of 1971.

A series of amendments to the original designs and funding increases followed thereafter. Notable among these were a 1972 increase in the Federal share of project cost, resulting from a state decision to participate and a legislative funding transition as P.L.-660 was superseded by the Federal Water Pollution Control Act, Amendments of 1972 Public Law 92-500 (P.L. 92-500).

To date, most of the facilities comprising the original and amended funding applications have been completed. Yet to be completed are facilities that would extend sewage collection service to an area immediately northeast of Norman's present urban center. A stop-work order for this construction was issued by the Administrator of EPA Region VI

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in September of 1974. The order was based on the Regional Administrator's determination that the city's original environmental assessment for this sewer extension did not meet the requirements of the National Environmental Policy Act, or the specific requirements of EPA regulations.

B. EPA ROLES AND RESPONSIBILITIES RELATIVE TO THIS PROJECT

Under Title II of P.L. 92-500, the Environmental Protection Agency is given authority to fund the cost of the construction of sewage collection facilities for which state and local governments offer financial support.

Section 102(2)(c) of the National Environmental Policy Act of 1969, Public Law 91-190 (P.L. 91-190), requires that a detailed Environmental Impact Statement be prepared on all "major Federal actions significantly affecting the quality of the human environment."

C. PURPOSE AND SCOPE

This document is the Draft Environmental Impact Statement, based on the environmental assessment submitted by the City of Norman. The Environmental Impact Statement evaluates the need for the proposed improvements from the standpoint of social and economic benefits, identifies the adverse and beneficial impacts of the alternatives on the man-made and natural environment, and suggests how adverse effects can be minimized. The preparation of this statement has been guided by the policies and procedures outlined in Section 102(2)(c) of the National Environmental Policy Act of 1969.

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II. BACKGROUND

A. CENTRAL OKLAHOMA: A REGIONAL GROWTH PERSPECTIVE

The four county Central Oklahoma region (Figure II-1) defined as the Oklahoma City Standard Metropolitan Statistical Area (SMSA) has experienced instantaneous and steady growth since the opening of public land to white settlers in 1889.

Growth in the SMSA, as elsewhere in the state, has been closely tied to the diverse influences of agriculture, the oil industry, heavy manufacturing, and, more recently, government installations and defense-related industries.

The four counties within the SMSA - Canadian, Cleveland, Logan, and Oklahoma - and 42 local cities comprise the Association of Central Oklahoma Governments (ACOG), one of eleven voluntary planning districts in the state established to coordinate responses to common problems. A recently published ACOG study reported a 24.5 percent increase in the area's population between the 1960 and 1970 censuses, and concluded that Central Oklahoma was one of the fastest growing regions in the country (ACOG, 1975). Later ACOG population data suggest that the growth rate may have actually increased in the five years since 1970 and is likely to continue increasing in the future.

While the entire ACOG region is steadily growing, some areas are growing at a substantially faster rate than others, especially when viewed in terms of percent change. This is particularly true of the satellite communities surrounding Oklahoma City. Of these, the most phenomenal growth has occurred in the City of Moore, immediately south

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of Oklahoma City. The trend toward suburban living now prevalent in all metropolitan areas of the country was chiefly responsible for Moore's stunning 952 percent growth (from 1,783 to 18,761) between the years 1960 and 1970. Oklahoma City reported only a 12 percent increase in population for the same period.

B. THE CITY OF NORMAN, OKLAHOMA: RECENT AND PROJECTED GROWTH

The City of Norman is located in Cleveland County, the second fastest growing county of the four counties within the ACOG region. Cleveland County population increased from 47,600 in 1960 to 81,839 in 1970, a rise of approximately 71.9 percent over the ten-year period. Growth was not evenly distributed; certain urban areas grew faster than others. Still, the numbers are indicative of a trend in the county toward rapid urbanization, a trend that updated population estimates for 1974 suggest is continuing today.

Norman's location in the SMSA is shown in Figure II-1. Being farther south than Moore, Norman would be expected to be less subject to growth pressures from metropolitan Oklahoma City. Yet between 1960 and 1970, Norman experienced a net population increase from 33,412 to 52,117, equivalent to the Moore increase for the same period.

C. REGIONAL AND LOCAL CONSEQUENCES OF GROWTH

Growth on the order recently occurring in Central Oklahoma has typically brought about two types of problems: the immediate problem of housing supply, and the long-term problem of ensuring that development

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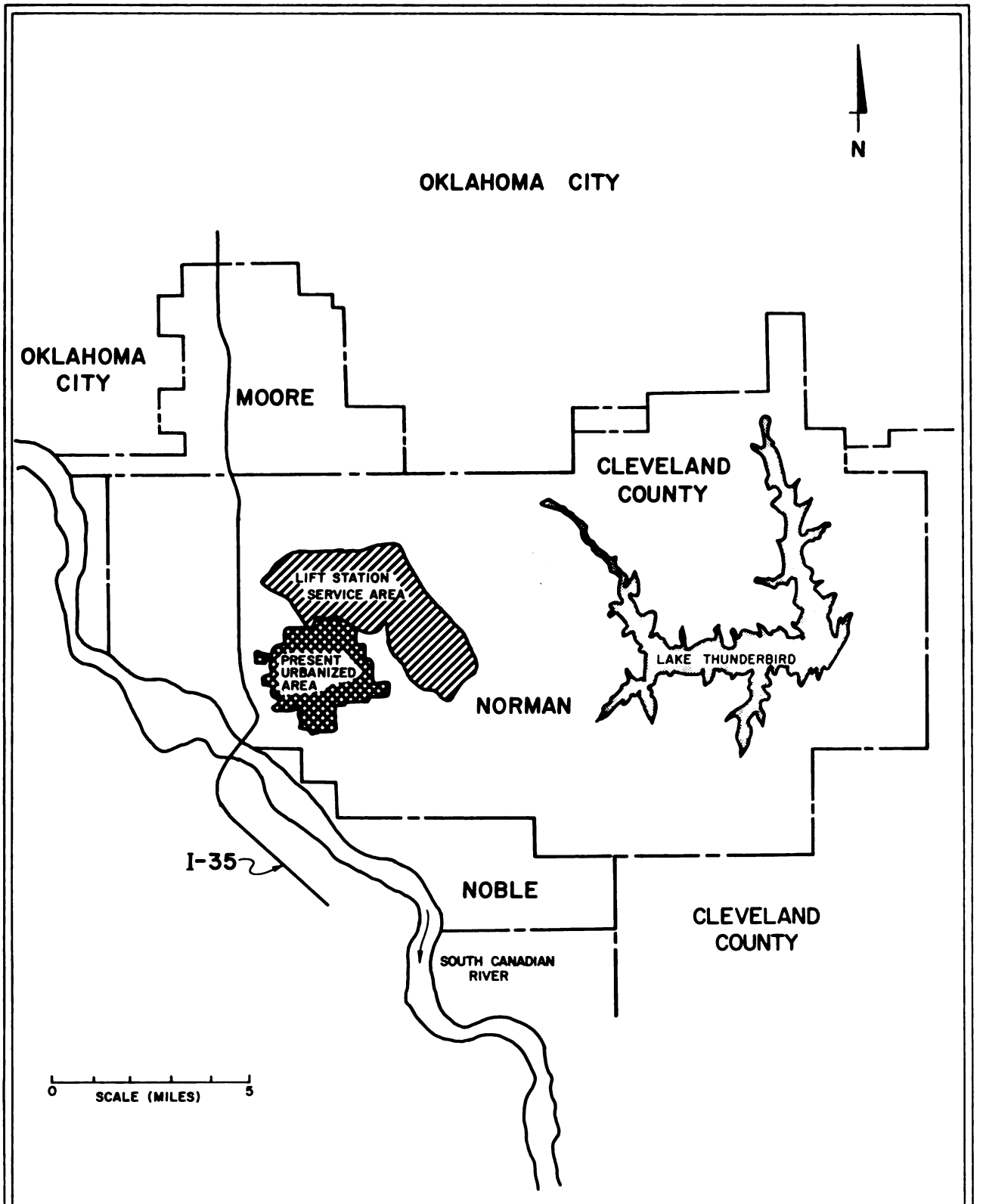

LOCATION OF THE CITY'S PROPOSED ACTION

FIGURE NO. II - I

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is consistent with overall community objectives regarding the future quality of life in the local area. With occasional exception, the construction industry in Central Oklahoma has been successful in satisfying demands on housing availability. However, planning groups in the area are presently coping with the less delineable problems of patterning development for most efficient provision of municipal services and consistency with long-term community objectives.

A recent ACOG report on Central Oklahoma housing identified "scatterization and sprawl" as the primary problems confronting the planning region (ACOG, 1972). According to the report, new residential developments are often separated from pre-existing developments by large tracts of undeveloped land. Such poor planning imposes an obvious inconvenience on residents within these subdivisions who must travel long distances to reach public facilities such as schools, churches, and shopping complexes. But the burden of providing basic municipal services to these outlying areas was cited in the ACOG report as perhaps even more costly to the community at large.

In response to this problem, most of the cities within the ACOG region have adopted land use plans to ensure that urban expansion into contiguous areas is undertaken in a systematic matter. Norman's plan, entitled the Urban Area Plan, is intended to guide the "ultimate" development of the city. The specifics of the Urban Area Plan will be discussed in detail in Chapter III. The protection of the city's reservoir, Lake Thunderbird, is a particular concern addressed by the plan.

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D. WATER QUALITY AND WATER QUANTITY PROBLEMS IN THE NORMAN AREA

Norman's water supply comes from deep wells and Lake Thunderbird, a 6,100 acre impoundment located within the boundaries of 1961 annexation but approximately six miles east of the presently urbanized section of the city. Lake Thunderbird's location within the corporate boundaries is shown in both Figures II-1 and II-2.

Lake Thunderbird was constructed on the Little River by the Bureau of Reclamation in 1965. It is a multi-use reservoir intended to provide municipal and industrial water supply, flood control, fish and wildlife propagation, and recreation. However, the designated highest priority function of the lake is to provide water supply for Norman, as well as Midwest City and Del City, communities in the northern section of the watershed. Lake Thunderbird is regulated by the Central Oklahoma Master Conservancy District, an agency with members representing each of the three cities.

The recreational value of the lake to Central Oklahoma is substantial, and it is one of the most intensely used recreational facilities of its type in the county. The Little River State Park established to manage the lake shoreline reported a summer weekend average of about 7,500 visitors per day in 1973 - a number clearly indicative of the lake's recreational significance to the region. Such a high level of visitation has suggested overuse to many and has aroused local concern for management practices in the park. Many obvious signs of overuse have been reported in studies prompted by this concern (Norman Urban Esthetics Committee, 1973). The Oklahoma Division of State Parks, the

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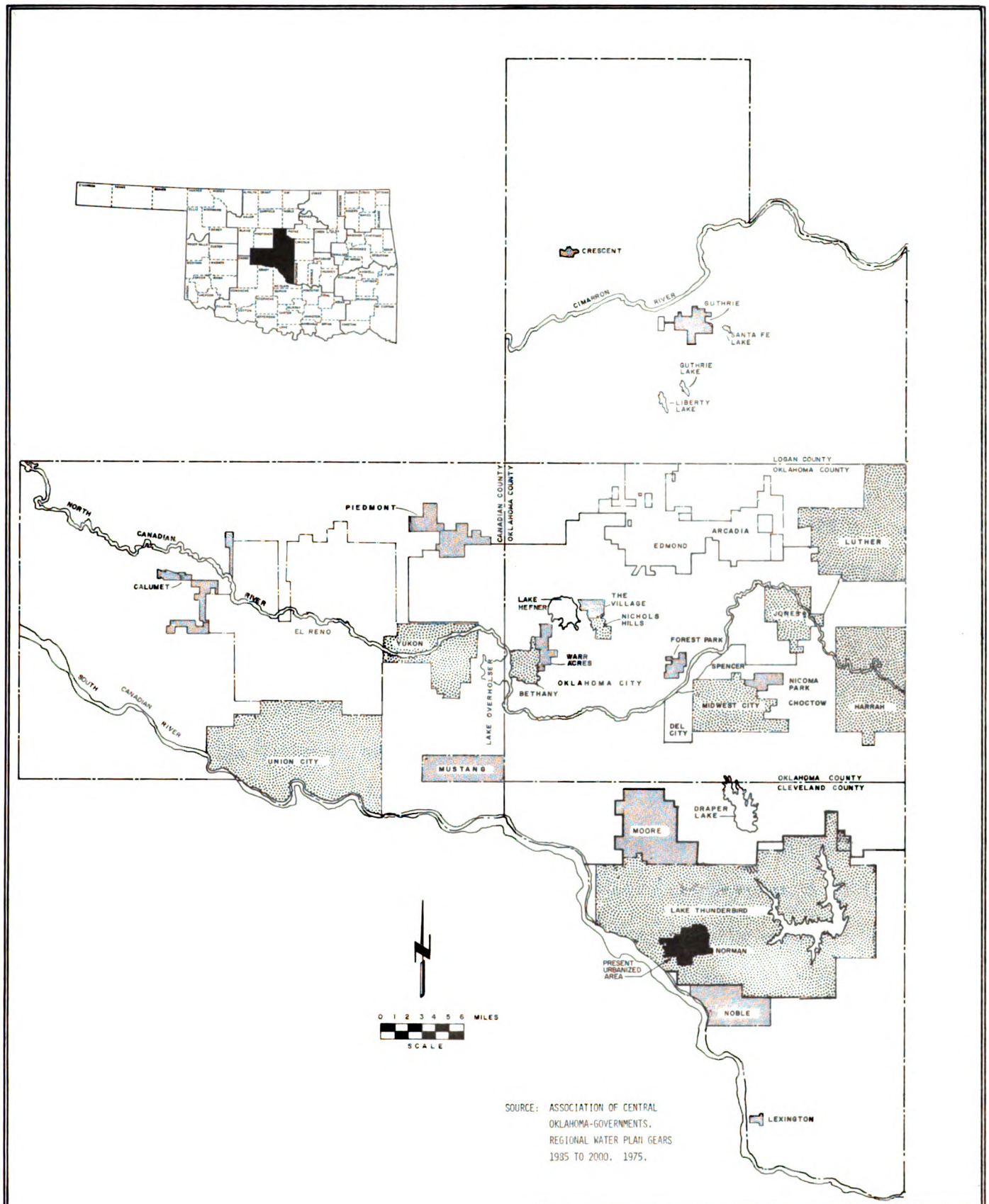

SOURCE: ASSOCIATION OF CENTRAL OKLAHOMA-GOVERNMENTS. REGIONAL WATER PLAN GEARS 1985 TO 2000. 1975.

OKLAHOMA CITY SMSA

FIGURE NO. II – 2

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Master Conservancy District, and the City of Norman are now considering means of controlling such conditions.

However, recreational overuse is not the only problem now experienced by Lake Thunderbird. The naturally high concentration of nutrients available from within the watershed plus the contribution from urban and agricultural activities have enriched the lake to a level where troublesome algal blooms have begun to occur. Siltation from the highly erodable soil of the watershed also threatens the quality of the lake waters during high-runoff periods.

Within the last few years, an additional problem has presented itself in the form of increasing residential development within the watershed. The southeast portion of metropolitan Oklahoma City, Moore, Midwest City, and Del City are expanding within the upper reaches of the basin; and Norman is witnessing more development within the western portion of the watershed.

The Little River is one of two watershed sub-basins within the City of Norman. While the predominantly rural eastern and northeastern sections of the city drain to the Little River and, hence, Lake Thunderbird, the majority of the present urban area drains southwestward to the South Canadian River. The quality of water in the river is vastly different from the lake. For reasons of flow and quality variation, the South Canadian River is unsuitable as an economical water supply source and therefore has other uses, including the transport and assimilation of treated wastewaters. Effluent compliance with waste load allocations specified by the State is the principal water quality consideration applicable to the river.

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While Norman's present water demand is satisfied by combined deep-well and reservoir sources, the existing facilities may not be adequate to meet all contingencies and will undoubtedly have to be supplemented if Norman's future needs are to be served. At present Norman has 22 wells with a maximum capacity of 5.5 mgd. Together with the current conservancy district allocation of 6.0 mgd from Lake Thunderbird, they provide the city a total maximum available supply of 11.5 mgd (ACOG, 1975). This is well above the city's average consumption of 5.5 mgd, but close to the maximum demand of 11.2 mgd. Moreover, the Insurance Service Office considers that Norman is presently about 3.6 mgd short of theoretical storage requirements for fire-fighting needs.

Projections of future demand suggest that these maximum-day shortfalls may become more acute in the next several decades, even though average-day demands can continue to be met by the capabilities of the present system.

Projected water demands for Norman are 7.8 mgd by 1980, 9.9 mgd by 1985, 13.2 mgd by 1990, 15.0 mgd by 1995 and 17.3 mgd by 2000 (ACOG, 1975). The average-day projection for 1985 is within the capacity of the system. The maximum-day demand for 1985, however, would exceed the capability of the present system by 8.2 mgd. Recognizing this problem, the City of Norman is still reviewing possible improvements to the water supply system.

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E. NORMAN'S WATER QUALITY AND QUANTITY OBJECTIVES

As the local base of governmental authority, the City of Norman shares in the obligation to solve the water quality and quantity problems enumerated in the preceding section; that is, to provide services commensurate with the immediate and future needs of its citizens, and to plan development in a way that does not conflict with or unduly compromise the quality of a water source or, in a broader perspective, the quality of the local human environment.

A commitment to the latter objective was voiced by the Norman City Council on October 15, 1974, in a declaration that sewage collection facilities would be constructed in the Little River basin subject to several conditions. Among these was the stipulation that "the Environmental Impact Statement reveals no material adverse environmental impact to the City of Norman, to those areas to be sewered under Contract #4, and to Lake Thunderbird" (City of Norman, 1974).

F. A PLAN FOR GROWTH IN NORMAN

Recognizing the eventuality of substantial growth, Norman developed a plan in 1972 for providing sewage collection, waste distribution, and arterial street services to areas west and northeast of the existing center of urbanization. The plan, published as the Public Works Master Plan, was a guide for city improvements through the year 1995. Design and phasing of these improvements were based upon the assumed maximum holding capacity of the two fringing areas, and the precept that the city's growth could be so rapid as to exhaust the capacity of these areas within 20 years. The plan advocated the need to provide urban

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services to these areas on a package basis which can be taken to infer that sewage, water, and road improvements should be constructed concurrently.

This Environmental Impact Statement will consider the elements of the Public Works Master Plan eligible for Federal construction grants authorized by Section 201(g)(1), of the Federal Water Pollution Control Act, Amendments of 1972 (P.L. 92-500). These are limited to wastewater collection and treatment works and related facilities.

G. THE ELEMENTS OF WPC-OKLA-505

The initial application for Federal pollution control funds to construct the sewage system improvements described in the 1972 Public Works Master Plan was submitted to the appropriate governmental agencies in 1970. Included in that application was a simultaneous proposal to expand the city's wastewater treatment plant. The total application was approved by the Environmental Protection Agency in early 1971 as Grant No. WPC-OKLA-505. The city later requested that certain changes be made in the configuration and extent of the collection system to enhance its efficiency. The collection system improvements as revised in the Public Works Master Plan together with the plant expansion now comprise the elements of WPC-OKLA-505. For funding purposes, the various improvements were separated into the six construction contracts described below. The juxtaposition of these facilities is shown in Figure II-3.

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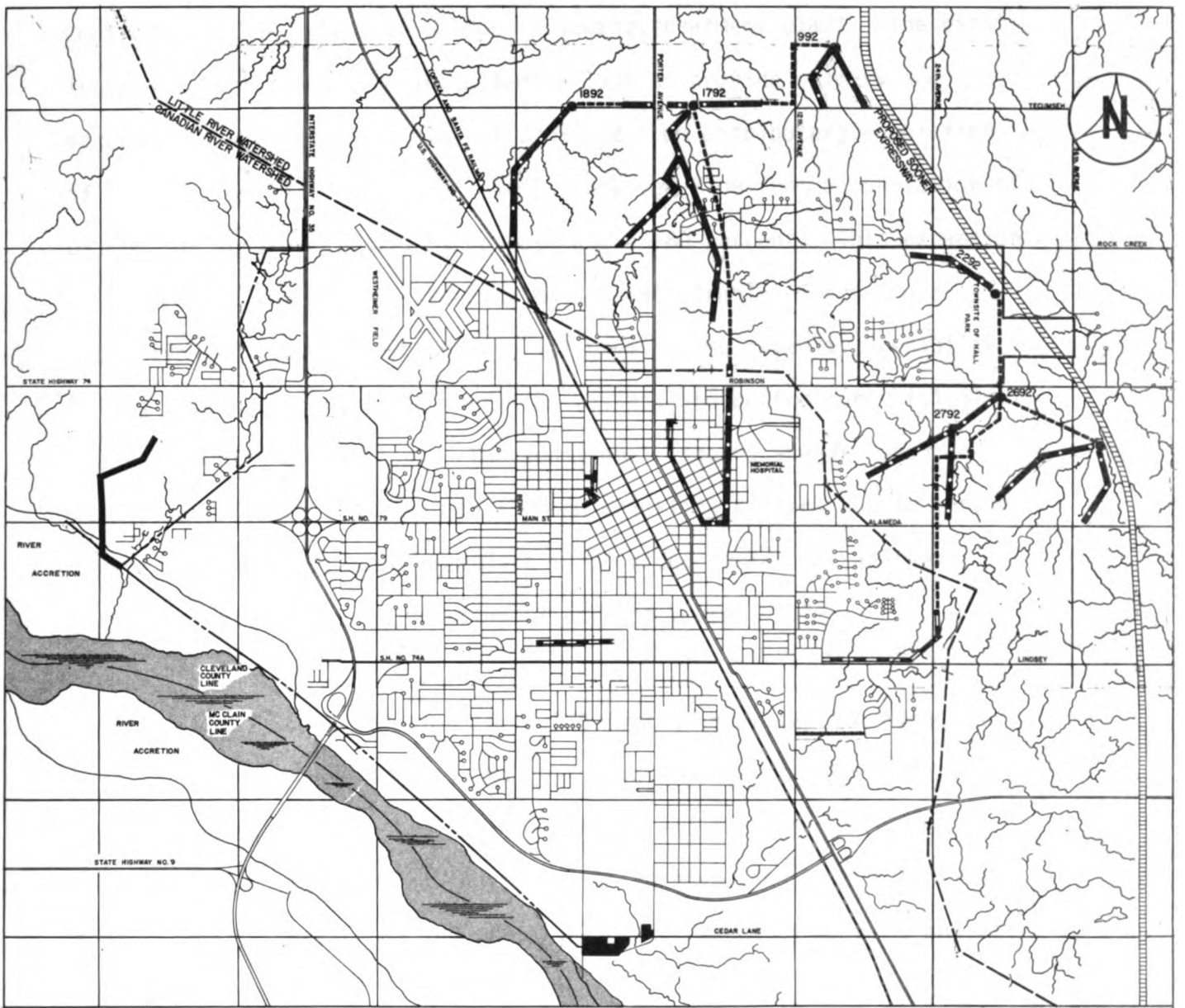

LEGEND	
CONTRACT NO. 1	
CONTRACT NO. 2	
CONTRACT NO. 3	
CONTRACT NO. 4	GRAVITY FORCE
CONTRACT NO. 5	
CONTRACT NO. 6	

Scale

0 1 Mile

LOCATION of W.P.C.-
OKLA.-505 FACILITIES

FIGURE NO. II — 3

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Contract No. 1 - Expansion of Norman sewage treatment plant. The existing plant facilities were installed in 1966 to provide primary and secondary treatment for a flow of 3.45 mgd from a tributary population of 30,000. By 1971 the plant's units received flow from a population of 54,000, or were overloaded by approximately 180 percent. This expansion will increase the plant's capacity to a level capable of serving a population of 100,000, by doubling its comminuting capacity, rehabilitating inactive primary sedimentation basins, and adding more biological secondary units and lagoons. The additional lagoons are designed to stabilize effluent from the old and new trickling filters and to ensure that a minimum of primary treatment is provided during wet weather periods of high hydraulic loading (Black and Veatch, 1971).

Contract No. 2 - Construction of 48,060 feet of gravity line along the west side of Norman. The area to be served is west of Interstate 35 and bounded by the city limits to the north and the Canadian River to the west and south. The new outfall will receive flow from a lift station presently serving an industrial plant northwest of Norman, and will also alleviate two existing lagoons (Russell, Gravlin, and Douglas, 1972). The industrial plant is located in a 1,060 acre industrial park within the Little River drainage basin.

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Contract No. 3 - Replacement of three overloaded gravity lines and construction of an eastside outfall. The three overloaded lines are within the present urbanized area of Norman. The eastside outfall will upgrade service to residential areas in the southeast sector of the Candian River drainage, and will eventually receive flow from the easternmost of two proposed primary lift stations in the Little River watershed. The total length of gravity line to be laid under Contract No. 3 is approximately 15,660 feet (Frederickson, 1975).

Contract No. 4 - Construction of lift stations, gravity lines, and force mains in northeast Norman. Two primary and four auxiliary lift stations and their appurtenances will be constructed to connect an 8.3 square mile area of the Little River watershed into the existing sewage collection system. Approximately 49,345 feet of gravity and pressure line will be installed (Norman Utilities Authority, 1973).

Contract No. 5 - Construction of a 1,385 foot outfall to serve the Oakhurst subdivision on the east side of Norman, with accommodation for later extension to serve areas farther north and east in the Canadian River watershed (Frederickson, 1975).

Contract No. 6 - Construction of a 6,667 foot lateral gravity main adjacent to the Contract No. 2 westside outfall (Frederickson, 1975). This main will serve the Brookhaven subdivision, west of Interstate 35.

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H. CURRENT PROJECT STATUS

Contract No. 4, the Little River collection subsystem is the only WPC-OKLA-505 contract yet to be completed. Construction of these improvements was in progress when a stop-work order for the Federal share of funding was issued by the EPA Regional Administrator on September 3, 1974. Work was interrupted to enable preparation of an Environmental Impact Statement, in deference to growing public controversy surrounding the facilities. Engineering for both of the primary lift stations, excavation of one station site, and construction of one gravity line segment were completed prior to the work stoppage. The engineering and construction contractors with investments in Contract No. 4 were compensated by a joint action of the city and EPA. The settlement amounts are summarized in Section I of this chapter.

As described in the earlier WPC-OKLA-505 summary, Contract No. 4 is designed to extend sewer service into the Little River watershed northeast of the present urbanized area of Norman by constructing two primary and four auxiliary lift stations and a network of gravity lines and force mains. Together, these facilities would pump sewage generated by new development in the Little River watershed back into the city's existing wastewater treatment system in the South Canadian watershed. The purpose of the project is to increase the available supply of vacant sewered land in anticipation of a substantial increase in the city's population during the next twenty years. An additional objective is to alleviate conditions at several existing lift stations that are presently close to being overloaded, and to retire several existing oxidation ponds.

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A detailed description of all of the Contract No. 4 improvements, including pump and sewer line specifications and station layouts, is presented with the service area description in Section IV (Alternatives).

I. COSTS AND FINANCING

The total cost of WPC-OKLA-505 was estimated by the City Engineer in July of 1974 to be $7,506,000 (Washburn, 1974). As shown in Table II-1, this estimate includes technical services, legal, administrative, contingency, and testing costs as well as construction costs. An itemization of construction costs for each discrete contract and an indication of the contract status at the time of the estimate are also presented in Table II-1.

As shown in the table, the total estimated construction cost of Contract No. 4 improvements is $1,494,460. Through January 1, 1975, a sum of $89,680 had been paid to the city's engineering consultant and local construction contractors as compensation for work related to lift stations 1792 and 2792. The Federal share of the total project cost is $4,128,300.00, or 55 percent of the total.

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TABLE II-1

ESTIMATED PROJECT COSTS[1]

JULY 2, 1974

Cost Element			Cost
Construction			
	Contract No.	Status	
	1	Near Completion	$3,293,012
	2	Near Completion	1,510,563
	3	Completed	237,152
	4	Engineering Only Completed	1,494,460
	5	Completed	32,052
	6	Completed	137,795
		Subtotal	6,705,036
Technical Services			430,942
Legal and Fiscal			50,702
Administrative			91,761
Contingency			128,000
Testing			99,559
		Subtotal	800,964
		TOTAL	$7,506,000

[1]Source: WPC-OKLA-505 Offer And Acceptance Forms submitted to EPA Region VI by B. J. Washburn, Norman City Engineer, on July 2, 1974

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III. THE ENVIRONMENT WITHOUT THE PROPOSED ACTION

A. CLIMATE

Only a limited amount of climatological data is readily available for Norman. Therefore, the majority of the following information was extrapolated from information available for Oklahoma City, about 20 miles north (U. S. Department of Commerce, 1974).

The mean annual temperature in the area ranges from 60°F to 62°F. However, the mean monthly temperature ranges from the low 40's in January (the coldest month) to the low 80's in July and August (the warmest months).

The daily temperatures in January range from a maximum of around 48°F to a minimum of around 25°F. The July temperature ranges from a maximum of around 95°F to a minimum of around 70°F. During an average year, summer maximum temperatures will exceed 90°F about 65 days and reach or exceed 100°F on about 10 days. Winter minimum temperatures at or below freezing (32°F) occur on an average of 80 to 85 days.

The relative humidity ranges from a mean of 80 percent near sunrise to a mean of 55 percent near sunset.

The mean annual precipitation ranges between 30 and 35 inches a year. The majority of the precipitation falls in the spring with May being the wettest month. The mean monthly precipitation ranges from a low of around 1.2 inches in January to a high of around five inches in May.

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The maximum daily rainfall was 9.04 inches in October, 1908. An average year has about 80 days with .01 inches or more of rain. The mean annual snowfall averages less than 10 inches per year. Extreme seasonal snowfalls have ranged from 25 inches per season to only trace amounts.

Southerly winds prevail over the region throughout the year with the exception of January and February when northerly winds prevail. This shift in wind direction is due to the passing of winter storm centers. The wind speed normally ranges from 10 to 15 miles per hour. Wind speeds have been recorded in the 70 to 80 mile per hour range. An annual wind rose for Oklahoma City is presented in Figure III-1.

Severe storms such as thunderstorms, hailstorms, and tornadoes have occurred during every month of the year but are very common from April until the end of June. Thunderstorms are by far the most common severe storm, and occur on an average of 50 days per year. Hailstorms and tornadoes are closely associated with thunderstorm activity.

Atmospheric diffusion potential in the area is considered to be good due to the relatively high average wind speed and the moderate mixing depths that have been calculated for the area (Holzworth, 1971).

B. PHYSIOGRAPHY

Cleveland County, Oklahoma, is located within the Osage Plains section of the Central Lowland Physiographic Province (Fennemen, 1930). Topography of the area is the result of differential erosion by running water of strata of unequal resistence. The land surface is characterized by eastward facing cuestas held up by sandstone, westward gently

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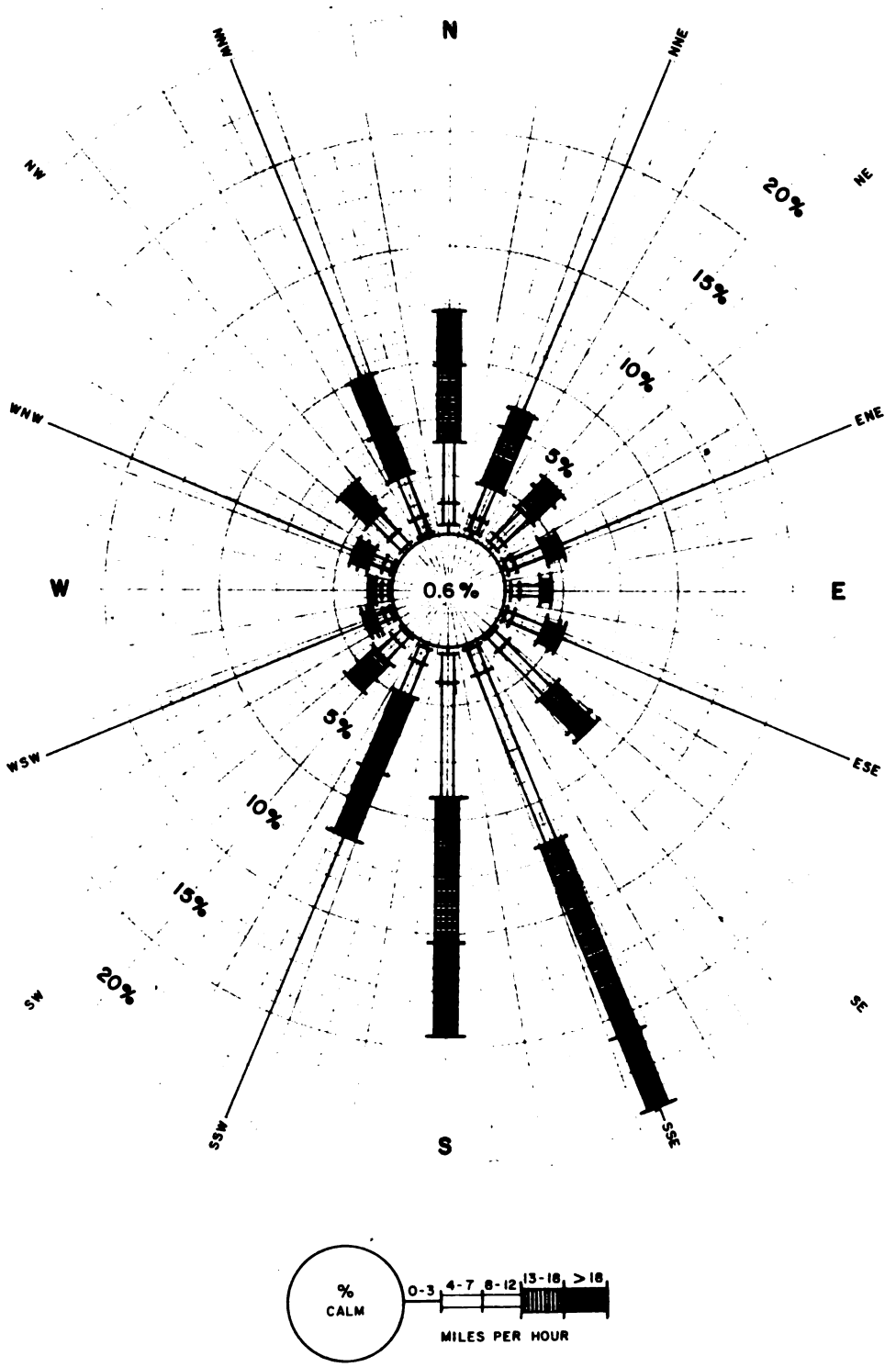

ANNUAL FREQUENCIES OF WIND DIRECTIONS AND SPEEDS AT OKLAHOMA CITY

FIGURE NO. III – 1

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sloping prairies, and wide alluvial-filled valleys. The land surface within the area to be served by the proposed lift stations, hereafter to be referred to as the service area, attains a maximum elevation of 1,240 feet msl and a minimum elevation of 1,100 feet msl. The topography of the proposed service area is shown in Figure III-2. There are no land forms that are unique to the service area (Johnson, 1976).

The primary drainage pattern within the service area is dendritic, with minor disruption due to erosion along bedrock fractures. In general, the streams of the area flow to the north and east. The majority of the service area is within the Little River drainage basin: the only exceptions are several small areas draining into tributaries of the South Canadian River. These areas are also identified in Figure III-2.

The service area is comprised of two major basins, consisting of Rock Creek drainage and tributaries thereof, and tributaries draining into the Little River. Rock Creek is a major tributary of the Little River. The Rock Creek drainage can be subdivided into three minor drainage basins (A, B, C) as shown in Figure III-2. In general, the hilltops within the three minor drainage basins are slightly undulating with slopes of one to two percent predominant. The slope on the upland hillsides ranges from two to six percent, while the lower hillsides range from 10 to 20 percent slope. The lowland floodplains of the Rock Creek minor basins are nearly level, with general slopes of approximately one percent.

The portion of the service area that drains directly into the Little River can also be subdivided into three drainage basins (D, E, F). Drainage basin D has a slope similar to that of basins A, B, and C,

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Legend:

MAJOR DRAINAGE DIVIDE

MINOR DRAINAGE DIVIDE

Note:

BASE MAP FROM U.S. GEOL. SURVEY 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAPS MOORE QUADRANGLE AND NORMAN QUADRANGLE.

TOPOGRAPHY and DRAINAGE PATTERNS

FIGURE NO. III – 2

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except that its floodplain is steeper. Drainage basins E and F have nearly level uplands. The slope of the upland hillsides in basin E and F ranges from two to six percent. However, 10 percent slopes occur in a few hillside areas. The floodplains of basins E and F are nearly level.

C. SITE GEOLOGY

The regional structural setting of rocks that outcrop in the area is that of a westward to southwestward dipping homocline, with dips ranging from 30 feet to 35 feet per mile (Wood and Burton, 1968). There are no apparent local flexures which are manifested by surface rock outcrops in the proposed service area, nor are there any surface faults that have been mapped.

The bedrock of the area includes the Hennessey Shale and the undifferentiated Garber sandstone and Wellington Formation of the Permian System (Wood and Burton, 1968). A geologic map of the study area is shown in Figure III-3. The Garber sandstone and Wellington Formation outcrops in two small areas in the southeast section of the service area. The Garber and Wellington consist of lenticular beds of cross-bedded sandstone with irregularly interbedded silty to sandy shale. The sandstone layers are fine to very fine grained and loosely cemented. The average diameter of the sand grains have been reported to be 0.155 mm and the maximum grain diameter to be 0.35 mm (Wood and Burton, 1968). The most common cementing agent within the sandstone is fine red mud, with irregular masses cemented by calcite, dolomite, and barite.

The Hennessey Shale outcrops throughout the study area. The character of the formation is predominantly reddish-brown shale with layers

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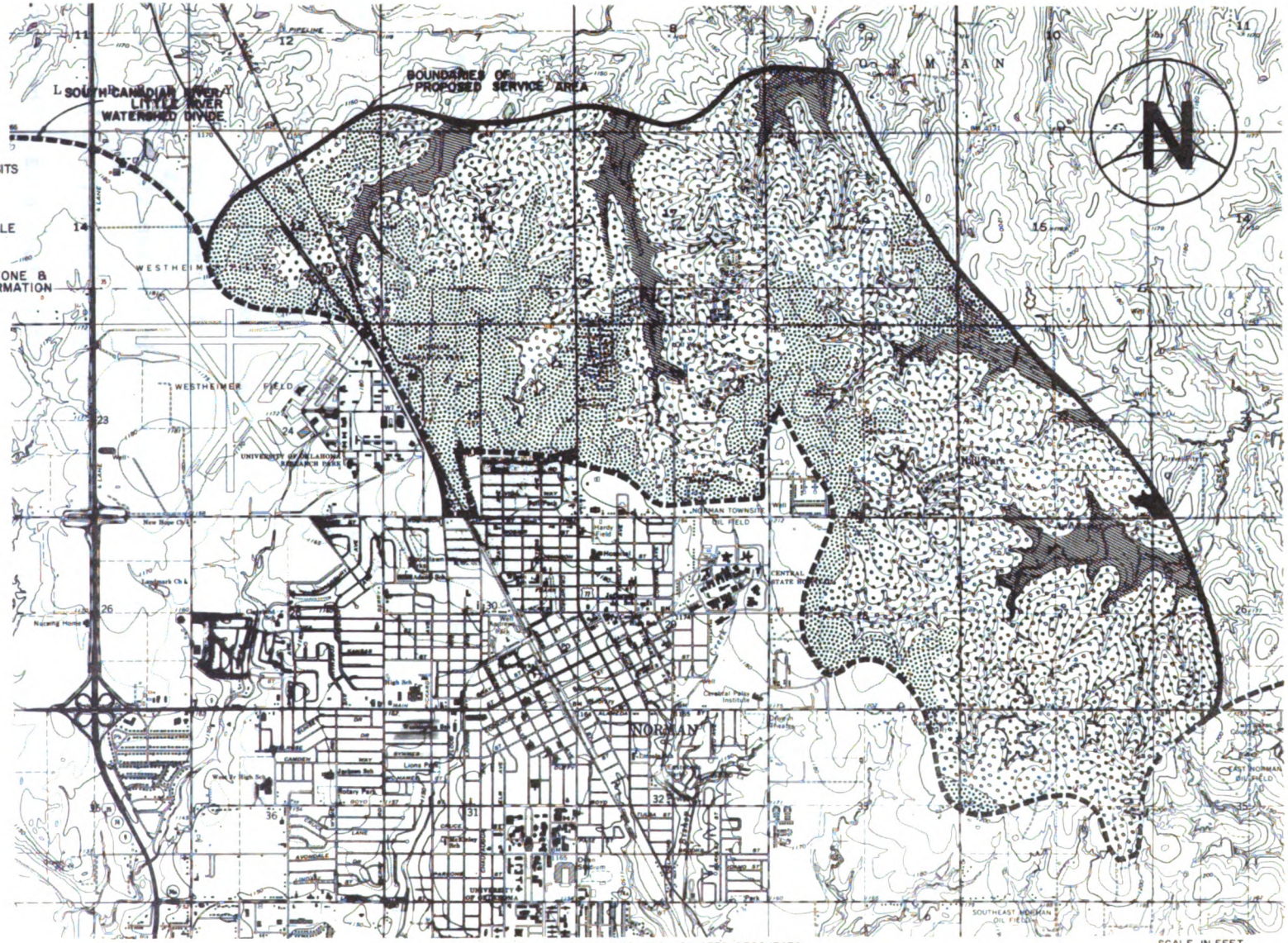

FROM: WOOD AND BURTON, 1968, GROUND-WATER RESOURCES IN CLEVELAND AND OKLAHOMA, COUNTIES, OKLAHOMA: OKLA. GEOL. SURVEY CIRCULAR 71.

SURFICIAL GEOLOGY of the LIFT STATION SERVICE AREA

FIGURE NO. III - 3

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of siltstone and fine grained sandstone (Wood and Burton, 1968). Lenticular beds of fine grained sandstone occur near the base of the formation, exposed in the eastern sections of the service area. The Hennessey Shale generally forms a low-relief belt throughout the area. Fossil amphibians and reptiles have been found in the outcrops of the Hennessey Shale in other locations in Oklahoma, but no studies have been conducted to document the occurrence of these paleontological elements in the service area (Johnson, 1976).

Quaternary alluvial terrace deposits cover much of the area shown in Figure III-3. Relief upon the terrace surface is low, with a marked absence of surface drainage. The terrace deposits consist of lenticular beds of clay, silt, sand, and gravel and the terrace deposits in the study area disconformably overlie the Hennessey shale. The deposits are moderately to highly permeable. Commercial deposits of sand and gravel often occur in terraces, but to date the occurrence of commercial deposits has not been investigated in the service area (Johnson, 1976).

The modern creek valleys within the service area are filled with alluvium consisting of sand, silt, and clay. The topographic surface of the alluvium is relatively flat, and occupies the lowlands of the area.

With respect to seismic risk, Cleveland County is rated Zone 2, indicating that the maximum expected earthquake could produce only moderate damage (ESSA U. S. Coast and Geodetic Survey, 1969). As previously described, the topography of the service area is relatively gentle, and the bedrock which outcrops and underlies the alluvium and

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terrace deposits is lithified. The relationship between gentle topography and lithified bedrock at or near the surface yields a low potential for mass movement due to earthquake (Nuttli, 1973).

D. SOILS

Soils that cover the lift station service area are of three primary parent materials: bedrock shales, alluvium, and terrace alluvium. The soils of bedrock parent material are typically acidic in the surface layers and neutral to basic with depth. All of the local soils show high levels of available soluble phosphorous. A map of soils in the service area is shown in Figure III-4. The bedrock or parent material, unified soil classification, and topographic position of the local soils are indicated in Table III-1.

The alluvial soils of the study area are of the Yahola soil series. The Yahola occurs on gentle (0-1 percent) slopes and occupies the creek floodplains. The Yahola is characteristically a silty clay to silt with moderate permeability. Runoff is also moderate.

The Reinbach and Bethany soil series represent soils of the service area that have developed from terrace alluvium. The Reinbach series occurs on 0-1 percent slopes and is found on low level stream terraces in the creek floodplains. The Reinbach series is characteristically a silty clay to sandy silt with moderate permeability. Runoff across the Reinbach soils is typically slow. The Bethany soil series covers a great extent of the service area and is found on 0-3 percent slopes with 0-1 percent predominant. The Bethany soils have developed on upper level

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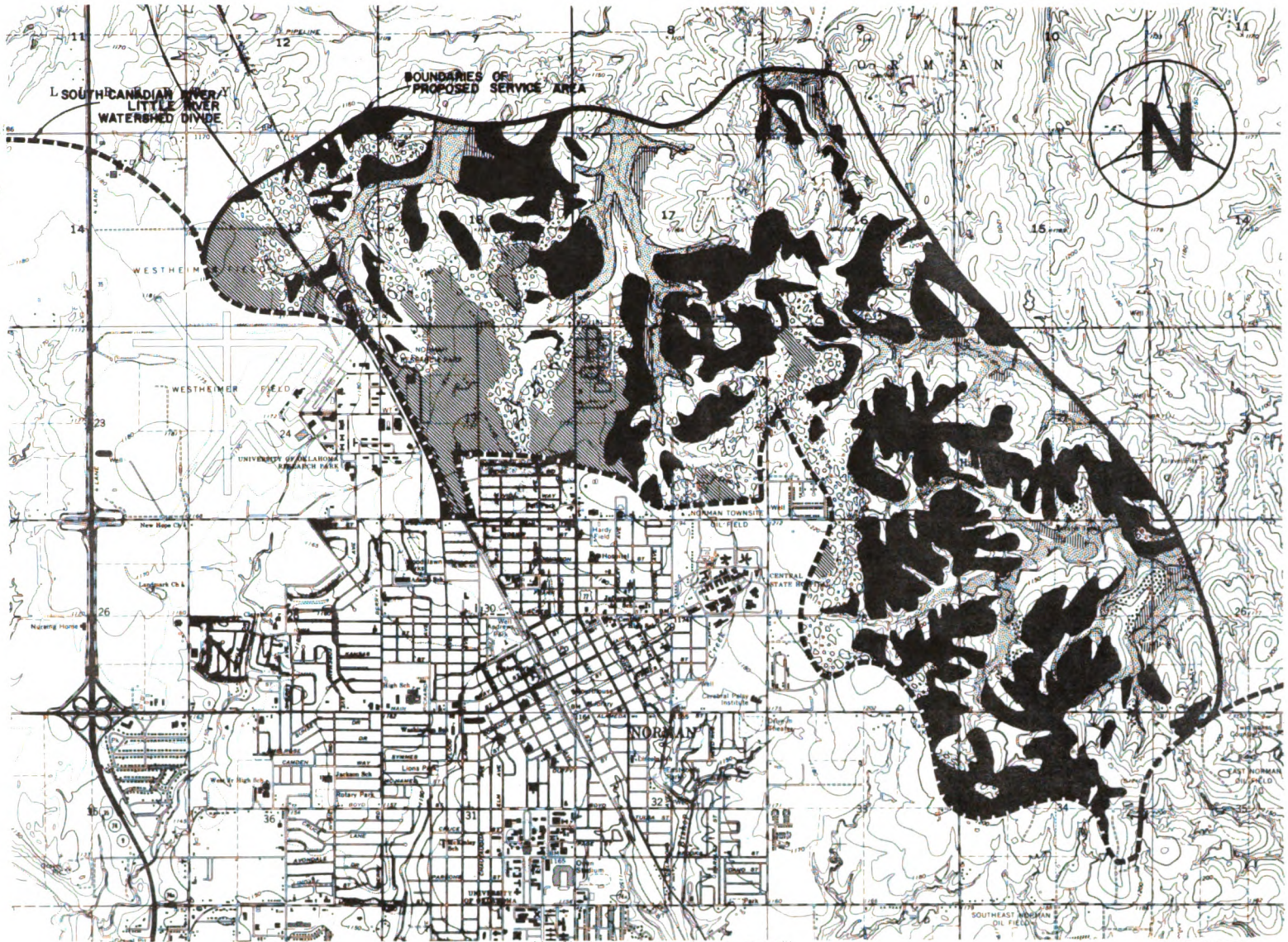

FROM: BUCKHANNAN, W.H., 1954, SOIL SURVEY OF CLEVELAND COUNTY, OKLAHOMA. U.S. DEPT. AGR. SOIL CONSERV. SER., AND OKLA. AGR. EXPER. STATION.

SOIL SERIES WITHIN the SERVICE AREA

FIGURE NO. III - 4

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TABLE III-1

SOILS OF THE LIFT STATION SERVICE AREA

(Hayes, 1968)

Soil Series	Bedrock or Parent Material	Unified Soil* Classification	Topographic Position
Bethany	Terrace Alluvium over shale		Nearly level upland or high terrace
A horizon		CL	
B horizon		CH	
C horizon		CL	
Kirkland	Shale		Nearly level to gently undulnating erosional uplands
A horizon		ML	
B horizon		CH	
C horizon		CL	
Reinbach	Terrace Alluvium		Nearly level low stream terraces lying a few feet above present floodplains
A horizon		SM	
C horizon		SM	
Renfrow	Shale		Undulating erosional uplands with gradients of about 2 to 7 percent; commonly 2 to 4 percent
A horizon		ML	
B horizon		CL	
C horizon		CL	
Vernon	Shale		Gently sloping to steep hillsides
A horizon		CL	
C horizon		CL	
Yahola	Alluvium		Nearly level floodplains
A horizon		CL	
C horizon		ML	
Zanies	Sandstone or sandy shale		Gently rolling erosional upland; convex surface with slope from 1 to 6 percent; commonly 1 to 4 percent
A horizon		SM	
B horizon		CL	
C horizon		CL	

*Unified soil classification calculated from index properties of various soil series for Cleveland published in Hayes, 1968.

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terrace alluvium overlying shale bedrock. The surface soil is typically silty, and is underlain by clay grading to shale with depth. The Bethany series has a low permeability and runoff is slow. Buckhannan (1954) concludes that the Bethany soil series proposes no erosion problem except in areas of rapid runoff.

The Kirkland, Renfrow, Vernon, and Zanies soil series have developed over the Hennessey Shale in many sectors of the service area. The Kirkland series occupies one to three percent slopes and has low permeability. Runoff is relatively slow. Erosion is not a specific problem on virgin soils of this series, although sloping cultivated areas and areas subject to rapid runoff show marked signs of erosion (Buckhannan, 1954). The Kirkland series is comprised of a surface silt or silty clay underlain by clay.

The Renfrow series of the area occurs on one to seven percent slopes and has low permeability. Runoff is moderate to rapid. The Renfrow series is much like the Kirkland, but is found on steeper slopes. Soils of the Renfrow series are highly erosive in tilled areas. The Renfrow soils have a silty surface layer and grade with depth to clays and silty clays.

The Vernon soil series are thin soils developed on two to twenty percent slopes. The Vernon series represents a thin shallow cover over sandy shale and shale bedrock. Runoff is very rapid while permeability is low. The soils of the Vernon series are erosive and gullies exposing red shale beds are common.

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The Zanies soil series occurs on slopes of one to eight percent and is much like the soils of the Renfrow series except more permeable. Parent material is generally sandstone or sandy shale with thin sandy surface soils. The Zanies soils are also highly subject to erosion (Buckhannan, 1954).

All the soils of the study area have been recommended as being suited for pasture or cultivation with the exception of the soils of the Vernon series (Buckhannan, 1954). The soils of the Vernon series are thin and relatively non-productive when cultivated. Consequently areas covered by the Vernon series are recommended for pasture only. Typical crops grown on soils of the study area are cotton, sorghum, wheat, oats, alfalfa, and corn.

The Soil Conservation Service has no watershed projects in the study area to control soil erosion and rainfall runoff (McCambell, 1976).

E. RATE OF SILTATION

Soil erosion is a natural phenomenon dependent upon precipitation, soil type, soil cover, and topography. The rate of erosion in a localized area can be accelerated by human activity, specifically, alteration of the latter two conditions.

Each of the soil types identified in Section D has an allowable rate of erosion that will permit the soil to regenerate itself and remain productive. The U. S. Soil Conservation Service in Norman has estimated these rates to be within a range from two to five tons per

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acre per year (Bourlier, 1975). Some soils in the study area, especially the Vernon and the Renfrow, are unproductive because of erosion losses greater than the allowable.

The Agricultural Research Service in cooperation with the Soil Conservation Service has developed a method of predicting soil loss based on erosion factors in the Universal Soil Loss Equation (USLE).

While the equation was originally developed for farm lands, recent research has been conducted to expand the use of the equation to entire watersheds (Williams and Bundt, 1972). Applying the equation to the Little River watershed yields an average soil loss for the study area of 18 tons per acre per year, of which 75 percent comes from the Vernon and 15 percent from the Renfrow.

Soil eroded from the service area is deposited downslope as colluvium or in stream beds as alluvium. The percentage of sediment delivered to any specified downslope or downstream location is called the sediment delivery ratio. This ratio is dependent on drainage basin size, and for the Little River at the Lake Thunderbird dam is about 10 percent. This means that about 1.8 tons per acre from the study area should be trapped by Lake Thunderbird each year. The Bureau of Reclamation designed Lake Thunderbird to allow for 35,000 acre-feet of accumulation in 100 years (Gerald Wright, 1975). This amounts to about 2.3 tons per acre per year.

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F. HYDROLOGY

The hydrology of the Little River watershed is extremely important to the water supply of the area, for precipitation in the watershed is the ultimate source of municipal and industrial water for several cities. Both surface water supply and in part the groundwater supply are replenished in the watershed. Runoff in the watershed is retained by Lake Thunderbird, which as previously mentioned is the major source of municipal water for Norman, Midwest City and Del City. Groundwater from alluvial and bedrock aquifers constitutes a minor source of supply, and is relied upon primarily to fill peak demands.

1. Surface Water

Cleveland County is drained by the Canadian River and the Little River and their tributaries. However, all waters of the area are wholly within the Canadian River watershed. The Canadian River, forming the southern boundary of Cleveland County, originates in eastern New Mexico and flows in a generally eastward direction, ending at its confluence with the Arkansas River approximately 40 miles west of the Arkansas-Oklahoma state line. All waters of the area are tributary to the Mississippi River and subsequently to the Gulf of Mexico. The river has a gradient of about four feet per mile southeastward. Its average rate of flow past the gaging station near Purcell is about 1,300 cfs (Wood and Burton, 1968).

The boundaries of the 256 square mile Little River watershed are shown in Figure III-5. The Little River drains about 50 percent of

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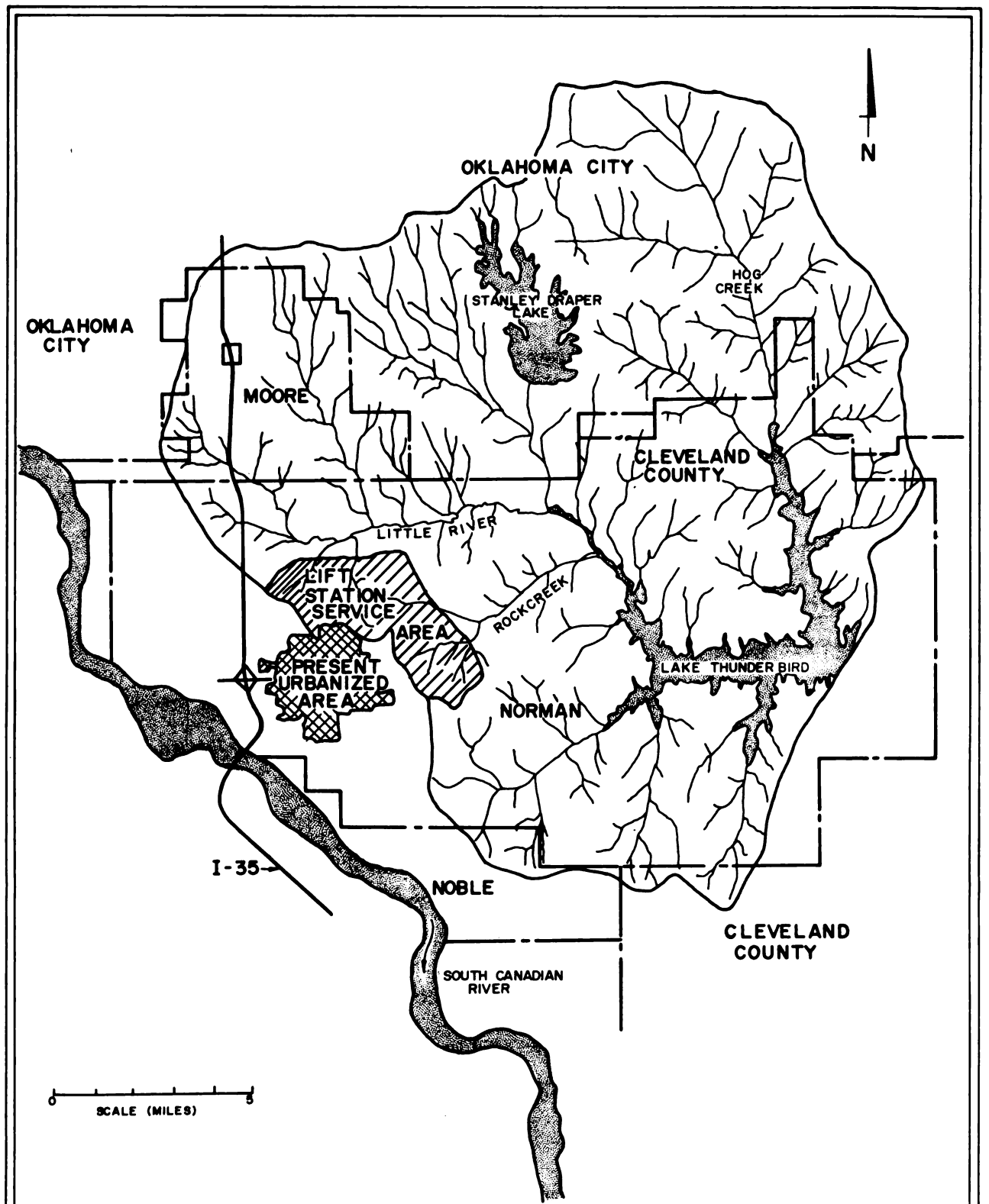

LITTLE RIVER WATERSHED
ABOVE LAKE THUNDERBIRD DAM

FIGURE NO. III – 5

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Cleveland County and has a gradient of about 12 feet per mile southeastward. Its average rate of flow past the gaging station east of Norman during the 11 years of record prior to the construction of Lake Thunderbird in 1965 was 63 cfs (Wood and Burton, 1968). Since 1965, flow in the river has been completely regulated by lake discharge. Flow ranged from 0.35 to 754 cfs in calendar year 1973, numbers that reflect the influence of stream regulation. Potential flooding in the watershed is generally confined to the alluvial areas of streams shown in Figure III-6.

Lake Thunderbird has a storage capacity of approximately 195,000 acre-feet, of which 75,000 acre-feet is allocated to flood control, 85,000 acre-feet to municipal and industrial water supply, and 35,000 acre-feet for sediment accumulation (Wood and Burton, 1968).

Stanley Draper Lake located above Lake Thunderbird in the watershed has a capacity of 100,000 acre-feet and is used as a storage reservoir for Oklahoma City. Storage in the reservoir is supplemented by water pumped from Lake Atoka in the southeastern part of the state.

2. Groundwater

The Garber sandstone and Wellington Formation of the Permian System consist of interbedded lenticular sandstones, shales and siltstones 800 to 1,000 feet thick (Wood and Burton, 1968). The sands of these formations constitute the most important source of groundwater in the area; the two formations as a whole are considered to be one aquifer. Fresh water in the general Norman area is obtained between depths of

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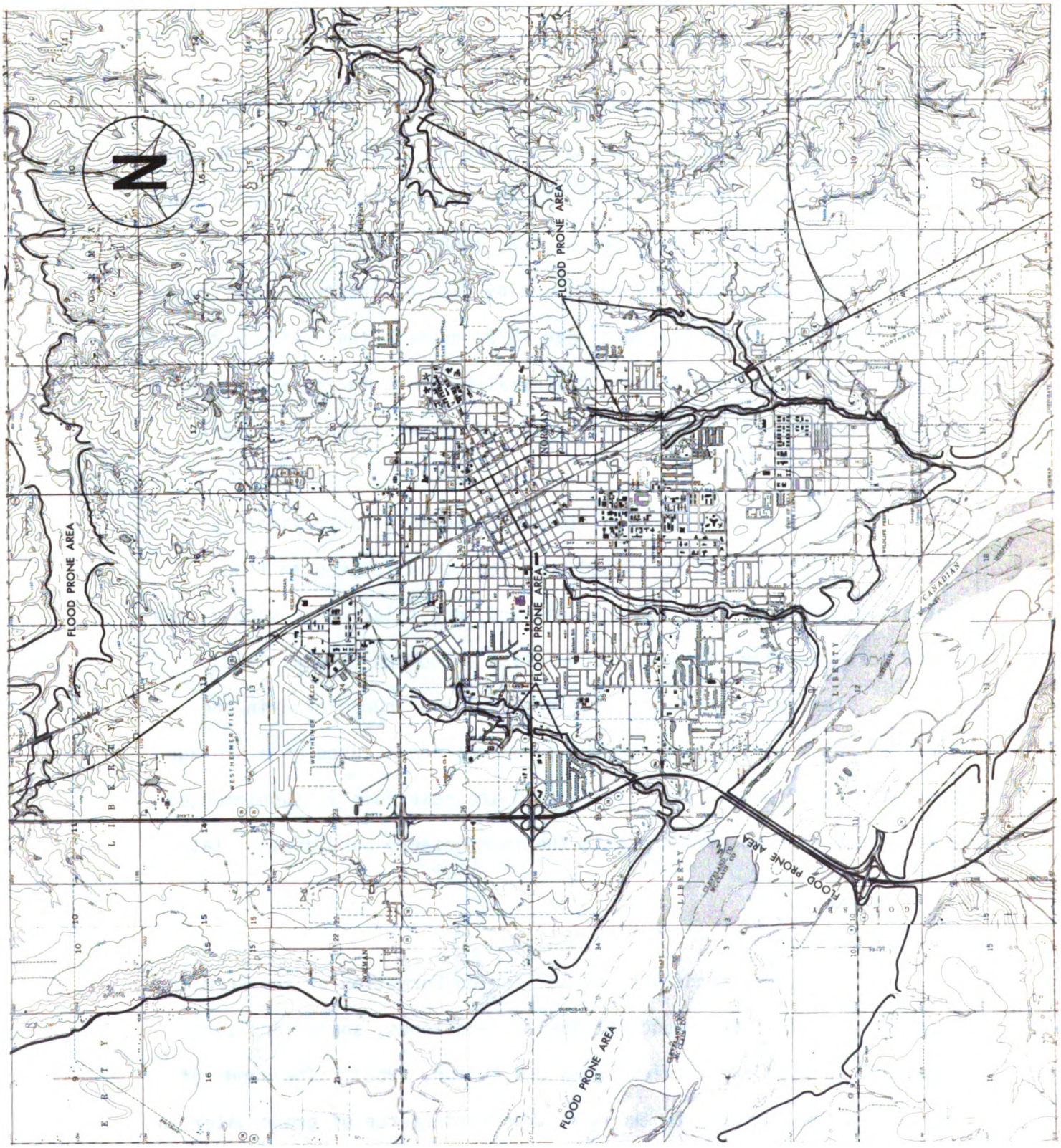

SOURCE: U.S. GEOLOGICAL SURVEY, WATER RESOURCES DIVISION, OKLAHOMA CITY.

SCALE 1:24,000

FLOOD PRONE AREAS OF WEST NORMAN

FIGURE NO. III – 6

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100 feet, or less in the recharge area, and 1,000 feet. The maximum depth of potable water is determined by the occurrence of salt water in the base of the aquifer. The fresh-water base in the vicinity of the lift station service area occurs at a depth of approximately 400 feet.

Yield from wells in the Garber-Wellington is variable over short distances. Figure III-7 is a short section of the aquifer near Norman. Wells 8N-2W-5dba and 8N-2W-9bcc, forming the boundaries of this one-mile section, lie along Federal Highway 77 approximately three miles south of the lift station service area. The section demonstrates the aquifer's lenticular nature which explains the variable well yield: some wells tap significantly more sand then others. Yields of municipal and industrial wells tapping the aquifer range from 50 to 450 gpm and produce drawdowns of 50 to 430 feet (Wood and Burton, 1968). This results in a specific capacity of about one gpm per foot of drawdown.

The recharge capabilities of the aquifer are demonstrated by the ability of the water levels to recover after heavy pumping and severe droughts. The potential for recharge prior to the completion of Lake Thunderbird was estimated to be 15 million gallons per square mile per year in the outcrop area of the Garber-Wellington (Wood and Burton, 1968). The effect of the lake on recharge has not been established, but it should increase the recharge potential.

As a rule, water taken from the Garber and Wellington is potable. It is generally hard, and at least at some Cleveland County well sites can be high in dissolved sulfate, chloride, fluoride,

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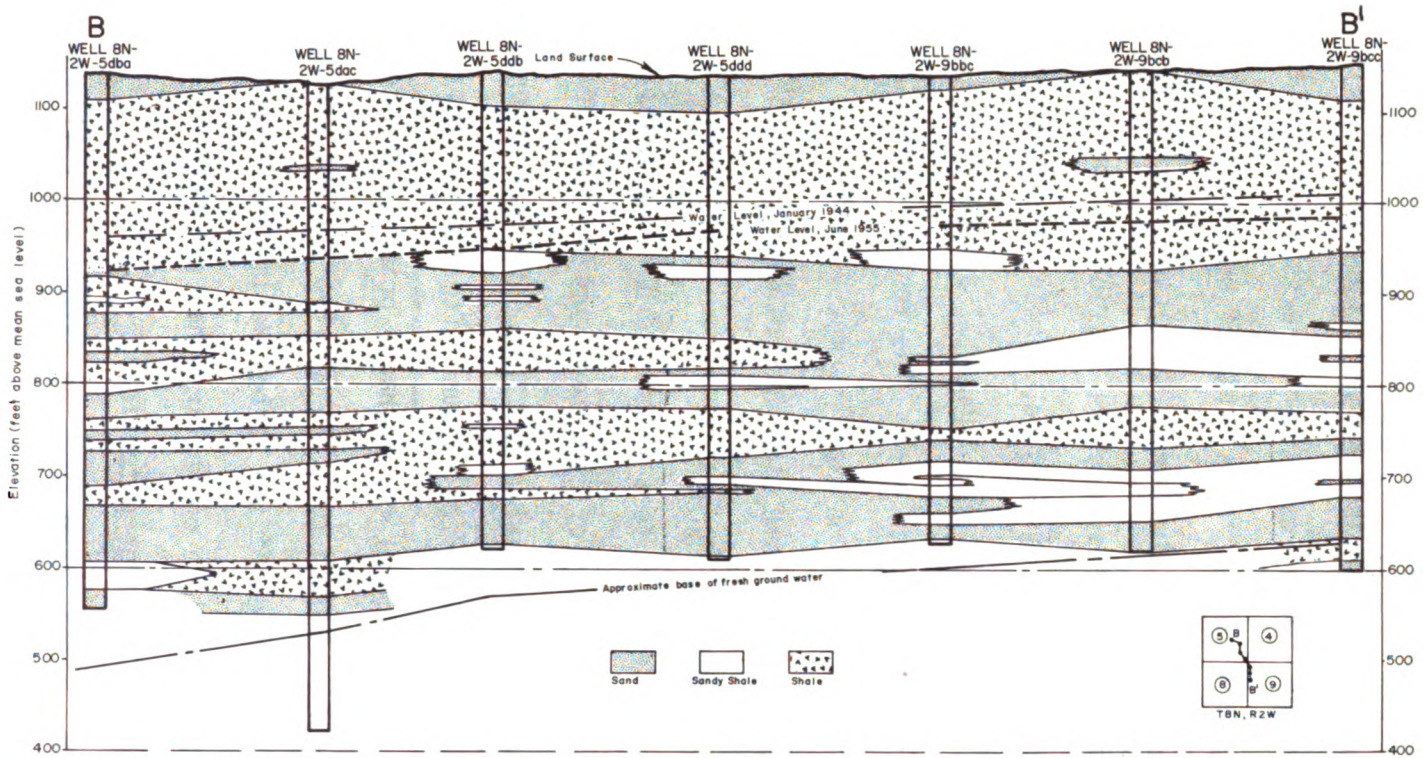

CROSS-SECTION OF GARBER SANDSTONE & WELLINGTON FORMATION IN THE NORMAN AREA

(Source: Groundwater-Cleveland and Oklahoma Counties, Oklahoma Geological Survey Circular Nº. 71)

CROSS-SECTION OF THE GARBER SANDSTONE & WELLINGTON FORMATION IN THE NORMAN AREA

FIGURE NO. III - 7

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nitrate, and solids (Wood and Burton, 1968). A limited chemical analysis of groundwater from 5 wells in the service area is presented in Table III-2. The location of the five wells is shown in Figure III-8.

While the surveys upon which the Table III-2 data are based are not recent, the fact that no new major industrial consumers have begun operations in the Norman area since the data was collected would suggest that they may be fairly representative of present conditions.

G. SURFACE WATER QUALITY

The immediate project area consists of two sub-basins. The majority of urbanized Norman is directly within the Canadian River watershed. However, some urbanized and developing portions of Norman, located east and northeast of the present urban center, are within the Little River watershed (Figure II-1). Yet, in reality the entire area is within the Canadian River basin: the confluence of the Little River and the Canadian River is located approximately 100 miles downstream from Norman. In the context of the discussion presented in this section, however, the Little River and Canadian River will be considered separate watersheds.

Water quality within the Canadian and Little River basins differ from each other in several respects. The Little River, in particular Lake Thunderbird, has relatively high quality and serves as the principal source of water for the cities of Norman, Moore, and Del City. As such, the quality of the water in Lake Thunderbird and in the Little River above the dam is of considerable importance to the citizens of the

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TABLE III-2

GROUND WATER QUALITY RECORDS WITHIN THE SERVICE AREA

Well No.	Well Depth	Collection Date	Calcium/Magnesium Hardness (mg/l as $CaCO_3$)	Sodium (mg/l)	Bicarbonate (mg/l as HCO_3)	Carbonate (mg/l as CO_3)	Sulfate (mg/l as SO_4)	Chloride (mg/l)	Nitrate (mg/l as NO_3)	Dissolved Solids (mg/l)	Specific Conductance (Micromhos at 25° C)
9N-2W-9cbc	408	1-51	226	42	359	0	9.4	8.5	1.9	320	546
9N-2W-17daa	600	1-51	121	59	254	11	10.0	7.2	3.0	236	431
9N-2W-20abc	616	4-44	30	144	288	18	61.0	8.0	1.0		632
9N-3W-13c99	605	5-44	13		301	30		5.0			586
9N-3W-13dcd	615	5-44	9		290	28		4.0			546

Source: Wood, P. R. and Burton, L. C., 1968. Ground-water Resources in Cleveland and Oklahoma Counties, Oklahoma. Oklahoma Geological Survey. Circular No. 71.

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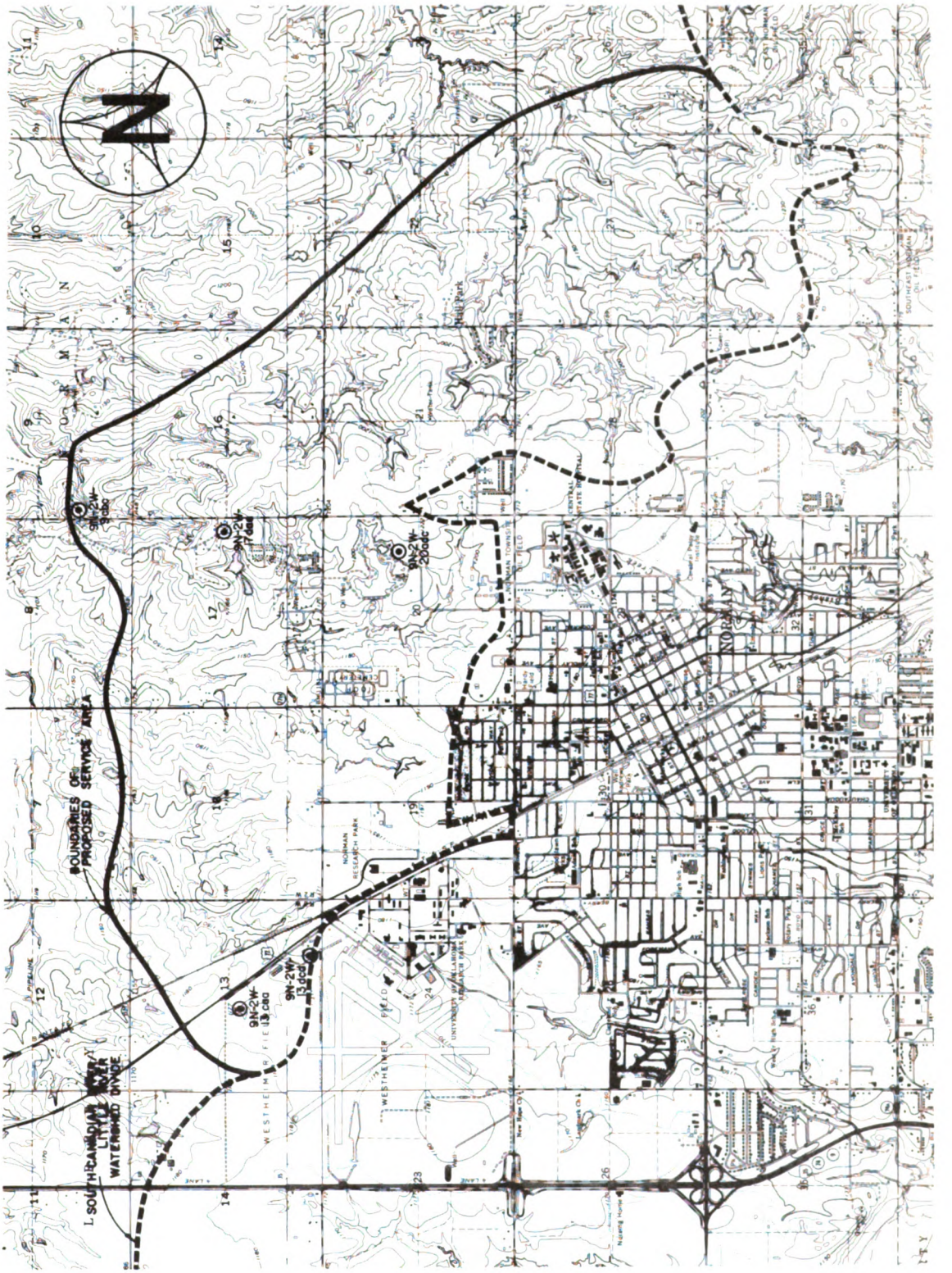

LOCATION OF WELLS FOR WHICH GROUND-WATER QUALITY DATA AVAILABLE

FIGURE NO.: III-8

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area and to the various governmental agencies with water quality jurisdiction.

The Canadian River below Norman is not used for water supply and, consequently, one of its assigned uses is to receive, transport and assimilate treated wastes from a number of industries and municipalities within its basin. A special limitation which prohibits any future discharge of pollutants applies to the Lake Thunderbird watershed. In addition, the state has adopted an anti-degradation statement designed to protect waters whose existing quality is better than minimum standards.

Wastewaters from the Norman area are currently treated at the recently expanded municipal wastewater treatment plant. Effluent from the plant is discharged to the Canadian River south of the Interstate 35 bridge. The Oklahoma State Department of Pollution Control has established waste load allocations for the Canadian River watershed which set requirements for all discharges in the basin. In accordance with these allocations, the City of Norman must discharge an effluent with a 5-day biochemical oxygen demand no greater than 20 mg/l and a suspended solids concentration no greater than 30 mg/l. The Department of Pollution Control's policy toward population growth is to require the same degree of wastewater treatment (and hence the same effluent concentrations) although the total quantity of treated wastewater discharged to the stream may increase (Peterson, 1975). Wastewater treatment facilities in existence at the present time are designed to meet State standards while allowing growth to a projected population of 100,000 in the year 1995.

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Water quality has been measured both in the Canadian River southeast of Norman and at Lake Thunderbird for several years. The U. S. Geological Survey measured the chemical quality of the Canadian River at Noble, approximately five miles below the Norman treatment plant outfall, from October 1964 to May of 1974. The results of this long-term survey indicate that Canadian River water at this location is typically hard, high in chlorides, sulfates, total dissolved solids, and nitrogen. These chemical characteristics collectively render the water undesirable for consumption or conventional irrigation practices. Water quality data for the Canadian River at Noble is presented in Table III-3.

Water quality has also been monitored in the Little River watershed above and below Lake Thunderbird. Data has been collected regularly by the U. S. Environmental Protection Agency, the Central Oklahoma Master Conservancy District, with the assistance of the Oklahoma State Department of Health, and the City of Norman, as well as the U. S. Geological Survey. In addition, data has been collected by the University of Oklahoma in connection with classroom studies and graduate research projects.

The results of water quality sampling indicate that water in the Little River watershed above the Lake Thunderbird dam is moderately hard (above 200 mg/l as $CaCO_3$), relatively low in sulfates (5-30 mg/l), moderately low in dissolved solids (200-300 mg/l) and low in turbidity, at least from the standpoint of water supply. A compilation of recent chemical and physical water data for Lake Thunderbird is presented in Table III-4. The data was acquired for the Oklahoma State Department of

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TABLE III-3

SUMMARY OF HISTORICAL WATER QUALITY FOR

THE CANADIAN RIVER NEAR NOBLE, OKLAHOMA

PERIOD OF RECORD: October, 1959 through May, 1974

PARAMETER	MINIMUM	MEAN	MAXIMUM
Flow (cfs)	0.2	229.4	49,400.0
Dissolved Calcium (mg/l as Ca)	14.0	180.0	248.5
Dissolved Magnesium (mg/l as Mg)	7.0	62.0	340.5
Dissolved Sodium (mg/l as Na)	5.8	243.3	631.0
Dissolved Bicarbonate (mg/l as HC_3)	74.0	222.3	469.0
Hardness* (Ca, Mg - mg/l)	160.0	370.3	540.0
Dissolved Nitrate* (mg/l as N)	0.74	2.0	4.3
Dissolved Nitrate* (mg/l as NO_3)	3.3	8.9	19.0
Dissolved Nitrite* (mg/l as N)	0.00	0.05	0.37
Dissolved Sulfate (mg/l as SO_4)	2.1	134.3	570.0
Dissolved Chloride (mg/l as Cl)	7.0	112.9	880.0
Dissolved Solids (mg/l as residue on evaporation at 180°C)	7.0	330.7	2,140.0
Specific Conductance (micromhos/cm at 25°C)	187.0	560.0	3,640.0

*Determined from records only for Water Year October 1973 to September 1974, as published in USGS Water Resources Data For Oklahoma, Part 2. Water Quality Records. 1974.

Source: U.S. Geological Survey, Water Resources Division, Oklahoma City, Oklahoma. Frequency Printout for Canadian River Near Noble (Station 07229100).

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TABLE III - 4

LAKE THUNDERBIRD WATER QUALITY

State Station	Collection Date	Temp. (°C)	Total Hardness (mg/l)	Calcium Hardness (mg/l)	Alkalinity (mg/l as $CaCO_3$)	Chloride (mg/l as Cl)	BOD_5 (mg/l)	COD (mg/l)	DO (mg/l)	PH	Dissolved Solids (mg/l)	Suspended Solids (mg/l)	Volatile Suspended Solids (mg/l)	Sulfate (mg/l as SO_4)	Turbidity (Turbidity Units)	Nitrate (mg/l as N)	Organic N (mg/l as N)	Total N (mg/l as N	Total PO_4 (mg/l as P)
No. 2	04/09/74	11	192	104	182	27	2	26	12.0	8.3	288	16		27	15.0	<0.1	0.7	0.7	0.02
	05/01/74		192	127	170	37		15	12.5	8.1	283	95	1	27	5.8	0.1	1.0	1.2	0.03
	06/04/74	21	177	83	154	20		12	8.5	8.4		160	46	15		0.0			0.03
	07/17/74	30	199	87	178	26	3	22	7.5	8.5	260	4	3	29	5.0	<0.1	0.9	0.9	0.13
	08/08/74		193	84	168	29	4	24		8.3		18	16	13	11.0	0.5	1.0	1.7	0.01
	09/19/74		226	93	170	26	6	24		8.2	227	1	27		3.5	0.3	1.7	2.0	0.01
	10/24/74	18	233	113	186	45	2	28	7.5	6.9	286	13	6	20	11.0	<0.1	1.4		0.01
	12/19/74	40			168	24	2	7	13.0	8.3	224		142	13	9.9	0.5	1.2	1.7	0.03
	01/22/75				180	28	3	16		8.3	243	7	2	13		0.3			0.01
	03/05/75	5	186	112	179	26	3	15	13.0	8.3	260			11		0.3		1.1	0.01
	04/26/75		191	92	169	30	<4	16		7.9	238	16	12			0.5	0.4	0.9	0.01
	05/13/75		187	87	171	34			10.0	8.2						<0.1			0.01
	06/26/75		185	103	160	32	5	16		8.2	172	26		8		<0.1	0.7	0.7	0.01
	08/07/75		170	90	154	29	9	8		8.3	132	13	8	19		<0.1	1.3		0.04
	09/08/75		256	82	188	33	9	11		8.3	281	18	6	11	14.0	<0.1	1.4		0.09
No. 3	04/09/74	11	179	93	146	27	1	11	10.5	8.4	238	12			18.0	0.6	0.8	1.4	0.02
	05/01/74		195	122	170	27		16	9.0	8.2	257	5	2	15	4.4	0.1	1.1	1.1	0.03
	06/13/74	20	195	99	166	18		12	9.5	8.3		53	16	13		0.0			0.03
	07/24/74	27	199	106	187	26	3	33	4.5	8.1	247	7	7		8.0	<0.0	0.8	0.8	0.04
	08/08/74		185	90	177	26	4	20		7.8		7	5	11	7.0	<0.1	1.0	1.5	0.03
	09/19/74		217	102	174	11	3	24		8.2	210	21	2	13	3.0	0.6	1.7	2.3	0.01
	10/24/74	18	226	113	225	37	6	32	9.5	6.8	388	24	4	16	9.7	<0.1	1.4	1.4	0.01
	12/19/74	4			165	26	3	7	12.0	8.2	219		146	11	9.5	6.0	1.3	7.3	0.04
	01/22/74				173	26	2	19		8.3	226	7	2	8		<0.1		0.7	0.04
	03/05/74	5	184	99	177	28	2	<4	13.0	8.3	267			15		0.2		1.1	0.01
	04/16/75		193	90	189	32	<4	12		8.3	245	16	10			0.5	0.8	1.3	0.01
	05/13/75	18	187	87	170	43			9.0						8.1	<0.1			0.01
	[illegible]		[illegible]	[illegible]	162	32	6	16		8.0	186	20	4	8		<0.1	0.9	0.9	0.01
	[illegible]		[illegible]		[illegible]	25	15	28		7.7		10	1	8		<0.1	1.1		0.07
	[illegible]				[illegible]	42	13	15		8.0	293	12	8	11	17.0	0.3	1.1		0.04

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TABLE III-4 (CONTINUED)

LAKE THUNDERBIRD WATER QUALITY

State Station	Collection Date	Temp. (°C)	Total Hardness (mg/l)	Calcium Hardness (mg/l)	Alkalinity (mg/l as $CaCO_3$)	Chloride (mg/l as Cl)	BOD_5 (mg/l)	COD (mg/l)	DO (mg/l)	PH	Dissolved Solids (mg/l)	Suspended Solids (mg/l)	Volatile Suspended Solids (mg/l)	Sulfate (mg/l as SO_4)	Turbidity (Turbidity Units)	Nitrate (mg/l as N)	Organic N (mg/l as N)	Total N (mg/l as N)	Total PO_4 (mg/l as P)
No. 4	04/10/74	13	187	120	179	37	2	16	9.0	8.4	310	10		22	12.0	0.2	0.8	1.0	0.02
	05/01/74		197	122	183	35		14	9.0	8.5	275	16	2	8	5.2	<0.1	1.0	1.0	0.19
	06/04/74	20	208	99	182	22		12	9.5	8.3		32	4	11		0.0			0.11
	07/17/74	30	176	78	176	28	2	29	7.5	8.4	363	5	1	102	4.0	<0.0	0.9	0.9	0.01
	08/08/74		188	95	170	29	4	24		8.2		8	6	23	6.0	0.2	1.1	1.6	<0.01
	09/19/74		221	102	189	26	2	24		8.3	246	2	11	11	2.7	<0.1	1.2	1.2	<0.01
	10/29/74	18	237	101	168	39	6	32	9.0	8.0	252	21	2	16	9.8	0.3	1.4	1.7	0.03
	12/19/74	40			168	26	2	18	12.0	8.3	234		136	17	6.5	2.3	1.2	3.5	0.04
	01/22/75				173	26	2	16		8.2	230	7	2	11		0.2		1.0	0.02
	02/27/75	5	205	103	179	28	3	15	10.0	8.3	263			11		0.2	0.9	1.1	<0.01
	04/10/75		199	90	189	34	4	24		8.3	268	9	7			0.5	0.6	1.1	<0.01
	05/13/75	18	197	93	170	37			12.0	8.3									
	06/26/75		181	97	164	32	6	20		8.1	187	6		11		<0.1	1.1	1.1	<0.01
	08/07/75		174	86	152	27	<5	8		8.4		11	4	11		<0.1	1.4		0.05
	09/17/75		209	101	179	31	10	11		8.0	259	7	2	5	9.4	0.2	1.3		0.03
No. 5	04/17/74	13	214	107	182	35	1	11	7.5	8.5	305	12		29	6.0	<0.1	0.9	0.9	0.01
	07/17/74	29	182	92	176	26	2	33	7.5	8.4	239	4		15	16.0	<0.1	0.9	0.9	0.02
	10/24/74	18	254	89	166	43	4	28	6.5	8.0	260	25	2	18	15.0	0.3	1.6	0.9	0.03
	01/22/75				171	28	2	4		8.3	227	6	2	8		<0.1			0.02
	04/10/75		197	94	180	36	<4	12		8.4		10	8			0.9	0.4	1.3	<0.01
	06/26/75		183	99	162	30	5	24		8.3	178	8		11		<0.1	0.8	0.8	<0.01
	09/18/75		225	95	181	33	13	15		7.6	264	13	5	5	8.4	<0.1	1.7	1.7	0.05
No. 6	04/17/74	13	219	112	196	32	8	17	9.0	8.5	348	27		50	25.0	<0.1	0.9	0.9	0.02
	05/01/74		208	148	192	37		17	10.5	8.3	299	25	4	15	35.0	0.2	1.0	1.2	0.09
	06/04/74	22	211	114	170	22		16	9.0	7.5		38	18	19		0.0			0.05
	07/17/74	31	185	78	178	26	3	26	7.5	8.5	252	10	4	23	8.0	<0.0	1.0	1.0	0.10
	08/08/74		185	84	164	29	6	27		8.4		6	5	42	30.0	<0.1	1.3	1.7	0.01
	09/19/74		189	98	180	26	2	24		8.3	243	1	21	15	8.0	<0.1	1.4	1.4	<0.01
	12/19/74	40			173	26	3	32	13.0	8.2	249		139	24	5.5	1.4	1.3	2.7	0.05
	01/22/75				193	32	2	27		8.3	259	10	2	11		<0.1			0.02
	02/27/75	5	200	95	195	32	2	15	13.0	8.1	297			17		<0.1		1.0	0.01

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TABLE III-4 (CONTINUED)

LAKE THUNDERBIRD WATER QUALITY

State Station	Collection Date	Temp. (°C)	Total Hardness (mg/l)	Calcium Hardness (mg/l)	Alkalinity (mg/l as $CaCO_3$)	Chloride (mg/l as Cl)	BOD_5 (mg/l)	COD (mg/l)	DO (mg/l)	PH	Dissolved Solids (mg/l)	Suspended Solids (mg/l)	Volatile Suspended Solids (mg/l)	Sulfate (mg/l as SO_4)	Turbidity (Turbidity Units)	Nitrate (mg/l as N)	Organic N (mg/l as N)	Total (mg/l as N)	Total PO_4 (mg/l as P)
No. 6 Cont.	04/10/75		230	112	213	47	<4	16		8.5	309	20	17			0.2	0.5	0.7	0.04
	05/13/75	18	210	95	181	45			9.0	8.1						<0.1			
	06/26/75		196	103	175	35	7	20		8.2	232	13		15		0.2	0.9	1.1	0.02
	08/07/75		183	89	159	31	7	16		8.4	175	11	1	13		<0.1	1.4		0.01
	09/18/75		217	111	179	42	15	26		8.2	283	17	8	8	14.0	0.1	1.8		0.04
No. 7	10/24/74	18	407	176	393	37	10	32	6.5	7.9	497	25	4	32	15.0	0.1	1.8	1.8	0.04
	01/22/75				427	26	2	12	6.5	8.2	496	11	3	19		0.2		0.9	0.01
	04/10/75	12	226	129	200	36	<4	16	12.7	8.3	272	21	17			0.2	0.8	1.0	0.07
	06/26/75		196	103	173	37	5	20		8.3	181	57		8		0.3	0.8	1.2	0.02
	09/18/75		217	89	177	35	14	19	6.5	8.2	264	17	2	5	21.0	0.2	1.8	2.0	0.04
No. 8	04/17/74	13	246	117	174	27	3	17	9.0	8.4	292	32		35	26.0	0.2	0.8	1.0	0.02
	07/17/74	28	199	109	182	28	2	22	9.3	7.9	253	6	5	19	15.0	0.2	0.9	1.1	0.05
	10/24/74	18	240	115	184	35	4	32	9.5	7.5	262	25	8	16	13.0	0.3	1.5	1.8	0.05
	01/22/75				171	28	2	23	8.3		227	35	7	8		0.3		1.1	0.08
	04/10/75	12	212	99	184	36	4	44	12.0	8.1	665	155	130			0.7	1.0	1.7	0.01
	06/26/75		194	108	169	32	3	16		8.1	176	54		15		0.3	0.8	1.2	0.08
	09/18/75		225	105	193	31	13	19		8.0	283	54	8	11	12.0	0.5	1.4	1.9	0.04
No. Samples		35	67	67	78	78	66	74	43	76	63	66	57	64	42	67	66	58	76
Minimum		4	170	78	146	78	1	4	4.5	6.8	132	1	1	5	2.7	<0.1	.4	.7	<0.01
Mean		19	206	102	182	20	5	19	9.6	8.2	267	22	19	17	11.6	0.2	1.1	1.4	0.03
Maximum		40	407	176	427	47	15	44	13.0	8.5	665	160	146	102	35.0	2.3	1.8	7.3	0.19

Source: [illegible] Conservancy District. Norman. 1975

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Health by the Central Oklahoma Master Conservancy District, in performance of its water supply monitoring programs. A 16 month period from April of 1974 to September of 1975 is represented. Sampling was conducted at the seven surface water stations indicated in Figure III-9.

An important topic which has recently generated considerable study and discussion is that of eutrophication in Lake Thunderbird. Eutrophication is a process of enrichment of a lake with nutrients. The increase of nutrients leads to an increase in aquatic plant production. Over time, this process results in the change from a lake to a bog or marsh. The process of eutrophication is one which occurs naturally over a long perod of time. The time element may be shortened, however, by the effects of man's activities on the water body.

A useful indication of the level of enrichment in a lake is the concentration of major plant nutrients. Phosphorus and nitrogen are widely considered as the most important nutrients required for plant growth. Sawyer (1952) suggested that as much as 0.01 mg/l of inorganic phosphorus can be present in a lake without danger of troublesome algal blooms occurring. Other studies have indicated that inorganic nitrogen and phosphorus levels above 0.3 and 0.01-0.015 mg/l, respectively, at the beginning of the growing season may result in algal blooms (Ingram, 1960 and Lackey, 1961). Although many other substances are required to sustain algal growth, phosphorus and nitrogen are considered the two nutrients that most often govern the extent of algal production.

Present levels of phosphorus and nitrogen in Lake Thunderbird have been relatively constant. The nitrate concentrations shown in

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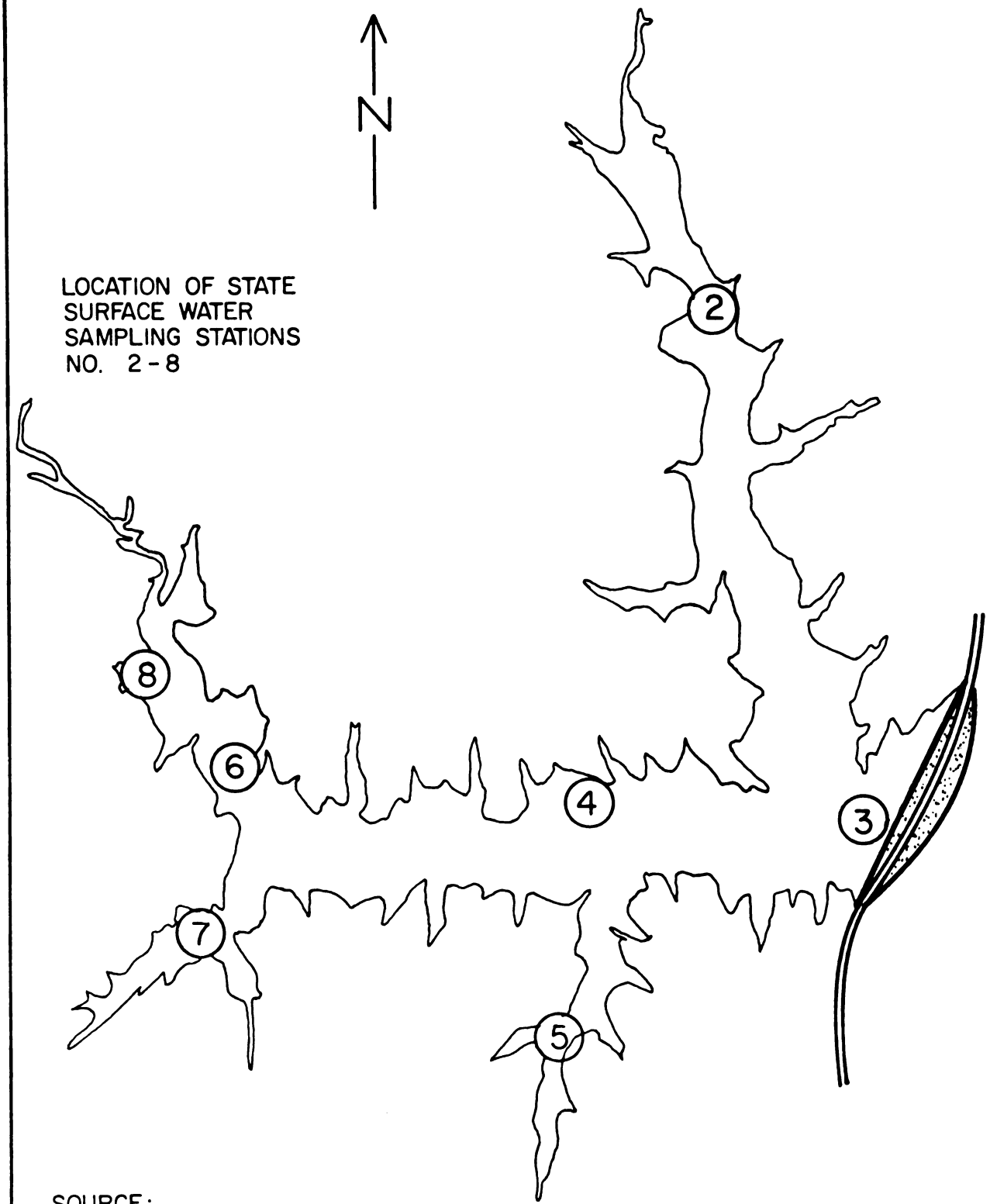

SOURCE:
OKLAHOMA DEPARTMENT
OF HEALTH

LAKE THUNDERBIRD
WATER QUALITY STATIONS

FIGURE III-9

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Table III-4 average between 0.2 and 0.3 mg-N/l and total phosphate concentrations average slightly above 0.03 mg-P/l. When compared to the generalized "threshold" levels cited above, it can be seen that the Lake Thunderbird waters equal the threshold in terms of nitrogen and are apparently above threshold in terms of phosphorus. The phosphorus concentrations cited are total phosphorus, which was analyzed more regularly than inorganic phosphorus. The ortho-phosphate measurements which were taken indicate a 3:1 ratio of total phosphorus to dissolved ortho-phosphate. Applying this ratio to the average 0.03 mg-P/l concentration of total phosphorus yields an average concentration of 0.01 mg-P/l dissolved ortho-phosphate in the lake. This indicates that the waters of Lake Thunderbird are at the threshold which marks the potential for troublesome algal blooms.

The nutrient situation described above is indeed borne out by the occurrences of blooms of the blue-green algae Anabaena during the latter part of the past several summers. These blooms have resulted in noticeable odor problems in raw water taken from the lake. According to the Central Oklahoma Master Conservancy District, the odor coincided with the presence of high Anabaena concentrations (Tucker, 1975). The odor perceived by water users was a musty odor which Palmer (1962) and others have reported to occur when moderate to abundant quantities of Anabaena are present.

Appreciable amounts of the mold-like bacteria referred to as Actinomycetes have also been reported to occur in Lake Thunderbird (Brown, 1975). Actinomycetes proliferate in waters where high concentrations of plankton or organic matter rich in nitrogen are present.

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The musty odor of freshly turned earth is attributed to the presence of Actinomycetes, and high concentrations can contribute to the similar odor created by the Anabaena.

Milfoil, a rooted aquatic weed, has proliferated in the shallow areas of the Lake Thunderbird shoreline. Water milfoil extracts nutrients from the bottom sediments in order to satisfy its nutrient requirements (De Marte, 1974). However, the widespread occurrence of water milfoil in Oklahoma and throughout the southwest suggests that the occurrence of milfoil is not necessarily an indicator of eutrophication, but rather a rapidly growing nuisance organism particularly suited to the area.

Bacteriological samples have been collected from Lake Thunderbird by several investigators. Unfortunately, a regular sampling program has not yet been established. Studies by Dr. L. W. Cantor (1973) and R. J. Wagenet (1972) have indicated that bacteriological levels in the main body of the lake, in the area of the influent arms, and in the area of the water supply intake were low and within the limits established for raw water used for drinking water supplies (U. S. Public Health Service, 1962). Other areas of the lake which receive high recreational use, however, were shown to exhibit higher bacterial levels during the summer (maximum-use) months. These higher counts sometimes exceeded the maximum allowable level of 400 fecal coliforms/100ml established by the State of Oklahoma. These levels were generally recorded on Sundays in the bathing and marine areas. Rapid die-off of the bacteria was observed and the elevated concentration did not affect the main body of the lake

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or the water supply intake. Researchers appear to agree that present and anticipated future recreational activities on the lake will not jeopardize its role as a water supply.

In summary, the waters of Lake Thunderbird can be described as good in quality and suitable for public drinking water supply with the present form of treatment. Nutrient levels are variable but, especially in the case of phosphate, are at a threshold for occurrence of troublesome algal blooms as evidenced by bloom events during the past several summers. No health problem is associated with these blooms, although a slight musty odor in the water supply has been associated with high *Anabaena* concentrations. The aquatic weed milfoil has proliferated along much of the lake shoreline, but represents a nuisance rather than a serious water quality problem.

H. PRESENT WATER QUANTITY AND QUALITY MANAGEMENT

1. Lake Thunderbird

The major portion of responsibility for the management of water quality/quantity in Lake Thunderbird resides with the Central Oklahoma Master Conservancy District. The District was formed in 1954 in an effort to promote the construction of the reservoir. The District now exists under a State statute and is governed by a seven-man Board of Directors which meets monthly. This Board oversees the operation of the project, maintains the lake level, maintains the dam and its facilities, oversees the State Parks and Wildlife lands, and monitors water quality through the implementation of a set of rules and regulations.

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Other individuals or agencies with jurisdiction over Lake Thunderbird include the Department of Public Health and Welfare, the Lake Thunderbird Sanitarian, the U. S. Corps of Engineers, the Bureau of Reclamation, the U. S. Environmental Protection Agency, and those municipalities whose boundaries fall within the watershed.

2. Little River and South Canadian River

At the State level, several agencies have a common and direct jurisdiction in the Little River watershed (below the dam) and the South Canadian River watershed (below Norman). These agencies are the Oklahoma Water Resources Board, the Health Department, as mentioned in the preceeding section, and the Oklahoma Department of Pollution Control. The Water Resources Board has permit authority over both industrial discharges and water users in Oklahoma, including allocation of surface and groundwater supply. Oil and gas industries are excepted, and are regulated instead by the Oklahoma Corporation Commission. The Health Department has the responsibility for safety of water supplies and also regulates municipal discharges in the State. The Department of Pollution Control is a water resource and water quality planning agency with authority to assign waste-load allocations.

In addition to these State agencies exerting direct water regulatory authority in the two watersheds, others have jurisdiction in which consideration of water quality is intrinsic. These include the Oklahoma Department of Wildlife Conservation, whose interest pertains to fish and wildlife resources, and the Oklahoma Conservation Commission,

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which has a concern for water quality in relation to its land use implications.

As in the case of Lake Thunderbird, ACOG jurisdiction encompasses much of the Little River watershed below the dam as well as all of the South Canadian River watershed within Cleveland County (Figure II-1). ACOG is basically an areawide planning and review agency for Federal and State funding. There are no major domestic water users below Norman on either watercourse.

Federal water quantity and quality jurisdictions over the Little River and South Canadian River are identical to those applicable to Lake Thunderbird, excluding the Bureau of Reclamation.

I. BIOLOGY

1. Terrestrial Flora

According to Shelford (1963), vegetation of the eastern portion of the state is generally characteristic of the temperate deciduous forest biome; temperate grasslands dominate in the west. Consequently, Central Oklahoma has been characterized as an ecotone or edge between the forest and the prairie (Webb, 1950).

Specifically, Weaver and Clements (1938), concluded that the upland forests of Oklahoma constitute the western extension of the oak-hickory vegetation association common in the eastern portion of North America. Post oak, blackjack oak, black oak, and black hickory are common overstory trees. Rice and Penfound (1959) studied these forests in detail. They found that well developed oak-hickory forests occur

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commonly in the eastern portion of the state but become progressively more open to the west. From east to west, the oak-hickory forest community, oak-hickory savannah, oak savannah, and prairie are common upland cover types in the Little River watershed (Johnson, 1970; Kennedy, 1973).

Lowlands forests are found along stream banks and flood plains. These riparian associations were studied by Rice (1965) who found that elm, pecan, green ash, blackberry, and black walnut were among the dominant overstory species.

Forested lands were common in early Oklahoma. However, following the opening of the state to settlement, these extensive acreages of forestland were reduced by lumbering and by clearing for cultivation. Bruner (1931) reports, for example, that "all the best and most accessible timber" in the state had been cut by the early 1930's. Large acreages of cut-over land were planted in such crops as small grains, sorghum, peanuts, and cotton. However, these lands were often marginally poductive under cultivation and/or become badly eroded due to poor farming practices. They were subsequently abandoned or utilized for grazing, now a common land use in the Little River watershed.

Booth (1941) studied the succession of these old fields in Kansas and Oklahoma. He concluded that four stages could be recognized. A weed stage lasting for two to three years is followed by an annual grass stage persisting for nine to 13 years. Perennial bunch grasses then dominate for in excess of 30 years. Succession culminates in

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return to a tall grass prairie climax community which is self-perpetuating. These findings have been confirmed by Perino (1971). Vegetation common to these prairies in the Little River watershed are big and little bluestem, switchgrass, and Indian grass. Scientific names of all of the above mentioned species, photographs of representative stands, and additional descriptive information of these vegetation types are presented by Kuckler (1974).

2. Terrestrial Fauna

The birds of Oklahoma have been studied by Nice (1931) and Sutton (1967). Johnson (1957) and Taft (1950) studied the habitat preferences of birds in shelterbelts and the prairie-forest ecotone of central Oklahoma. These workers have concluded that the avifauna of Oklahoma is diverse. Species common to eastern, western, and mid-western North America are found here commonly.

Of particular importance are those species that are hunted for recreational pleasure and/or are endangered due to over exploitation, habitat alteration, illegal killing or other causes. The Oklahoma Department of Wildlife Conservation reports that seven of the eleven endangered wildlife species known or thought to exist within the state are birds (ODWC, n.d.(a)). Included are the southern bald eagle, whooping crane, ivory-billed woodpecker, red-cockaded woodpecker, Bachman's warbler, peregrine falcon, and eskimo curlew. None are likely to be residents of the Little River watershed or to occur within the watershed in significant numbers during any season of the year. However, the bald eagle and peregrine falcon may be occasionally sighted

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near Lake Thunderbird because both are attracted to large water bodies where they commonly over-winter.

Both migratory and resident bird species may be hunted within the Little River watershed. Public hunting lands, however, are limited to the Thunderbird Public Hunting Area. This area consists of two tracts totalling about 2,400 acres located adjacent to the Little River Arm and the Hog Creek Arm of Lake Thunderbird (ODWC, 1973). Quail, waterfowl, and wild turkey are hunted there. Other Oklahoma game birds that are likely to occur within the watershed include the woodcock and mourning dove (ODWC, n.d.(b); ODWC, n.d.(c)). In addition to being available on the Thunderbird Public Hunting Area, these and other species such as geese are likely hunted on private lands and larger stock ponds in the watershed.

Mammals likely to occur within the Little River watershed are discussed in detail by Hayes (1954). Although recreationally important mammals occur within the watershed, the three endangered mammals thought to occur within the state (red wolf, black-footed ferret, Indiana bat) are likely not found there due to the absence of suitable habitat.

Squirrel, rabbit, and whitetail deer are common game animals within the watershed. Mink and other furbearers are also likely to be found, particularly in bottomlands (ODWC, n.d.(d)). However, hunters rather than trappers are most common within the watershed. For example, in 1973-74 almost 115,000 hunting licenses were sold throughout the state in comparison to less than 1100 amateur and commercial trapping licenses (ODWC, 1975). Therefore, commercial or recreational harvesting

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of furbearers is probably an insignificant use of the wildlife resource within the watershed.

3. Aquatic Communities

The Little River watershed is tributary to the Arkansas River. Prior to the construction of several large impoundments such as Lake Thunderbird in the last several decades, the basin had no significant lakes. Thus, native fishes are mainly fluviatile (Cross, 1967) and probably consist primarily of forage species and minnows (cyprinids). In addition, many small streams within the basin diminish in quality progressing downstream from their headwaters. Lack of gradient, temperature increases, siltation, dewatering, and sewage and agricultural runoff probably all contribute to this process.

Stream fisheries may be classified as either trout or warm-water habitats. According to the ODWC (n.d.(e)), trout are found only in the Lower Illinois River in east central Oklahoma and the Blue River in southeastern Oklahoma. Both areas exist primarily as "put-and-take" fisheries whereby trout are periodically replenished by stocking. Trout do not occur in the Little River. Hence, this river as well as others in the Arkansas basin naturally possess poor commercial and/or recreational fishing opportunities.

The fishery within the Little River watershed has been enhanced by constructing stock ponds and Lake Thunderbird. Ponds in the area are located exclusively on private lands. Hence, opportunities for public fishing are afforded to area residents only by Lake Thunderbird.

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Although 175 species of fish are known to occur in Oklahoma, only 16 of these are considered to be popular game species (Bennett, et al., n.d.) and none are endangered (ODWC, n.d.(a)). These game species include largemouth bass, smallmouth bass, spotted bass, striped bass, white bass, channel catfish, blue catfish, flathead catfish, rainbow trout, walleye, northern pike, black crappie, white crappie, bluegill, green sunfish, and redear sunfish. According to Summers (1975), five of these popular species have been stocked in Norman Reservoir beginning in 1965. Stocked species include largemouth bass, channel catfish, flathead catfish, blue catfish, and walleye. A tagging survey conducted during 1970 and 1971 demonstrated that largemouth bass, white crappie, sunfish, channel catfish, white bass, and walleye were commonly harvested by anglers in the lake.

Wagenet (1972) reported that over 2.3 million persons visited Lake Thunderbird during 1971. Many of these visitors were probably fishermen. Unfortunately, accurate information concerning fishing pressure and harvest rates from the lake are not currently available. According to Summers (1975), an intensive creek census to determine harvest rates for fish species was conducted from June 1, 1974 to July 1, 1975. During the period from October, 1974 to October, 1975, fishing pressure was surveyed by conducting aerial overflights. It is anticipated that the results of both of the above studies, when available, will allow more definitive conclusions to be reached concerning the productivity and importance of the Lake Thunderbird fishery. However, even the paucity of currently available information suggests that Lake Thunderbird currently contains a productive fishery and is the only

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public recreational fishery of significance within the watershed. Commercial fishing does not occur.

J. EXISTING AIR QUALITY

Cleveland County is located in the Central Oklahoma Air Quality Control Region (AQCR #184). This region has been classified as Priority III for sulfur dioxide, nitrogen dioxide, and carbon monoxide, and Priority I for particulates and photochemical oxidants. The applicable ambient air quality standards are presented in Table III-5. It should be noted that the Oklahoma primary and secondary standards are the same as the Federal primary and secondary standards.

Only limited ambient air quality data are available for the Norman area. However, some EPA data for 1975 are available for Oklahoma City, located about 20 miles north of Norman within the same AQCR. Data for ozone indicate a second high maximum value of .107 ppm, and data for carbon monoxide show no violation of the standard (10 $\mu g/m^3$ maximum 8-hour concentration).

The only available ambient air quality data for Norman are from a single particulates monitor located at the Cleveland County Health Department, 641 East Robinson, at the northern edge of urbanized Norman. Air quality trends for Norman from 1970 to 1974 as measured by the annual geometric mean of particulates are shown in Figure III-10 (EPA, 1973, 1974; Oklahoma State Department of Health, 1975). The State of Oklahoma implementation plan indicates that the background particulates concentration is estimated to be 30 micrograms per cubic meter ($\mu g/m^3$) annual geometric mean.

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TABLE III- 5

OKLAHOMA AMBIENT AIR QUALITY STANDARDS

POLLUTANT	PRIMARY	SECONDARY
SULFUR OXIDES (SULFUR DIOXIDE)	80 mg/m^3 (0.03 ppm) Annual Arithmetic Mean	1300 mg/m^3 (0.5 ppm) Maximum 3-Hour Average*
	365 mg/m^3 (0.14 ppm) Maximum 24-Hour Average*	
PARTICULATE MATTER	75 mg/m^3 Annual Geometric Mean	60 mg/m^3 Annual Geometric Mean
	260 mg/m^3 Maximum 24-Hour Average*	150 mg/m^3 Maximum 24-Hour Average*
CARBON MONOXIDE	10,000 mg/m^3 (9 ppm) Maximum 8-Hour Average*	Same as Primary
	40,000 mg/m^3 (35 ppm) Maximum 1-Hour Average*	Same as Primary
PHOTOCHEMICAL OXIDANTS	160 mg/m^3 (0.08 ppm) Maximum 1-Hour Average*	Same as Primary
NON-METHANE HYDROCARBONS	160 mg/m^3 (0.24 ppm) Maximum 3-Hour Average (6 - 9 am)*	Same as Primary
NITROGEN OXIDES	100 mg/m^3 (0.05 ppm) Annual Arithmetic Mean	Same as Primary

* Not to be exceeded more than once per year

Source: Oklahoma Department of Health and Welfare. Air Quality Control Implementation Plan. 1972.

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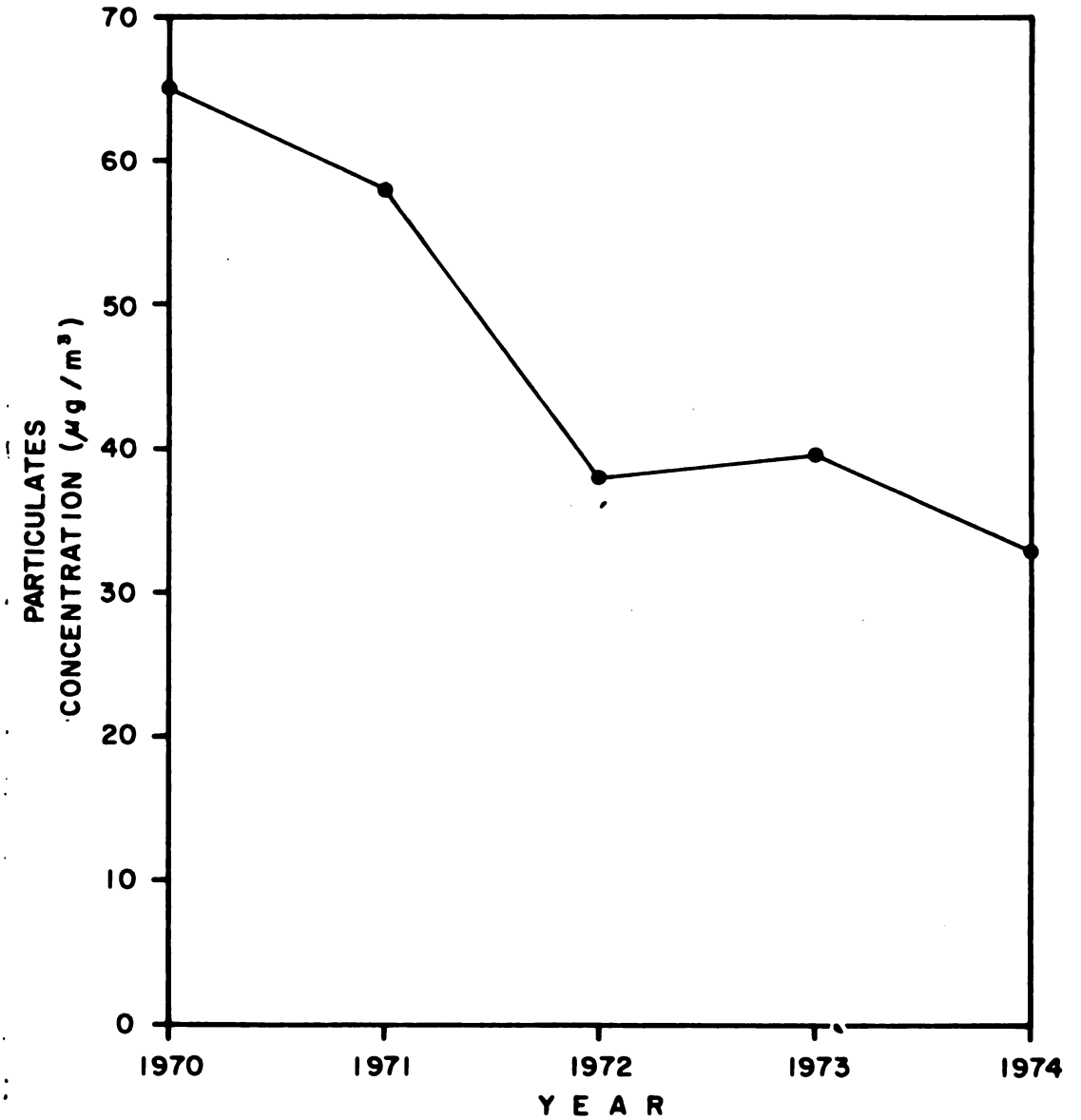

PARTICULATES CONCENTRATION
AT NORMAN:
TRENDS IN ANNUAL GEOMETRIC MEAN

FIGURE III-10

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Norman lies within the boundaries of the Central Oklahoma Air Quality Maintenance Area (AQMA) for particulates and photochemical oxidants (EPA, 1974a). Accordingly, Norman will be subject to the forthcoming Air Quality Maintenance Plan which will contain measures to maintain the air pollution levels below the national ambient air quality standards.

Emission rate and emission density data from combined point and area sources for Cleveland County are indicated in Table III-6. The contributions from point sources are based on 1974 data while the area source contributions are based on 1972 data.

K. EXISTING NOISE QUALITY

Ambient noise field data for the proposed service area are limited. A noise study was conducted for the Norman airport (Westheimer Field) expansion, but no ambient monitoring data were collected. The School of Civil Engineering and Environmental Sciences of the University of Oklahoma conducted a brief monitoring survey in Little River State Park (Canter, 1973) which provides the only field data considered representative of the majority of the service area.

The Little River State Park survey consisted of daytime spot checks at 15 locations near the shores of Lake Thunderbird, five miles east of the service area, in September of 1973. Background levels ranged from a low of 38 dBA to a high of 58 dBA, and averaged a little less than 44 dBA. Peak levels ranged up to 85 dBA near an air-powered boat. A listing of typical A-weighted noise source levels and human response criteria is presented in Table III-7.

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TABLE III-6

AIR POLLUTANT EMISSIONS IN CLEVELAND COUNTY

POLLUTANT	EMISSION RATE (TONS/YEAR)	EMISSION DENSITY ($TONS/mi^2$ Year)
Sulfur Oxides (Sulfur Dioxide)	303	0.57
Particulate Matter	434	0.82
Carbon Monoxide	39,651	75.2
Total Hydrocarbons	8569	16.3
Nitrogen Oxides (Nitrogen Dioxide)	4638	8.8

Source: Oklahoma State Department of Health, Personal Communication with L. McDougal. 1975.

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TABLE III-7

WEIGHTED SOUND LEVELS AND HUMAN RESPONSE

Sound Source	dB (A)*	Response Criteria
	150	
Carrier Deck Jet Operation	140	
		Painfully Loud
	130	Limit Amplified Speech
Jet Takeoff (200 feet)	120	
Discotheque		
Auto Horn (3 feet)		Maximum Vocal Effort
Riveting Machine	110	
Jet Takeoff (2000 feet)		
Shout (0.5 feet)	100	
N. Y. Subway Station		Very Annoying
Heavy Truck (50 feet)	90	Hearing Damage (8 hours)
Pneumatic Drill (50 feet)		
	80	Annoying
Freight Train (50 feet)		
Freeway Traffic (50 feet)	70	Telephone Use Difficult
		Intrusive
Air Conditioning Unit (20 feet)	60	
Light Auto Traffic (50 feet)		
	50	Quiet
Living room		
Bedroom	40	
Library		
Soft Whisper (15 feet)	30	Very Quiet
Broadcasting Studio	20	
	10	Just Audible
	0	Threshold of Hearing

* Typical A - Weighted sound levels taken with a sound-level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear.

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The EPA now recommends the long-term equivalent A-weighted sound level (L_{eq}) and a variation with a nighttime weighting, the day-night sound level (L_{dn}), for use in characterizing ambient noise levels (EPA, 1973a). Both measures are expressed in decibels (dB). The equivalent sound level is simply the equivalent steady noise level which, in a stated period of time, would contain the same noise energy as the time-varying noise during the same time period. The day-night sound level is the equivalent A-weighted sound level during a 24-hour time period with a 10 decibel weighting applied to the equivalent sound level during the nighttime hours of 10:00 p.m. to 7:00 a.m. Although no L_{dn} monitoring has been conducted in the service area, estimates made for other rural and residential areas (EPA, 1974c), and the daytime measurements made at Little River State Park indicate that existing day-night sound levels are probably in the range of 45-50 dB. Existing day-night sound levels in the vicinity of the airport and Highway 77 at the west edge of the service area are probably 10-15 dB higher.

L. LAND USE

1. Present Land Use

In 1961 the City of Norman was expanded in size from about 10 square miles to approximately 186 square miles. This instant growth was the result of annexation of land surrounding Lake Thunderbird. Of the newly sized city, about 40 square miles are in the watershed of the South Canadian River, and about 146 square miles are in the Little River watershed (Black and Veatch, 1971).

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Land uses within Norman range from the highly urbanized city center in the western section of the corporate boundaries to agricultural and recreational areas toward the east. Agricultural uses are generally in cattle feed production, grazing, and small farms (Strozier, 1975). Most of the existing urban development in Norman is within the South Canadian River watershed and is residential in nature. Increased development activity, however, has begun to expand from the urbanized area across the drainage divide to the north and east into the Little River watershed. To date, urbanization taking place in this area has been mainly limited to residential development. The incorporated community of Hall Park, composed of about 1.1 square miles, is located in this area. The general extent of urbanization, the location of Hall Park, and the depiction of the major drainage divide between the South Canadian and Little River watersheds appear in Figure II-2.

Land use in the 8.3 square mile area that would be served by the city's proposal (Contract No. 4) is predominately rural in nature. However, several new residential subdivisions are also present, along with mobile home parks and multi-family dwelling complexes. The trend to development is indicated by new single family home construction now occurring in several locations within the area. To determine the extent of this trend, an informal survey of area development was conducted in October, 1975. The survey consisted of an analysis of the most current USGS quadrangle sheets and a windshield housing count. Comparison of survey results with the number of dwellings on the USGS sheets showed that an increase in housing units of more than threefold had occurred since 1969, from 330 to more than 1,200.

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2. Planned Land Use

In February 1963, the City of Norman adopted the Norman Urban Area 1985 General Plan. In October 1964 the Norman Area Plan was adopted. Unlike the Urban Area Plan, which designated the time frame 1963 to 1985 for achievement of its particular goals, the Area Plan was a plan for "ultimate" development. The Urban Area Plan has been amended several times and a revision is contemplated (City of Norman Urban Esthetics Committee, 1974). The most current (April 1975) map of the Urban Area Plan indicating the physical expression of 1985 developmental goals is shown in Figure III-11. Urban Area 1985 General Plan Policies adopted in July 1966 provide a series of amended goals and principles by which development throughout the city could be guided (City of Norman Planning Commission, 1966).

In these Urban Area Plan Policies, a goal for the development of residential areas states that the Urban Area Plan should:

> "guide residential development so as to fully utilize the potential of the existing water and sewage systems and to avoid, if possible, overburdening the designed capacity of such systems before their entire service areas have been developed."

This concept was one of several policies developed for controlling the sequence in which land develops so that unnecessary or premature fiscal burdens are not placed on community citizens as the result of scattered or leap-frog development.

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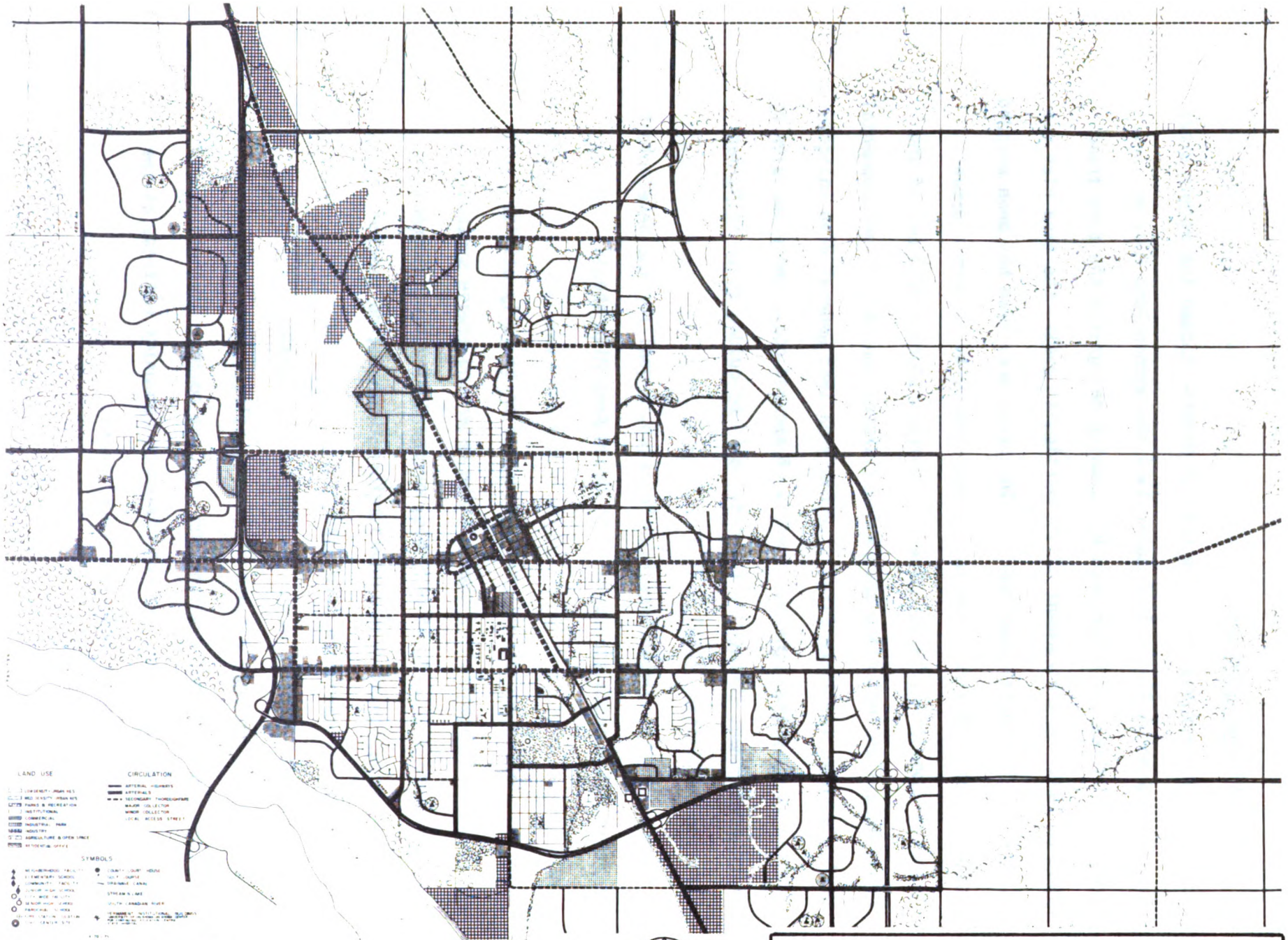

NORMAN URBAN AREA
1985

SOURCE City of Norman Planning Department

SCALE 1 IN. = 6600 FT

NORMAN LAND USE PLAN

FIGURE III - 11

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Another key element of the Urban Area Plan is that a neighborhood-community structure is to be used for planning residential areas. This primarily would provide for varied residential and commercial uses in cohesive units planned to contain from 5,000 to 10,000 people for each square mile. In the 1975 Residential Intensity Study prepared by the Norman Planning Department, an average population of 7,500 persons per square mile is recommended. This thesis is advanced on the assumption that community desires have been reflected in past development practices. Generalized models of residential land use development (hence population) for a square mile of land have been recommended by the Norman Planning Department and by the Association of Central Oklahoma Governments (Table III-8).

In general, basic community planning goals and policies guiding growth are also reflected in the General Plan policies for the Norman Urban Area 1985 Plan. In this document, policies have been clearly stated to encourage growth and rates of development where adequate facilities and services can be met by Norman's fiscal resources. The underlying principle is that controlled growth can be managed more efficiently in the community's effort to achieve coordinated arrangements of land use and minimum environmental impacts. In addition to the expressed desire for controlling haphazard development in Norman, particular concern is the protection of the Lake Thunderbird drainage basin from further degradation (City of Norman Urban Esthetics Committee, 1974).

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TABLE III-8

DIVISION OF A TYPICAL
PLANNED RESIDENTIAL SECTION
(One Square Mile) BY MAJOR USE GROUPS

	NORMAN	ACOG
	Percent	Percent
Commercial	3.1	4.0
Multi-Family	30.0	60.0
Single Family	30.0	
Streets	20.0	17.0
Quasi-Public	3.1	19.0
Parks, Open Space, and Schools	13.8	
	100.0	100.0

NOTE: Based on the Neighborhood Unit Concept as indicated on the Norman Urban Area 1985 General Plan.

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3. Land Use Regulatory Framework

In 1954 the City of Norman adopted a zoning ordinance which has been amended several times. The zoning ordinance provides for 19 classes of land use. Included among these are: Agricultural (2 classes); Residential (9 classes); Commercial (5 classes); Industrial (3 classes); and a flood district zone (Price, 1975). A map of general zoning outside of Norman's urban center is shown in Figure III-12.

Zoned residential lot sizes range from R-1-10, with a 6,000 square foot minimum to R-E, Residential Estates Dwelling District. This latter zoning type provides for large lot (2 acres) usage and allows private sewage disposal systems. Other low density zoning regulations are embodied in A-1, General Agriculture, areas which specify a 2-acre minimum size, and A-2, Rural Agriculture, areas which require a 5-acre minimum.

The design of the R-E zoning classification reflects community policy toward development of the Little River drainage basin and other rural portions of the city. When promulgated, this low density development regulation was supported by the Oklahoma Department of Health as a desirable deterrent to water contamination in this sensitive watershed. Several R-E zoned areas are located within the proposed service area.

4. Vacant Land

Studies were undertaken by the Norman Planning Department in 1968 and 1971 to determine the amount of available, unurbanized land within the South Canadian River watershed served by existing sanitary sewers. Other objectives of these studies were to provide an inventory

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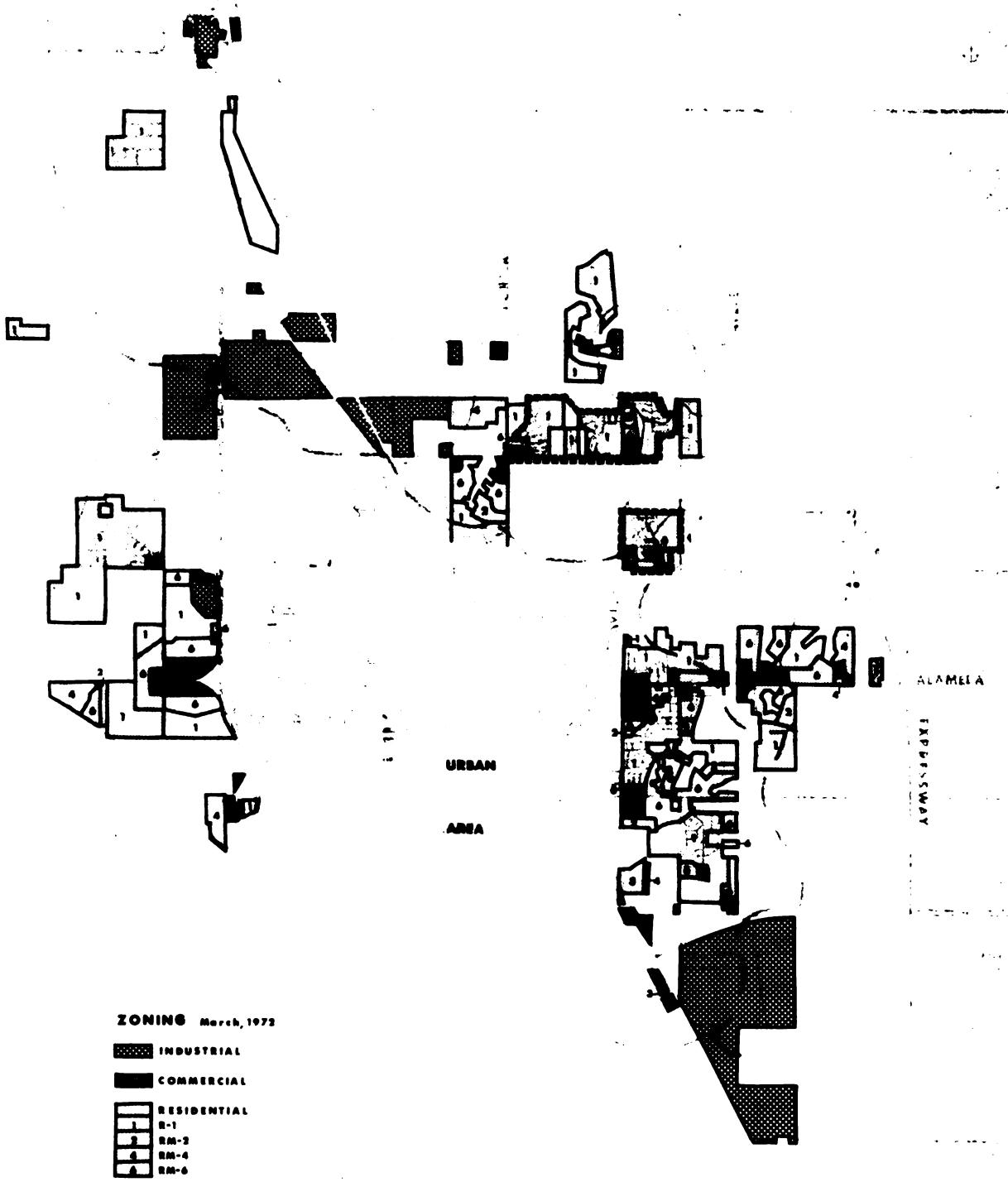

SOURCE: City of Norman Public Works Master Plan

N

SCALE: 1 IN. = 7540 FT

NORMAN GENERALIZED ZONING

FIGURE III-12

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of the general zoning classification of developable lands adjacent to the city's present urban area and an estimate of the projected population holding capacities for various planning areas.

Areas I and II include lands west of Interstate 35 and the present urbanized section of Norman. The studies indicate that these lands have not yet reached full development. Of approximately 22 square miles within Areas I and II, 9.5 square miles are vacant and potentially developable lands now served by sewer outfall lines (Table III-9).

Area III, including the proposed lift station service area, was inventoried in the Public Works Master Plan prepared by the City Engineering Department (City of Norman Department of Public Works, 1972). That study found that approximately 6.5 square miles of 7.1 square miles within Area III were vacant, but did not take into account the westernmost portion of the area already zoned for industrial and commercial use. Hence, for purposes of estimating population holding capacity, the 8.3 square mile lift station service area is treated as 7.1 square miles.

By applying expected densities and non-urbanization factors used by the Norman Planning Department, it is estimated that Areas I, II and III can together accommodate an additional 91,425 persons beyond the current Norman population (Table III-9). If only developable land in agriculture, single-family, and multiple-family zoning classifications is considered, approximately 7.47 square miles in Areas I (6.42 square miles) and II (1.05 square miles) are potentially available for residential use. Dividing the Planning Department estimate of population

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TABLE III-9

SUMMARY OF ZONING OF VACANT LANDS, NORMAN-1971, 1972
(in square miles)

	Study Area	Total Vacant Land	Generalized Zoning Classification of Vacant Land: Agriculture and Single Family	Multiple Family	Commercial	Industrial	Population Holding Capacity Available: Planning	Public Works
Area I	16.93	4.97	3.03	.56	.32	1.05	30,700 - 42,400	49,700
Area II	4.86	4.53	3.39	.49	.25	.39	31,200 - 45,400	45,300
Total	21.79	9.50	6.42	1.05	.57	1.44	58,650[1]	95,000
Area III	7.13	6.47	5.69	.61	.15	0	32,775[2]	64,700
Totals	28.92	15.97	12.11	1.66	.72	1.44	91,425	159,700

Source: City of Norman Planning Department. 1971. Vacant land study. Norman.
City of Norman Public Works Department. 1972. Master plan. Norman.
City of Norman Planning Department. 1974. Communication from Planning Director to City Manager, Norman.

[1] Population holding capacity was reduced by the Planning Department from an original estimated range of 61,900 to 87,800 in Areas I and II to 46,200 to 65,400 by applying a factor for non-urbanization of land then refined to 5[illegible],650.

[illegible],77[illegible] persons are estimated for accommodation in developable 4.37 square miles by the Planning Department, an average of 7500 persons per square mile.

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holding capacity in Areas I and II (58,650) by the total of developable land in residential zoning classifications in these areas (7.47 square miles) indicates that an average of about 7,850 persons per square mile may be accommodated in already sewered areas. Area III has been estimated by the Planning Department to contain only 4.37 square miles available for residential development after deducting areas set aside for other uses. The population holding capacity for the Area III proposed lift service area was estimated to be 32,775 or a density of 7,500 persons per square mile.

The Public Works Master Plan indicated full development of the entire 16 square miles of vacant land with an average density of 10,000 persons per square mile in addition to the current population. Zoning and non-urbanization factors were not accounted for in this estimate.

M. POPULATION TRENDS AND PROJECTIONS

Norman's population has exhibited an average annual growth rate greater than five percent since 1960, compared to an annual average rate of about two percent for the entire Oklahoma City SMSA. Cleveland County also has shown an average annual growth rate in excess of five percent, a growth similarity to be expected in view of the fact that Norman comprises about 65 percent of the county population. Population in the State of Oklahoma, however, has not grown nearly so rapidily. The State's annual growth rate since 1960 ranged from 0.8 to 1.9 percent.

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A comparison of population projections prepared by several sources generally indicates that the annual rate of Cleveland County growth will not continue at five percent, but will decline to about two percent by the year 2000. The lone exception to this conclusion was a projection prepared by the Association of Central Oklahoma Governments in 1972, using the vital statistics method. This projection concluded that annual growth would reach a steady rate of 5.3 percent; but was later judged by ACOG to be too high and unreliable because of the maintenance of a disproportionately high net migration rate occurring during the 1960-1970 period. Projections prepared for the State through the year 2000 show better conformance with past growth trends at about 1.0 percent. The annual rate of increase in the Oklahoma City SMSA indicates a reduction to about 1.2 percent by year 2000.

In general, population projections prepared for Norman, except for the forecast by the Norman Public Works Department, indicate a tapering off of the annual rate of growth to about 3.5 percent by 1985 and thereafter to about 2.0 percent by year 2000.

N. ECONOMIC PROFILE

The economy of Norman has been growing rapidly. Total employment grew by nearly 68 percent between 1960 and 1970, far more rapidly than in either Oklahoma or the Oklahoma City metropolitan area, in which Norman is the second largest city (Table III-10). Employment growth in Norman has been faster than its population growth, reflecting a high degree of labor force participation among Norman residents.

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TABLE III-10

LABOR FORCE CHARACTERISTICS, 1970

Area	Civilian Labor Force	Employment		Unemployment Rate	Percent White Collar Employees	Percent of Workers Employed Outside County of Residence	
		Total	Percent Change, 1960-70[1]			1960	1970
Oklahoma	968,430	928,031	18.1	4.2%	47.9	7.3	11.3
Oklahoma City SMSA	270,754	261,987	33.1	3.2	56.2	2.8	8.5
Cleveland County	32,808	31,547	87.2	3.8	58.7	22.1	36.0
Norman	21,160	20,224	67.8	4.4	64.5	19.8	22.5

[1]Date for 1960 show employment of those 14 years and over, while 1970 data show employment of those 16 years and over.

Source: U.S. Bureau of the Census. 1973. County and city data book, 1972. U.S. Government Printing Office. Washington, D. C.

U.S. Bureau of the Census. 1963. Census of population: 1960. Volume 1, characteristics of the population. Part 38, Oklahoma. U.S. Government Printing Office. Washington, D. C.

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The work force in Norman is predominantly white collar, with almost 30 percent involved in professional and technical occupations (Table III-11). This white collar orientation is a function of the presence of the University of Oklahoma, with its capacity for generating educational, research and administrative employment opportunities.

Median family income in Norman, $8,940 in 1969, was slightly less than that of the Oklahoma City metropolitan area but significantly higher than that of the State (Table III-12).

Although the economy has been growing rapidly, this growth has been predominantly in service-oriented activities, including those employed by the University of Oklahoma and the Central State Hospital.

The economic picture of Norman that emerges is one of a high dependence upon outside economic activities for jobs, goods and services. It appears that although Norman may not have the economic base necessary for self-sustained growth, it has been able to prosper due to its proximity to Oklahoma City. The outlook for economic growth in the Oklahoma City metropolitan area is strong, with a projected employment growth of over 34 percent between 1970 and 1980 (Table III-13). The rate of employment increase is projected to taper off to nearly 18 percent between 1980 and 1990 and 12 percent in the following decade.

It is difficult to estimate how much of this growth will involve economic activities in Norman. The extent to which Norman can attract some of these job opportunities might well be a major factor determining the city's future population growth.

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TABLE III-11

EMPLOYMENT BY OCCUPATION, NORMAN
1970

	Workers in Norman, 1970	
	Total	Percent of Total
Professional, Technical	5,772	28.5
Managers, Administrators	1,808	8.9
Sales and Clerical	5,456	27.0
Craftsmen, Foreman	1,839	9.1
Operatives	1,209	6.0
Laborers	599	3.0
Farm Workers and Managers	202	1.0
Service and Household Workers	3,339	16.5
TOTAL	20,224	100.0

Source: U.S. Bureau of the Census. 1973. Census of population: 1970. Vol. 1, characteristics of the population. Part 38, Oklahoma. U.S. Government Printing Office. Washington, D. C.

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TABLE III- 12

INCOME CHARACTERISTICS, 1969

Area	Median Family Income	Percentage of Families Below Low-Income Level
Oklahoma	$7,720	15.1
Oklahoma City SMSA	9,337	9.4
Cleveland County	9,087	9.5
Norman	8,940	9.9

Source: U.S. Bureau of the Census. 1973. County and city data book, 1972. U.S. Government Printing Office. Washington, D. C.

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TABLE III-13

PROJECTED EMPLOYMENT, OKLAHOMA CITY SMSA
1970-2000

Sector	(Figures in thousands) 1970	1980	1990	2000
Agriculture	4.5	3.3	2.6	2.2
Mining	7.0	7.5	6.9	5.9
Construction	13.6	17.1	18.3	18.8
Manufacturing	38.2	57.0	75.5	94.7
Public Utilities	16.8	21.2	24.0	25.4
Trade	57.9	72.4	80.8	85.6
Finance, Insurance, Real Estate	15.6	20.5	23.5	25.9
Services	38.1	54.3	69.8	85.6
Government	70.4	99.2	113.3	120.1
Total	262.1	352.1	414.7	464.1[1]
Percent Increase	-	34.5%	17.6%	11.9%

[1]Difference in total due to rounding.

Source: Oklahoma Employment Security Commission. As presented in: Association of Central Oklahoma Governments. 1972. Economic and population study and projections. Oklahoma City.

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O. AESTHETICS AND ARCHAEOLOGIC AND HISTORIC SITES

Topography in the project area is flat to gently rolling. Undeveloped land, with the exception of stream areas, are generally free of tree cover and mostly used for the grazing of livestock. Many of the streams in the area have been impounded to form stock ponds from approximately one to ten acres in size.

The area is dominantly rural in nature. However, single family home construction, mainly in subdivision developments, has occurred in several locations. Several multi-family developments are also located in the area as is a large mobile home park.

Access to the area is by gravel or bituminous roads which occur regularly along section lines. Residences or farms in the area are served by subdivision streets, private roads, or driveways from the public roads along the section lines.

The extreme western portion of the project area has been developed to some extent with an industrial area and a part of the Norman Research Park.

There are no properties within the project area of either the primary or auxiliary lift stations which are listed in either the National Register of Historic Places or the Directory of National Parks and Landmarks (U. S. Department of the Interior, 1972a and 1972b). The Oklahoma Historical Society recognizes two buildings within the currently developed portion of the city as being of historic interest according to Lester (1975). They are the Lindsay Home located at 508 North Peters Avenue and the President's Home, located on the campus

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of the University of Oklahoma. Additionally, Lester (1975) states that the site of an encampment used by Washington Irving is also of significance to the Oklahoma Historical Society. This site is located about two miles southeast of the face of the Lake Thunderbird dam; hence, it is not within the project area.

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IV. ALTERNATIVES

A. DETAILED DESCRIPTION OF THE CITY'S PROPOSAL

The City of Norman proposes to extend sewage collection service in Norman into the 8.3 square mile section of the Little River watershed shown in Figure IV-1. As indicated in Chapter II, the city had received a grant to construct a system of six lift stations and associated gravity sewers and force mains that would connect into existing facilities in the South Canadian River watershed. The following is a description of the city's proposal.

1. Design Rationale

The proposed sewage facilities are designed to take best advantage of topographic and hydrographic conditions in the service area by using gravity flow to the maximum extent in collecting and transporting sewage across the ridgeline to the South Canadian watershed. The topographic and hydrographic character of the service area is described in detail in Sections III(B), Physiography, and III(F), Hydrology, of this impact statement. These earlier sections identify six subbasins within the service area and arrange them in two groups of three: the northern three, which drain directly to the Little River; and the eastern three, which drain to the Little River via Rock Creek, a major tributary. The subbasins are delineated in Figure III-2. A lift station (actually a pump house) will be located at the lowest point in each of the six subbasin drainages to collect gravity flow from all residences above it in the watershed.

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The six stations would operate in independent groups of three, one primary and two auxiliary stations per group. The auxiliary stations would lift flow from their respective areas through force mains to the primary station, which in turn would pump the tributary flow plus flow from its own service area across the ridgeline.

2. Function of Lift Station Systems 1792 and 2792

As shown in Figure IV-1, the two primary lift stations are 1792 and 2792. Station 1792 and its auxiliary stations, 992 and 1992, would serve the northern half of the proposed service area. Together they would lift a 4.4 square mile area into the city's existing collection system: 1792 would lift 2.4 square miles, 992 and 1992 would together lift a total of 2.0 square miles.

Lift station 2792 and its auxiliary stations, 2292 and 2692, are designed to collect flow from the eastern half (the East Alameda Street section) of the service area. The primary station would serve an area of 1.6 square miles and the two auxiliary stations would serve a combined area of 2.3 square miles.

Besides providing sewage collection service to new areas, both the 1792 and 2792 systems would enable retirement of a number of oxidation ponds serving existing subdivisions in these areas. The schedule of retirements has not yet been determined, and would probably depend upon the residual capacity of each pond at the time that the project is completed.

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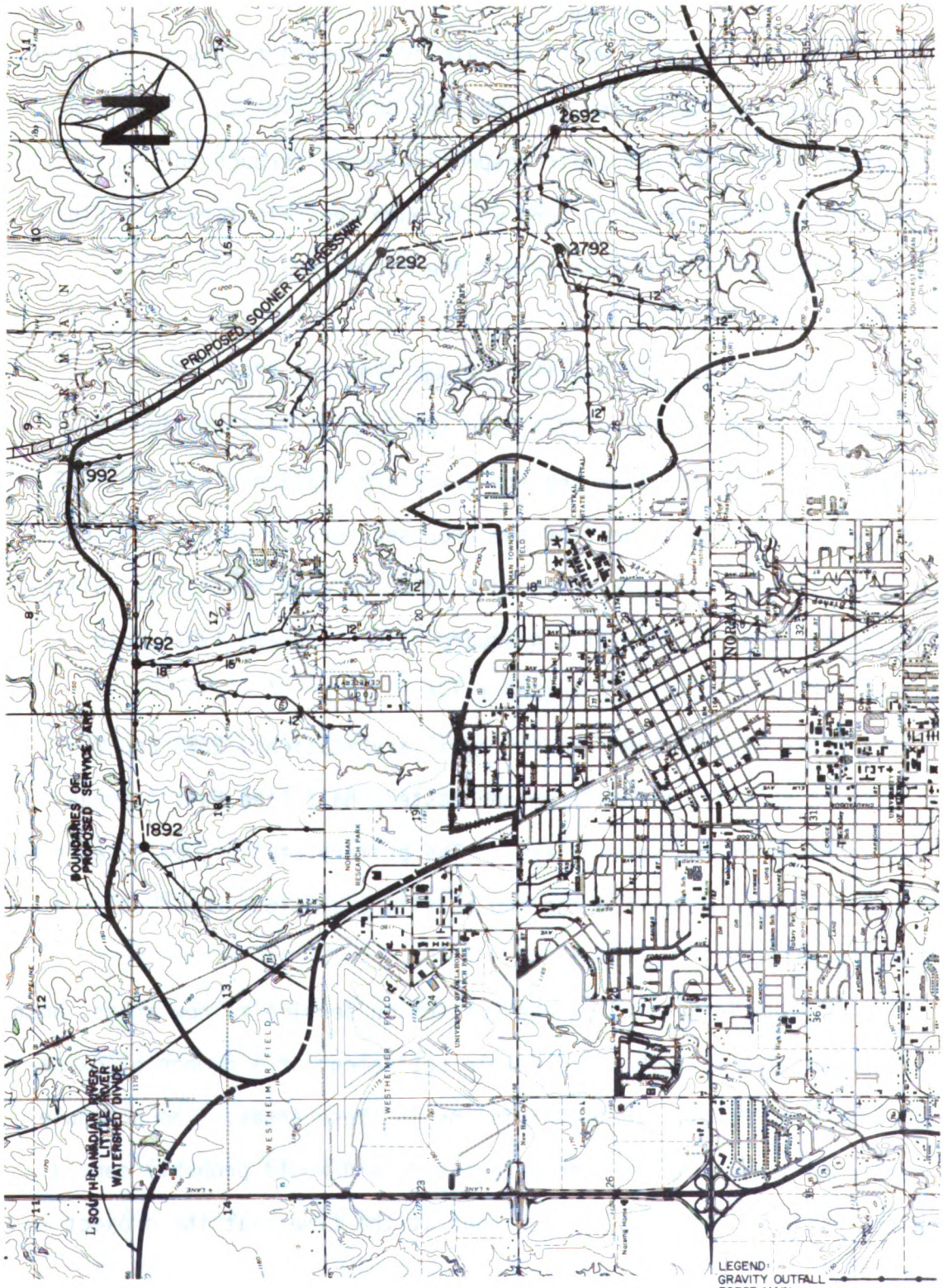

NOTE: SIZE OF AUXILIARY STATION SEWER LINES YET TO BE DETERMINED.

CONTRACT NO. 4 IMPROVEMENTS

FIGURE NO. IV-1

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The 1792 system is designed to receive flow from one such oxidation pond and, in addition, would relieve two small lift stations that are presently close to being overloaded. These stations now serve the Woodcrest and Crystal Heights Subdivisions. The 2792 system would eventually replace five oxidation ponds, including four in Hall Park township. The location of all facilities to be supplanted by the proposed lift station systems as proposed by the city are shown in Figure IV-2.

3. Sequence of Implementation

Both primary lift stations are to be built in the initial phase of the project and would tie into facilities already constructed under other WPC-OKLA-505 contracts. The auxiliary stations would be added in later years as necessary to meet increased service demand. As yet, no specific schedule has been set for their construction.

4. Lift Station Description

All of the lift stations would essentially be underground facilities. With the exception of such above-ground support facilities as access roads and power lines, only a protruding entrance hatch, a concrete sump cover, and fenced dikes around an overflow lagoon would be visible. Simplified plot plans for stations 1792 and 2792 are shown in Figures IV-3 and IV-4, respectively, and can be considered to be typical of other stations. At the present time detailed engineering plans are only available for the primary stations and their appurtenant gravity

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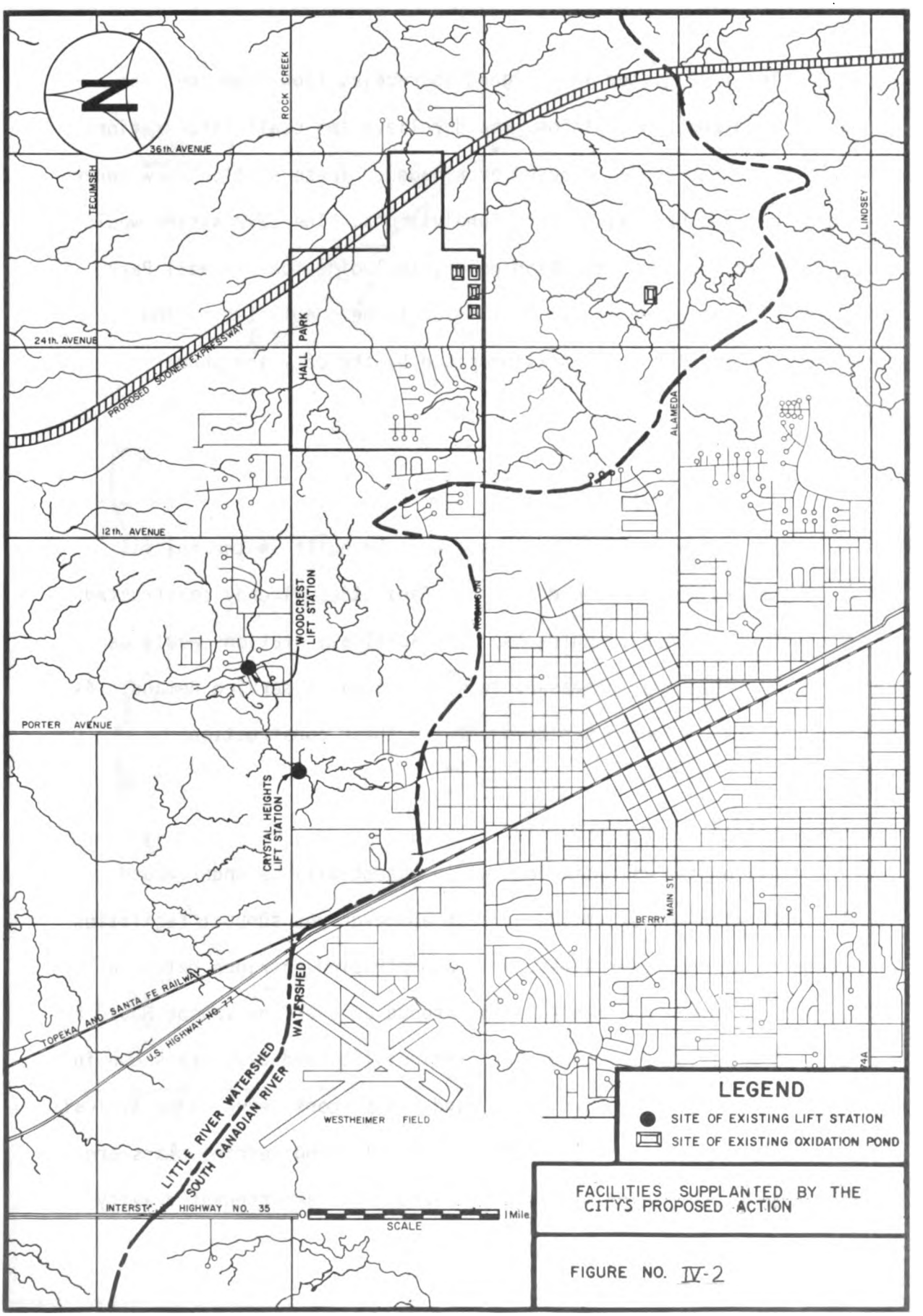

FACILITIES SUPPLANTED BY THE CITY'S PROPOSED ACTION

FIGURE NO. IV-2

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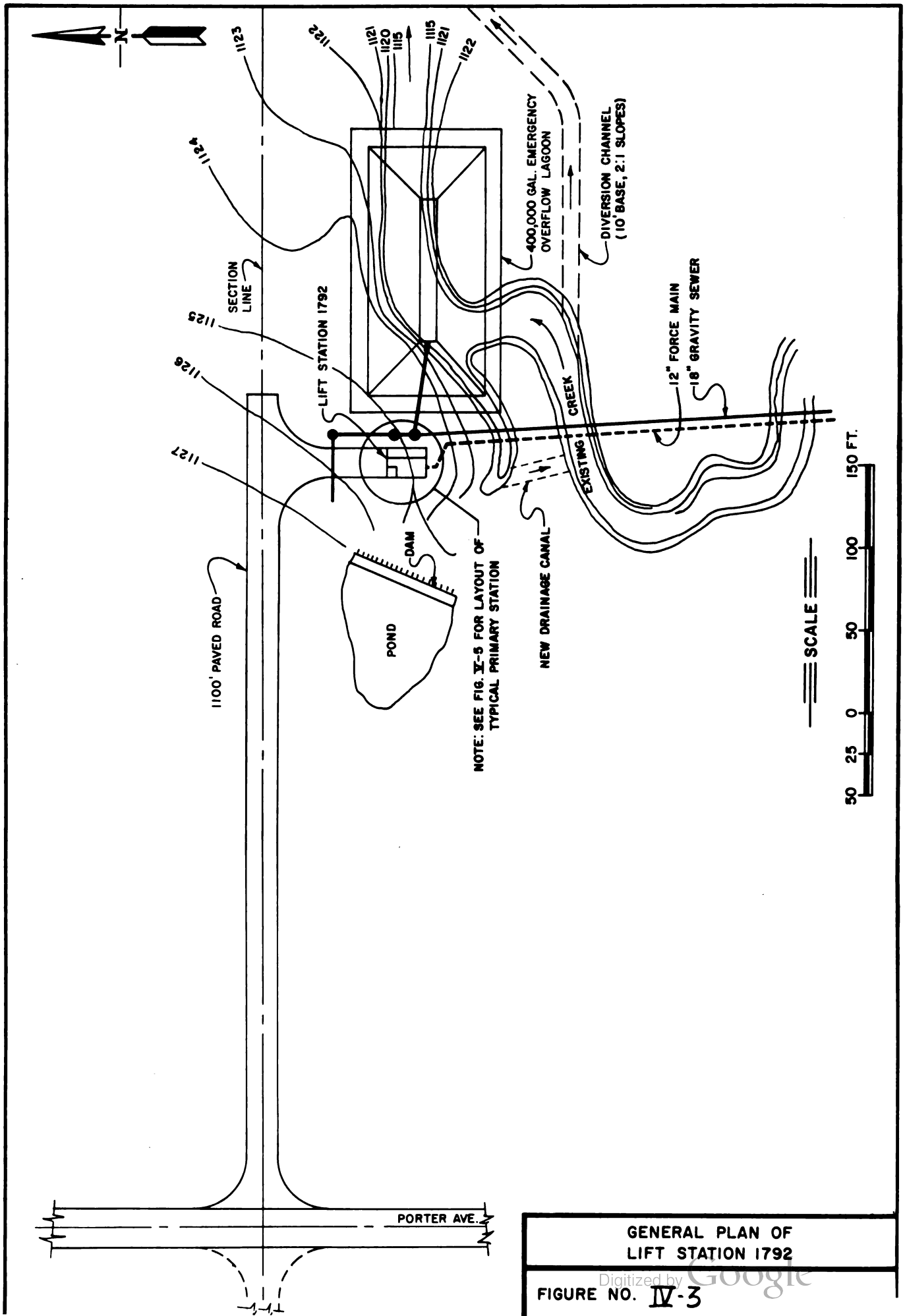

GENERAL PLAN OF LIFT STATION 1792

FIGURE NO. IV-3

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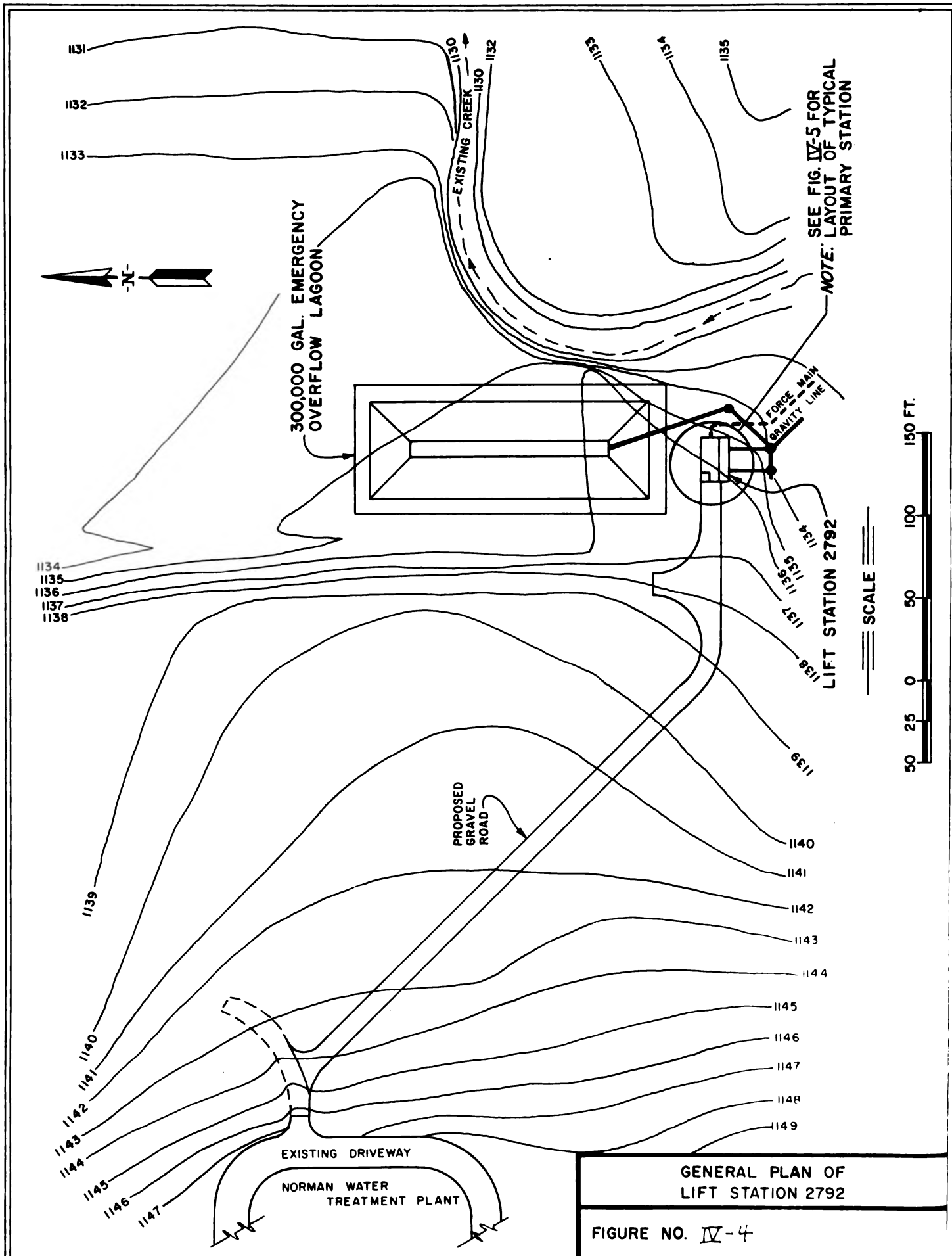

GENERAL PLAN OF LIFT STATION 2792

FIGURE NO. IV-4

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lines and force mains. Plans for the auxiliary stations have not yet been prepared.

A detailed elevation view of a typical primary station is shown in Figure IV-5. As indicated, the internal station layout would consist of separate wet well and pump room chambers with space intended to accommodate up to six pumps. However, in the initial project phase only two pumps would be installed at stations 1792 and 2792. The underground housing that encloses the pumps would be approximately 18 x 26 feet in plan view and 16 feet high, including the access hatch. The hatch cover would be built above maximum flood elevation.

Each lift station facility would require a significant amount of earthwork, both for the buried pump house and for the adjoining overflow lagoon. The excavation for the station itself would be approximately 25 to 30 feet deep, allowing for six to seven feet of backfill after the ceilings have been poured. The overflow lagoon, intended for use only during contingency situations, would be approximately eight feet deep at its center and have a 300,000 gallon capacity. Excess material from constructing both facilities are to be used in the lagoon dike walls and to contour site slopes.

Certain improvements would be necessary to provide access to the stations. Station 1792 would be built on a two acre lot east of the intersection of Porter Avenue and Tecumseh Road. Access will be gained by extending the present terminus of Tecumseh Road approximately 1,100 feet to the east. The new roadway would have a 20 foot wide bituminous asphalt surface paved to state highway specifications. Station 2792 would be constructed on a half acre site within the perimeter of

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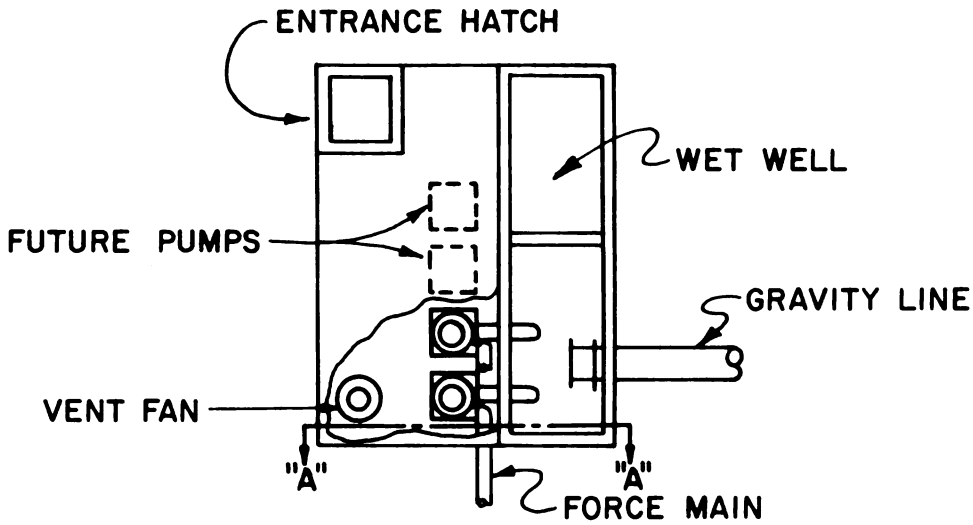
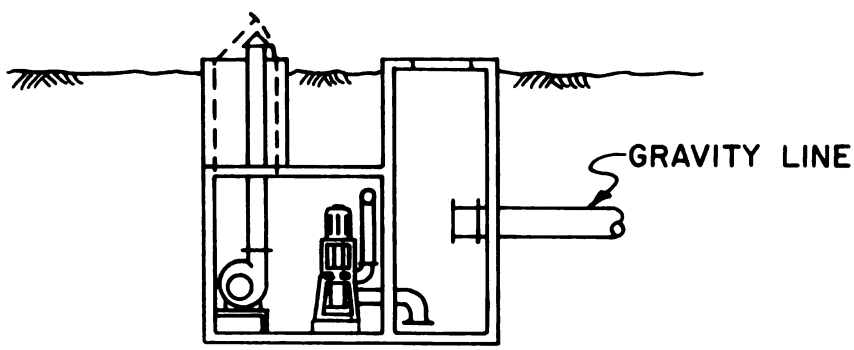


PLAN VIEW



SECTION "A"-"A"

ELEVATION VIEW

LAYOUT OF
TYPICAL PRIMARY STATION

FIGURE IV-5

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the present Norman water treatment plant. Access would be provided by extending an existing 20-foot wide gravel road approximately 500 feet.

5. Sewer and Force Main Description

The approximate lengths of gravity sewer pipe and force main to serve the proposed stations are indicated in Figure IV-1. Also shown on the figure are new gravity lines to be built in the Canadian River watershed to connect the proposed force mains into existing gravity sewers.

All of the proposed sewer lines are designed to be laid on a construction easement to vary from 72 to 100 feet in width, depending upon difficulty of terrain, agreements with landowners, and other accessibility considerations. After construction has been completed the right-of-way will revert to a permanent easement of 15 to 20 feet. Right-of-way maintenance responsibilities and restrictions would be specified in the easement documents. For the most part, the right-of-way would remain undisturbed after construction has been completed. The major exception would occur along those sections of force main right-of-way where additional lines may be needed in the future as station capacities are increased.

6. Diversions and Relocations

The city's facilities have been situated in the lowest points of their respective watersheds to maximize use of gravity flow. Several of these locations lie within or near existing stream channels, for the

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most part arroyos, that must be diverted in order to limit the number of stream crossings and avoid undue scour of the trench backfill. The actual extent of stream diversion required for each particular length of sewer line would be dependent upon the exact alignment determined in the engineering plans. To date, engineering plans for the city's proposal have only been developed for the outfall and force mains serving the primary lift stations. The only significant diversion indicated in these plans would be the necessity to construct the force main south of lift staton 1792, where approximately 2,200 feet of intermittent stream bed would be diverted to eliminate existing channel meanders. The new channel at this location would be approximately 1,700 feet long and 10 feet wide at its base, and would have a 2:1 sideslope. A description of this diversion has been forwarded to the Navigation Branch of the District Office, U. S. Army Corps of Engineers in Tulsa, Oklahoma, to determine need for a Section 404 alteration of navigation channel permit.

In addition to channel diversion, several power poles, buried gas lines, and secondary structures would also be relocated during construction of the various 1792 and 2792 collection facilities. Owners would be compensated for loss or inconvenience associated with these relocations. After completion of construction, all right-of-way would be seeded and otherwise restored to the best practical extent in keeping with the wishes of landowners.

7. Environmental Effects of the City's Proposal

Both primary and secondary impacts are considered for this alternative. Primary impacts are defined as effects which may be

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attributed directly to the construction and/or operation of the proposed facilities. In contrast, secondary effects are indirect or induced changes to the human environment resulting from the project. The above impacts may be determined to be either beneficial or adverse. Finally, impacts may be of either short or long duration. Generally, short-term impacts are associated with facility construction and are only of local importance. Long-term impacts occur during operation and maintenance and as a result of secondary or induced environmental changes.

8. Short-Term Impacts

Certain direct effects would be of short duration. They are associated with the construction phase of the proposed facilities and involve the effects of excavating for and installing the gravity sewers, force mains, underground lift stations, overflow lagoons, and access roads.

a. Impact on Soils, Geology, Vegetation, Streams, and Natural Drainage Patterns (Physiographic Impact)

The lift stations and associated collection lines are designed to take best advantage of gravity flow within their respective watersheds. The stations would be located at the lowest point within their drainage basins, and most gravity lines would be placed within or near stream bottoms. In order to preclude excessive scour of backfill following installation of sewers and mains, the stream near station 1792 would be diverted through a newly excavated channel 2,200 feet long,

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rendering inactive approximately 1,700 feet of existing streambed. Hence, existing drainage patterns will be altered in the vicinity of this facility.

Soil removed during excavation at both station sites and along sewer lines would be stockpiled and subsequently replaced during backfill operations. Engineering plans call for excess soil at the station sites to be used to construct lagoon dikes and to contour other on-site slopes. Vegetative cover would be destroyed at all sites so excavated. Erosion of soil from these areas will likely increase during the construction period. Dust associated with operation of earthmoving equipment is also probable. Erosion, wind-borne dust, and runoff from soil piles may reach adjacent waterways depending upon stream stage. Accordingly, increases in sediment load and turbidity will persist in these streams throughout the construction period. Where necessary, conventional methods would be used to control stream siltation including dry-cutting of new channels, incremental clearing, use of hay bales at the base of hillside slopes to contain soil loss, matting, a judicious use of spray stabilizers, and reseeding.

Construction of the lift stations would likely necessitate removal of a small number of bottomland trees. Tree and other vegetation removal would be by mechanical means. Vegetative debris would be chipped or otherwise reduced for probable offsite disposal without burning. No herbicides would be employed in implementing the project. Trees and other vegetation not removed but near earthmoving equipment would be protected from direct mechanical damage by binding

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wooden slats to the trunk or other appropriate means. Following construction, excavated sites will be graded and seeded as required by the landowner.

b. Impact on Social and Economic Patterns

Construction activities would be completed within a period of about two months with local construction companies being employed.

Total cost of the city's proposal is estimated to be approximately $1.5 million. Payroll monies would flow into the local economy as would monies resulting from the local purchase of construction materials. Although not significant in terms of area cash flow, the impact of these expenditures would beneficially affect the local economy.

c. Impact on Air Quality

The primary effects of the proposed facilities on ambient air quality will be limited to temporary increases of pollutants which would result from the operation of construction equipment. The major chemical pollutants involved would be carbon monoxide, hydrocarbons, and oxides of nitrogen from vehicle engines (EPA, 1972) and fugitive dust from any earthmoving operations. The vehicular emissions would be regulated by emission standards for new equipment. The generation of fugitive dust would be suppressed to a large degree by conventional water spraying techniques.

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d. Impact on Noise Levels

The primary effects of the proposed facilities on ambient noise levels would be limited to temporary increases in the immediate vicinity of construction activities. Machinery such as backhoes, power shovels, heavy trucks, compressors and pumps would generate noise in excess of ambient levels. Although not harmful to the public health, such noise may be heard by residents or others passing in the vicinity of the construction activity and, thereby, constitute a minor irritant. Noise levels at 50 feet from construction vehicles generally range from about 80-90 dBA. Assuming a drop-off of 6 dBA for each doubling of distance, a resulting noise level of about 50 dBA can be expected about 1/2 mile away during construction activities. If construction does not occur at night, the day-night sound level (L_{dn}) in areas farther than about 1/2 mile from these activities would probably be less than 55 dBA, the outdoor day-night sound level suggested (EPA, 1974c) to protect against activity interference and hearing loss in the vicinity of even sensitive areas such as hospitals.

e. Impact on Public Health and Convenience

The contractor would be required to maintain detours, barricades, signs, flags, lights, flagmen, and/or other safety precautions, as necessary, to protect the public and his construction crew from hazardous situations. In addition, no explosives would be used during the construction period; nor is work at night likely. Therefore, little risk to human safety is anticipated.

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Construction along or near roadways, however, may require periodic stoppage or detouring of vehicular traffic. Interruption of normal traffic flow will cause minor inconvenience to area residents and other travelers. As noted above, movement of construction equipment could produce dust along roadways and noise. Construction contract specifications require that dust be controlled and that roadways be cleaned of dirt and other material which may be deposited by the construction equipment.

No residences would be relocated in order to implement the proposed project. Several power poles, buried gas lines, and secondary structures such as garages and other buildings may, however, be relocated during construction. Disruption of electrical or other utility service during the construction period may cause brief local inconvenience.

f. Other Short-Term Impacts

Loss of vegetative cover during facility construction would also disrupt the activities of associated animals. Habitat of a small number of rodents, other small mammals, song birds, and insects would be lost. It is not expected that animals of recreational importance other than a very few quail, rabbits, and squirrels would be so affected.

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9. Long-Term Impacts

Certain direct effects associated with construction would be of long duration. Other effects would be exhibited over the long-term because they result from ongoing operation and/or maintenance procedures. Each would be discussed in the following subsections:

a. Impact on Physiographic Elements

As previously noted, stream diversion in the vicinity of station 1792 would be maintained for the design life of the project. Consequently, velocity in the straightened channel would be slightly increased, diminishing deposition in the channel and slightly increasing downstream scour. Although long-term, the impact is theoretically reversible because existing drainage patterns could conceivably be reestablished following abandonment of the sewer system. However, it is unlikely that any conventional abandonment practice would include reconstruction of meandering channels.

Roadways, rights-of-way, slopes, and embankments would also be maintained over the system's life. Exposed earth would be reseeded and would revegetate in grass species. Right-of-way for sewers and mains are planned to revert from a construction easement of 75-100 feet to one of 15-20 feet for permanent maintenance. Growth of trees and shrubs on this permanent right-of-way will be controlled either by city maintenance or by restrictions described in individual easements secured from landowners.

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Operation of the lift stations and maintenance of sewer right-of-way would not result in direct discharges to waterways in the vicinity of the facilities.

b. Impact on Social and Economic Patterns

Operation and maintenance of the proposed facilities would likely require the addition of two permanent employees to the city workforce. However, no measurable long-term effect on the local economy or society is likely to accrue from employing these persons. Total expenditures for operation and maintenance of the new system are anticipated to be about $22,000.00 per year according to the Norman City Engineer (Frederickson, 1975). Included in this total are costs for such direct expenses as power and routine part replacements as well as labor associated with operation of the facilities. Most of these funds would be spent locally.

c. Impact on Land Use

Land dedicated for long-term use by the proposed facilities, with the exception of roadways to the auxiliary lift stations, totals 192.0 acres (Table IV-1). Of this total, 10.5 acres would be occupied by the six primary and auxiliary lift stations. All would be constructed on 2.0 acre sites with the exception of station 2792 which would occupy a 0.5 acre tract within the boundaries of the existing Norman water treatment plant. Lands totalling 0.7 acres and 180.8 acres, would be required for roadways and sewer/force main right-of-way, respectively, and would revert to permanent easements

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TABLE - IV-1

ESTIMATED LAND REQUIREMENTS

FACILITY		ACRES UTILIZED Construction	Operation
1792 Collection System			
Primary Lift Station 1792			
	Station Site	2.0	2.0
	Sewer r/w	47.8	9.3
	Roadway	0.5	0.5
Auxiliary Lift Station 992			
	Station Site	2.0	2.0
	Sewer r/w	24.1	4.8
	Roadway	Unknown	Unknown
Auxiliary Lift Station 1892			
	Station Site	2.0	2.0
	Sewer r/w	22.7	4.5
	Roadway	Unknown	Unknown
	Subtotal	101.1	25.1
2792 Collection System			
Primary Lift Station 2792			
	Station Site	0.5	0.5
	Sewer r/w	38.0	7.6
	Roadway	0.2	0.2
Auxiliary Lift Station 2292			
	Station Site	2.0	2.0
	Sewer r/w	21.6	4.3
	Roadway	Unknown	Unknown
Auxiliary Lift Station 2692			
	Station Site	2.0	2.0
	Sewer r/w	26.6	5.3
	Roadway	Unknown	Unknown
	Subtotal	90.9	21.9
	Total	192.0	47.0

NOTES:

1. Area of lift stations 1792 and 2792 obtained from final engineering plans. All other station site areas are estimated.
2. Calculations of sewer easement areas consider parallel lines as one line segment.
3. Sewer easements are based upon 100 foot construction and 20 foot perpetual rights-of-way.

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(36.5 acres); land owners would be advised that additional force mains may be located within these rights-of-way in the future. Hence, construction of the facilities requires that the total amount of land be considered as dedicated to long-term use.

Construction of these facilities will allow the City of Norman to eventually abandon eight oxidation ponds and two small lift stations currently operating within the proposed service area. Lands currently occupied by these ponds could conceivably be converted to other uses compatible with such facilities.

d. Impact on Air Quality, Odor, and Noise

Primary effects on air quality associated with implementing the proposed project are twofold. First, emissions caused by construction equipment would affect ambient air quality. These are short-term impacts and have been previously discussed. Second, operation of the lift stations would also produce certain direct effects on ambient air quality related primarily to potential odor emissions from the stations and/or the associated overflow lagoons.

All project facilities incorporate conventional methods intended to minimize objectionable odors. Still, very localized odors may infrequently be perceptible wherever wastewater handling facilities are vented. The gravity sewers would be vented through man-holes, but should pose no odor problem due to the turbulence of flow and oxygen contact with the wastewater. Odors become a more significant concern when sewage is allowed to stand for extended periods and becomes anaerobic. It is unlikely that this would happen under normal operating

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conditions, even at the lift stations, which will be equipped with a vented wet well to damp inflow and prevent pump surge. Sewage in the wells will not be held long enough for anaerobic conditions to develop. Periodic utilization of the overflow lagoons will probably constitute the only appreciable potential odor source. However, it is expected that the lagoons would be used infrequently, mostly during brief periods of mechanical failure. In addition, because there would not be development in the immediate vicinity of the proposed stations, few persons will be affected by any odor episode.

Operation of pump motors and other related equipment would generate long-term noise at the lift stations. However, all equipment will comply with applicable noise level standards promulgated for worker protection under the Occupational Safety and Health Act of 1970 and Noise Control Act of 1972. These controls at the stations, in addition to their underground location, should prevent perception of significant site-related noise beyond the site boundaries.

As a beneficial impact, noise and odor emissions associated with the two lift stations to be retired in the 1792 area would be curtailed upon their deactivation.

e. Impact on Public Health and Convenience

Operation and maintenance of these facilities would not result in long-term adverse effects on public health and/or convenience other than infrequent minor inconvenience which may result from the potential odor emissions discussed above. No significant increases in area vehicular traffic are expected to result from facility operation or maintenance.

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No recreational site, park, or historic site is located in the project vicinity. Hence, relatively few persons other than neighboring residents would have occasion to view the facilities. Planting of grass and other landscaping activities would be undertaken as required to enhance the long-term aesthetic value of the sites to these viewers.

As noted earlier, existing sewage treatment facilities within the Little River watershed are now operating near capacity. These improvements would beneficially affect present and future area residents by reducing the potential for environmental degradation and public health problems associated with overloaded systems.

10. Secondary Impacts

As noted earlier, secondary impacts are those that would be indirectly related to constructing and operating the proposed facilities. They result directly, however, from other actions likely to be induced should the proposed sewage improvements be provided.

Provision of public services such as sewer, water, drainage, and transportation is a key element in guiding the growth and development of a community. Cities like Houston, Texas, for example, lack zoning ordinances and, therefore, rely solely on such controls as subdivision approvals, building permit issuance, and provision of a community service infrastructure to control land use. Construction of sewage improvements on the north side of Norman may generate effects similar to those observed in Houston and other communities around the country. As elsewhere, municipal investment would likely stimulate

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associated private investment in land improvements for residential and/or commercial purposes. Altered patterns of land use, social and economic activity, changes in population distribution and community structure may occur and additional public expenditures may be required.

In general, the character of the service area would likely change from its present predominantly rural nature to one of urban or suburban development. The change would come about through construction of single and multi-family dwellings, commercial enterprises, streets, and other structures and facilities related to such development. Hence, the types of short and long-term effects previously described in this chapter as being associated with construction activities would occur repeatedly. In contrast to the restricted local nature of the effects resulting from the sewage improvements, the effects of service area urbanization would likely not be locally restricted. The implications of these impacts transcend the service area boundaries. Therefore, consideration of secondary effects requires a shift in focus from one that encompasses only the immediate vicinity of the construction sites to one that includes the service area as a whole as well as other parts of the watershed.

Lake Thunderbird is located within this watershed. As noted in Chapter III, the lake serves as a primary component of Norman's water supply system as well as the area's dominant leisure time attraction. As such, it is the area's key element of environmental sensitivity. Maintenance of Lake Thunderbird in a state suitable for its important uses is a principal area planning goal. The significance of this goal has been recognized by the City of Norman, other area communities, the Association of Central Oklahoma Governments, and other planning and

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coordinating bodies of jurisdiction. Consequently, consideration of secondary effects as they relate to Lake Thunderbird's environmental quality constitutes a measure against which the significance of long-term secondary effects may be assessed. Where appropriate, this aspect will be discussed in the following subsections:

a. Impact on Physiographic Elements

Principal secondary physiographic impacts are similar to those described earlier in this chapter. Of particular significance, however, are those that may be quantitatively approximated with respect to their effect on Norman Reservoir. These are siltation and the influence of other non-point source waste materials likely to be generated as a result of extensive urbanization in the Little River watershed. Both may influence water quantity and/or water quality in the reservoir and are, therefore, discussed individually in subsequent subsections.

(1) Impact on Siltation

Excessive erosion may occur during the urban development phase if subsoils are exposed and sediment control practices are not followed. Nationally, the average sediment yield attributed to urbanization is 40 to 50 tons per acre according to studies compiled in 1970 by the Task Committee on Sedimentation of the American Society of Civil Engineers (ASCE, 1970).

With the exception of soils on steep slopes overlain by elements of the Vernon series, soils of the proposed service area may

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be anticipated to erode at a rate of about 50 tons per developed acre of land. Guy (1972) observed sediment production approaching 150 tons per acre from soils similar to the Vernon series near Washington, D. C. Since the Vernon series occupies about 10 percent of the service area, average sediment production within the area could approach 60 tons per urbanized acre per year.

The sediment delivery ratio (Chapter III.E) also governs ultimate sedimentation of the reservoir. Watersheds of the Red Hills physiographic province comparable in size to that of the Little River above Norman Reservoir have demonstrated delivery ratios of 15-20 percent. Consequently, of the potential 60 tons eroded, about 9 to 12 tons per developed acre could be expected to reach the reservoir. The remaining 80-85 percent would be deposited as colluvium or alluvium and ultimately incorporated into the soil profile of the downstream portion of the watershed.

ASCE (1970) studies have also shown soil loss resulting from residential development to be a normally distributed function of time. Losses both prior to and following the peak construction period are of lesser quantity than those that occur during peak construction activity. Although the bell-shaped curve may be compressed by accelerating the rate of watershed development, the area enclosed within it apparently remains constant. Hence, whether the proposed service area is developed incrementally over a long period or rapidly within a short time should not alter the total amount of sediment deposited in the reservoir.

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As noted in Section III.E, the design capacity for accumulated sediment in Lake Thunderbird is 35,000 acre-feet over 100 years (Wright, 1975) or 2.3 tons per acre of watershed per year. The proposed service area comprises about 4 percent of the watershed. Hence, complete urbanization of the service area may be calculated to reduce the 100 year design life of the reservoir by about two months; this value represents less than 0.2 percent of the 100 year design life. In reality, two months is not a meaningful value because allowable calculation error attributable to imprecision in estimating parameters such as areal extent of soil types, mean erosion rates, and delivery ratios is much greater. Hence, sedimentation due to urbanization within the service area must be considered as an effect of no significance in relation to long-term water quantity maintenance.

In addition to slightly increasing sediment delivery to Lake Thunderbird, urbanization would also change the service area's hydrologic character. Runoff after rainfall is typically more intense and of shorter duration in urban areas than in agricultural areas where permeability and flow resistance are higher. Consequently, it can be expected that the risk of flooding along small creeks below the service area will increase as development intensifies, and that ultimately some form of structural controls will be needed.

(2) Impact on Other Non-Point Source Discharges

Urbanization of the proposed service area would likely result in an increase in the quantity of nutrients and other non-point source waste materials discharged into the Little River watershed.

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Although domestic wastewaters originating within the area would be collected and pumped to the existing treatment plant, studies have shown that rainfall runoff from developed areas contains certain pollutants in concentrations equal to or greater than wastewater effluent after secondary treatment (Bryan, 1970; Colston, 1974; Clark and Molina, 1973). Hergert (1972) describes a "flush effect" whereby runoff first reaching a waterway from an urban environment contains higher concentrations of pollutants than does later runoff. Rural watersheds normally do not experience this "flush effect" because the early portions of a storm are absorbed by the more pervious ground cover (Dornbush, 1974; Pigg, 1975). In fact, runoff generally occurs much less frequently in non-urban areas than in urban areas where paved streets, parking lots, and rooftops produce large quantities of rainwater which quickly reach the drainageways.

Several researchers have shown that nutrient loadings associated with urban runoff can be quite high. Studies in Tulsa, Oklahoma (Cleveland, et al, 1970) and Durham, North Carolina (Bryan, 1970; Colston, 1974) indicate the average annual contributions of phosphorus from one urban acre to be approximately 4.0 pounds. Dornbush, et al (1974) found that the phosphorus contribution from agricultural land was only 0.1 to 0.7 pounds per acre per year. Nitrogen contributions have also been shown to be high in urban runoff waters (Clark and Molina, 1973).

Many factors influence the total amount of nutrients reaching a stream; "average" figures, therefore, can often be misleading. Environmental conditions such as local geology, soil type, annual

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rainfall, intensity of storm, and time since last storm, along with human factors such as land use, frequency of street cleaning, general community cleanliness, and amount of automotive traffic, all influence the pollution load from a particular area.

Quantification of nutrient or other additions from runoff requires site-specific analysis of runoff water quality. Such a study is currently underway in the Lake Thunderbird watershed. Pigg (1975) collected runoff samples from urban, semi-urban, and rural areas during consecutive rainfall events. The urban watershed consisted of 2.95 square miles within the City of Moore. Semi-urban and rural study areas consisted of 14 square miles and 45 square miles within the North Creek and Elm Creek tributaries, respectively, of the Little River basin. Approximately 36 inches of rain fell during the period of observation. Runoff totalled 24 inches. Although a final report has not yet been compiled, preliminary results are shown in Table IV-2. For all parameters listed, except Chemical Oxygen Demand (COD), measured concentrations were highest in the urban area, and lowest in the rural area. More significant, however, was the finding that an estimated 80 percent of the total runoff within the watershed originated in its urban portions.

Average phosphorus concentration in Lake Thunderbird may now exist at a threshold level; exceeding the threshold value may result in troublesome algal blooms adversely affecting the potability of the lake's waters. Assuming that the current contribution of phosphorus to these waters from the predominantly rural Little River watershed equals 0.1-0.7 pounds per acre per year (Dornbush, 1974), total yearly

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TABLE IV-2

NON-POINT NUTRIENT AND COD SOURCES IN THE LAKE THUNDERBIRD WATERSHED

	Mean Concentration (mg/l)		
Parameter	Urban	Semi-Urban	Rural
NO_3-N	1.87	1.33	0.230
NO_2-N	0.111	0.033	0.024
PO_4-P	0.557	0.363	0.026
COD	112	3	7

Source: Pigg, M.J. 1975. Unpublished data.

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watershed contribution is now within the range of 16,000 to 115,000 pounds. Assuming further that this entire phosphorus load were distributed throughout the water column, maximum theoretical phosphorus concentration in the 3.0×10^4 gallons of Lake Thunderbird water could range from 0.5-3.5 mg/l. Chapter III.G further reports measured concentrations of 0.02-0.07 mg/l in the main body of the lake. These values are about 2-4 percent of the calculated maximums. Hence, roughly 96-98 percent of the incoming phosphorous may be absorbed on clay particles, accumulated as organism biomass or otherwise rendered unavailable for continued algal growth. The unavailability of this phosphorus may now be limiting the growth of algae to blooms which are now reported to present only a minor water quality problem.

For purposes of further illustration, one may assume a phosphorus contribution to the lake of 3.3-3.9 pounds per acre following urbanization of the 5,312 acre service area. Total contribution would thus be about 18,000 - 21,000 pounds per year from service area runoff. Assuming that 96-98 percent of this phosphorus is also unavailable for uptake by algae results in a calculated addition of 0.01-0.02 mg/l to the waters of the lake. Such an addition is 14-100 percent of currently measured ambient phosphorus concentration. Because phosphorus now appears to be limiting algal growth to periodic blooms, additions of the above magnitude may aggravate bloom situations.

The assumption of 96-98 percent unavailability included in the above calculations is probably too high because a significant proportion of the incoming phosphorus is not measured in the

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water column as total available phosphorus; it has been previously incorporated into the algal biomass (as well as the biomass of other lake fauna). Hence, potential service area contribution to ambient levels (calculated as 14-100 percent) is likely understated. Similar calculations and findings may be feasible for other important micro- and macro-nutrients.

Other materials and organisms will enter the lake in addition to nutrients. For example, organic material will be transported to and biologically degraded in the lake, causing potential oxygen depletion in the hypolimnetic or bottom waters. Such occurrence could adversely affect the lake's fishing. Metals, especially lead and chromium (Pigg, 1975; Vitale and Sprey, 1974), are also present in elevated concentrations in urban stormwater. The addition of metals to a reservoir serving as a potable water supply is inadvisable from a public health standpoint (U.S.P.H.S., 1962; California State Water Resources Control Board, 1963). Finally, bacteria are known to be washed from urbanized areas in large amounts during runoff periods.

It is obvious that the above calculations and/or discussions represent only order of magnitude estimates of potential pollutant loading not supported by experimental results from the Little River watershed. Despite this important limitation, however, they illustrate potential impacts of high significance which may result from addition of nutrients and other non-point source discharges to the reservoir. In the absence of specific experimental findings to the contrary, accelerated urbanization within the Little River watershed

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must be considered an action which may have significant adverse impacts on the lake's ability to produce high quality water.

b. Impact on Social and Economic Patterns

The determinants of future growth in Norman's social and economic systems are complex. While one influence on this growth could be expansion of the sewer system into northern Norman, it is by no means the sole determinant. Potential emergence of an economic base independent of Oklahoma City, proximity of recreational areas and transportation routes, growth of the University of Oklahoma, and continuation of the relative desirability of Norman over other suburban areas for commuters to Oklahoma City will all play important but presently indeterminable roles. Future planning, zoning, and other land use restrictions would also affect the magnitude of growth as well as the growth pattern.

(1) Population Growth and Distribution

As noted earlier, the City of Norman is situated in the Oklahoma City Standard Metropolitan Statistical Area, an area where continued vigorous growth is expected. Access to Oklahoma City, a major urban and economic center 18 miles to the north, is provided by Interstate 35. The "rural" atmosphere of the larger part of Norman, the location of a major educational institution, the University of Oklahoma, and the recreational attractiveness of Lake Thunderbird have encouraged rapid development in the area. These factors have resulted in the substantial growth of Norman with a doubling of the population since

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1960 to a current total of more than 68,000 persons, at an average annual growth rate of about 5 percent since 1970.

Continuation of rapid growth is anticipated; a population of over 97,000 persons is expected to be reached by 1985, averaging an increase of about 4 percent each year. The growth rate is projected to decline to 3 percent by 1990 (at a population of about 111,000) and to about 2 percent until the year 2000 when Norman should have a population of about 137,000 persons.

According to the Norman Vacant Land Study, about 59,000 additional persons could be accommodated in lands already sewered. Hence, lands now available for utilization primarily as low density residential housing may accommodate a total of about 127,000 persons; this population exceeds the 100,000 person design capacity of Norman's current base wastewater treatment system. Should the lift stations be constructed, vacant lands capable of supporting about 32,000 persons would be made available. Thus, sewered land in Norman would have a maximum capacity for about 159,000 people. This number is far in excess of growth anticipated within the next 25 years. No evidence suggests that this action will alter Norman's projected growth rate so that an increase in population equivalent to the capacity of these areas will occur. Rather, the action will more likely present future inhabitants with a choice of residential location between the west and north sides of town. Hence, rather than altering either the rate of population increase or the total population attained, construction of these sewer improvements will most likely affect the distribution of the population

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by attracting residents to the north and east who could otherwise be accommodated to the west. Overall population density in both areas would subsequently be less than optimal under a mode of simultaneous settlement. Capacity in either area would likely be attained only in years following year 2000.

(2) Governmental Costs

Under conditions of population dispersion, vacant lands become interspersed with occupied areas. Police and fire protection, water, drainage, and streets, however, are provided to the vacant areas as the occupied areas are serviced. Hence, the total per capita cost, unlike the cost per unit of area, for providing all public services generally increases in proportion to the degree of dispersion of the population being served.

An examination of total and per capita revenues and expenses by Norman shows that Norman's per capita public expenditure burden is now substantially higher than that of Oklahoma City. Table IV-3 shows that total per capita governmental revenue in Norman exceeds that of Oklahoma City by about 16 percent. In contrast, however, Norman's total per capita general expenditure of $248 exceeds the $189 spent by Oklahoma City by more than 30 percent. Expenditures other than capital costs (mostly community services) are 43 percent higher in Norman than in Oklahoma City on a per capita basis.

Expansion of the sewerage system into the Little River watershed would likely cause further increases in the per capita cost of providing public services. This would probably result in higher

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TABLE IV-3

GOVERNMENT FINANCES, NORMAN AND OKLAHOMA CITY
1971-72

Category	Norman Total	Norman Per Capita[1]	Oklahoma City Total	Oklahoma City Per Capita[1]
General Revenue, Total	$ 9,550,000	$183	$58,188,000	$158
Intergovernmental Revenue	665,000		8,227,000	22
General Revenue from Own Sources	8,885,000	170	49,961,000	135
General Expenditure, Total	12,926,000	248	69,790,000	189
Capital Outlay	4,293,000	82	27,036,000	73
Other than Capital Outlay	8,633,000	166	42,754,000	116

[1]Differences in totals due to rounding.

Source: U.S. Bureau of the Census. 1974. Census of governments: 1972. Volume 4, government finances. No. 4, finances of municipalities, and township governments. U.S. Government Printing Office. Washington, D. C.

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service costs for city residents than would more intensive development in the South Canadian watershed. The additional cost burden would be imposed upon a city already facing a relatively high level of public expenditures and rapidly expanding service demands.

c. Impact on Planned Land Use and Land Development

Planning for anticipated growth and development has been addressed by the City of Norman through the adoption of a master plan and zoning ordinances. While development which is now taking place in the area to be served by the proposed lift stations and which would likely be accelerated by station construction is consistent with low density residential use outlined in the Urban Area Plan, the timing of such development is not. In the plan and in documents supporting its conceptual design, the objective of preventing the scattering of development in Norman has been recognized and addressed. For example, the Environmental Control Advisory Board issued a report in Feburary, 1975, which reviewed Norman's Capital Improvements Plan for fiscal years 1974-78. The following statements which appear on page 25 of this report exemplify attitudes guiding development of the current master plan:

> The Board supports orderly growth, but opposes the expenditure of a disproportionate share of the expenditures for sewer construction on developing areas. Indeed, the highest priority must be to improve deficiencies in already developed areas of Norman.

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Similar conclusions may be found in various ACOG planning documents. Because of the geographical extensiveness of Norman and the desirable diversity of environmental and cultural amenities in the city, particular attention has been given to the large capital expenditures required to develop a municipal service infrastructure in outlying land developments.

At present, about 9.5 square miles in the South Canadian watershed are sewered in areas generally planned for low density residential development but not yet fully occupied. Completion of the lift stations in the Little River watershed prior to full development elsewhere would continue to extend the geographical scope of municipal responsibility and would encourage an accelerated rate of growth in vacant land capacity beyond that embodied in current community planning goals. The complexity of the pattern that may emerge also increases as other areas outside of the sewered regions continue to be developed.

The general extent of land use development, as expressed in the master plan, also assumes the right-of-way of the proposed Sooner Expressway at the eastern limit of the urbanized area. Indications are at this time, however, that a firm alignment and timetable for construction of the expressway have not been selected by the Oklahoma Highway Department. Assumption that the physical presence of the expressway, should it be constructed, would constitute a barrier to development further eastward cannot be justified.

The problem Norman faces is its own size. The accommodation of growth in Norman can be controlled only through the functioning of an orderly and clearly expressed set of goals which make

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firm commitments to an allowable rate and pattern of growth. Under current community planning policies, the growth brought about by the proposed lift station construction appears inconsistent with the desire of achieving a coordinated rate of land development as expressed by local and areawide planning agencies.

d. Impact on Air Quality

The most significant impact of the proposed facilities on ambient air quality would result from secondary effects. Increases in population in that area would result in increased air emissions from additional vehicles, and from any commercial or industrial facilities constructed to serve the increased population.

As noted earlier, development of the proposed service area could increase Norman's population by approximately 30,000-40,000 people, all residing in the Little River watershed. For comparative purposes in the context of this air quality impact analysis, we have assumed a worst case, i.e., that this growth would be in addition to, rather than part of, the population increases projected for Cleveland County by the State of Oklahoma Employment Security Commission. The resulting population growth factors (estimated 1985 population/estimated 1974 population) are approximately 1.5 without the proposed lift stations and 1.8 with the lift stations. 1974 was chosen as the base year because the latest ambient particulate emissions data were assumed to be representative of 1974 (point source emissions were from 1974 and area source emissions were from 1972). It was assumed that particulate

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emission increases within the county would be directly proportional to the population increase of the county. This is also a worst case or conservative assumption because of the probability that regulations imposed as a result of Air Quality Maintenance Area designation will reduce expected emissions per unit of population by 1985.

Once this ratio of populations (and therefore emission rates) is determined, and given the 1974 existing particulates ($33\mu g/m^3$ annual geometric mean) and the natural background particulates ($30\mu g/m^3$ annual geometric mean) data from Chapter III, a "roll-back" model can be applied.

The results of applying the roll-back model to the particulate and population data indicate that ambient particulate concentrations (annual geometric mean) can be expected to increase in Cleveland County only $1\text{-}2\mu g/m^3$ under a "normal" growth assumption and $2\text{-}3\mu g/m^3$ assuming that growth induced by constructing the lift stations will be in addition to normal projected growth. These predicted increases are very small, and are not significant.

It is not possible to conduct similar analyses for other air pollutants because of the lack of ambient monitoring data. However, one may expect concentrations of the other air pollutants to also increase somewhat as a result of the induced population growth over those concentrations which would otherwise be expected. This increase should be no more than a factor of about 1.2 (the ratio of the population growth factors with and without the lift stations), and, in fact, could be much less as is the expected case for particulates, due to emerging air quality maintenance regulations.

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e. Impacts on Noise Levels

The increased population in the area and the resulting increase in human activities would gradually change noise levels in the service area from those typical of a rural land use pattern to those typical of suburban areas. That is, day-night sound levels (L_{dn}) could be expected to increase from the estimated existing rural levels of 45-50 dB to about 50-55 dB. Higher levels would continue to exist in the vicinity of transportation corridors and the airport, and will increase as the use of these facilities increases. In general, however, noise level increases due to induced growth would not be expected to be unacceptable from the standpoint of protection of public health and welfare with an adequate margin of safety.

f. Impact on Area Aesthetic Values

Urbanization of the proposed service area would alter its character from one of a generally pastoral setting to one with varying degrees of commercial and residential use. Such alteration may be aesthetically objectionable unless certain spatial and greenbelt principles recognized by the city and discussed in other planning reports are incorporated conceptually into the development program.

B. OXIDATION PONDS

An oxidation pond complex would provide a means of treating sewage that could be located within the proposed service area without building a new treatment plant. Several small oxidation ponds are now in operation in the area. In principle, oxidation ponds are simply shallow

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earthen enclosures that rely upon microbial organisms supplied with oxygen from algal photosynthesis to break down organic matter present in the wastewater. The waste is considered to be stabilized in conventional practice after retention for about 30 days.

The ponds now operating in the service area are, in theory, total retention ponds, for they have no outlet. In actuality, there is a substantial and determinable rate of water loss in these units due to evaporation and slight infiltration, for even in the case of impermeable clay linings, some infiltration is inevitable. Under steady-state flow conditions, the sum of these losses must equal in-flow.

While many complicated interactions occur in oxidation ponds, their design has a rather empirical basis. The above steady-state conditions are useful in obtaining a rough estimate of the unit size necessary to handle flow from the proposed service area if developed to its maximum capacity. Such estimates based upon precipitation and evaporation rates for Central Oklahoma and no allowable drawdown suggest that a facultative pond complex in excess of several thousand acres would be required to serve the 4.0 to 5.0 mgd flow from a population of 40,000. The magnitude of this number suggests the impracticality of such an alternative. No beneficial impacts are apparent. Adverse impacts of this alternative would be related to its inordinate land requirement, removing an unacceptably large area from both residential and agricultural uses.

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C. TREATMENT PLANT BELOW THE DAM

The possibility of building a new wastewater treatment plant along the Little River downstream of the Lake Thunderbird dam has been considered for several years by regional planning agencies. In fact, a designated site appears in several ACOG publications dating from the 1969 Water and Sanitary Sewer Regional Plan. The near-term prospects of Norman building a plant at this location were diminished in 1971 when the city elected to expand the existing plant rather than relocate it. The decision was based upon an engineering consultant's finding that the advantages of relocation were slight in comparison to the high initial cost of collecting and conveying sewage to a plant below the dam (Black and Veatch, 1971). In spite of this decision, it is conceivable that a regional plant may yet be constructed below the dam if warranted by development in the Little River watershed. However, no plans exist at present.

The plant site identified in the ACOG report is approximately 14 miles southeast of the proposed lift station service area. Although the 1971 study did not enumerate the various facilities required to convey sewage from Norman's urban area to this site, the number of intervening drainages would suggest that an extensive pumping system would be needed. If a system of this sort were used to connect the proposed sewer grid to a plant below the dam, its cost would be much greater than, and yet in addition to, the cost of the proposed action.

The cost of the plant itself is an even more significant consideration when compared to a proposal that utilized existing treatment capabilities. It is estimated that the cost of constructing a secondary

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treatment facility for a design flow of 4.0 to 5.0 mgd could range from three to five million dollars, excluding ancillary works such as outfalls and interceptors. The total expenditure for plant and outfalls is difficult to justify in view of the recent plant expansion undertaken to handle, among others, the very population growth that the second plant would serve. In this light, construction of a new plant below the dam would represent a duplication of facilities, cost, and concomitant burden on the taxpayer.

Two uncertainties also make a new plant an unattractive alternative. The first pertains to the possibility that water quality standards for the Little River below the dam will be raised in the future. As stated in Chapter II, flow in the river is completely controlled by releases from the lake. As water demand in the Central Oklahoma Master Conservancy District (COMCD) increases, so will the frequency and duration of low flow periods in the river. Hence, the concern for secondary discharges to the river can only be expected to become greater in the future, as will the possibility of increasingly stringent effluent limitations being enacted.

Equally uncertain is the degree to which a 14-mile outfall between the urbanized area of Norman and the dam vicinity would affect growth on its own accord. Suburban development has an undisputed propensity for areas crossed by sewage interceptors, outfalls, and force mains. Any significant growth to result from placement of lengthy new lines would further the scatterization of development problem already prevalent in the region. This would appear to be the principal adverse impact of new

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plant construction. Beneficial impacts would include the greater ease of expansion afforded a plant located away from the presently congested plant site, the waste dispersion advantages gained by multiple points of discharge, and the greater separation between plant and established residential areas.

D. DELAY ACTION

If the proposed action were delayed, the Little River watershed adjacent to presently urbanized Norman would be without centralized sewer collection service until growth in the presently sewered undeveloped lands approaches capacity. At that time, the proposed project would conform most closely to the Urban Area Plan.

This delay would encourage development in areas of the city that are presently served by sanitary sewers. Also, there may be a delay in development of the Little River watershed and a postponement of any adverse effects on Lake Thunderbird resulting from that development.

Lake Thunderbird serves as the primary component of Norman's water supply system as well as the dominant recreational facility in the area. If the vacant sewered lands were developed before those in the Little River watershed, measures might be found to mitigate the potentially adverse secondary effects of urbanization. These effects include siltation and increased runoff, which add to the nutrient and sediment load on Lake Thunderbird. However, delaying construction could only postpone secondary impacts of the proposed project.

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E. NO ACTION

The no action alternative would preclude the construction of the wastewater facilities identfied in Contract Number 4, WPC-OKLA-505 as discussed in Section I. Implementation of this alternative would necessitate the withdrawal of EPA grant funds for this contract. If the no action alternative were chosen, the Little River watershed area would be left without a centralized sewage collection system for the near future, providing that the city did not choose to fund the project. This area would have to continue its reliance upon existing oxidation ponds and several small lift stations to provide sewage service to the residents. Additionally, the existing facilities are incapable of handling any significant growth in the area.

The foremost and immediate impact of the "No Action" alternative would be to discourage any rapid expansion of Norman into the Little River watershed and forestall the adverse impacts of development on Lake Thunderbird as described in Section IV-A, Detailed Description of the City's Proposal. Furthermore, this alternative would result in a fixing of scattered development at the present level. Subdivisions in the service area delineated by the City's Plan could expect to remain separated from the existing urban sectors in the near future, while development in previously sewered areas would be encouraged.

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V. DESCRIPTION OF THE PROPOSED ACTION

The Environmental Protection Agency has evaluated the beneficial and adverse impacts of alternatives which could provide sewage collection facilities to the Northwest section of Norman.

In light of the potential adverse environmental effects which surfaced during the impact analysis of the various alternatives, the EPA has determined that the "No Action" alternative is the most desirable at this time. Specifically, it appears that implementation of structural measures that would provide sewage collection systems to this sparsely developed section of Norman could result in adverse secondary or project induced impacts from accelerated urbanization with the potential for further degradation of the water quality of Lake Thunderbird. Data collected during the course of this study, indicate that nutrient concentrations in Lake Thunderbird (particularly phosphorus) may now exist at a threshold level. Indeed, the lake has in the past experienced several nuisance algal blooms which have not only adversely affected water quality but also have impaired recreational aesthetics. Studies have also shown that urban areas contribute phosphorus, organics, bacteria, heavy metals, unburned fuels, oils, tars and other pollutants to local watersheds by runoff. Therefore, it has been concluded that further development in the watershed could have a long-term adverse effect on the water quality in Lake Thunderbird by adding to the nutrient load and possibly increasing the rate of eutrophication.

Furthermore, the current need for providing collection facilities for future area growth is not great. There are presently approximately

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9.5 square miles of sewered undeveloped lands in the South Canadian watershed. According to the Norman Vacant Land Study, about 59,000 persons could be serviced by the existing facilities. This is in addition to the current population of 68,000. Also, if sewage collection service were extended into the Little River watershed another 32,000 persons could be serviced. By implementing the proposed project the city would have a collection system capable of handling a population of about 160,000 while the existing wastewater treatment plant can service a total of only 100,000. It should also be noted that the city's population is not expected to reach this level in the next 25 years. The Environmental Control Advisory Board of Norman has also gone on record concerning the sewering of undeveloped lands. In a report reviewing Norman's Capital Improvements Plan for fiscal years 1974-78, the Board stated its support of orderly growth and its opposition to spending a disproportionate share of sewer construction expenditures on developing areas rather than on areas already developed.

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VI. ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

Implementation of the No Action Alternative will necessitate the withdrawal of the remaining EPA funds on Contract No. 4 of WPC-OKLA-505. Therefore, this action will not provide wastewater collection service to the unurbanized northeast section of Norman. While the no-action alternative will not halt future development in the area completely, it will probably inhibit growth until such time that more extensive wastewater collection and/or treatment facilities are constructed. Also, the proposed action would allow for more coordinated land development as desired by local and areawide planning agencies.

The selection of the no-action alternative will mitigate and conceivably eliminate the significant adverse secondary water quality effects (nutrient buildup, algal blooms, eutrophication, non-point discharge of toxic pollutants) on Lake Thunderbird associated with the development of the unurbanized area. These impacts have been discussed in detail in Section IV. Also, the impacts of construction (channel diversion and alteration of drainage patterns, relocation of utilities, destruction of vegetation and temporary degradation of water, air, and noise quality) would be avoided.

In the absence of wastewater collection facilities the unurbanized area will continue to depend on the existing five oxidation ponds now servicing subdivisions in the area. Also, two small lift stations that are close to being overloaded will remain in use.

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VII. SUMMARY OF ADVERSE IMPACTS OF THE PROPOSED ACTION

Withdrawal of grant monies for Contract Number 4 could have a slight adverse economic impact on the project area as these funds will not be available for use in the Norman area. Also, the no-action alternative will make it necessary for the City of Norman to continue its reliance on the existing oxidation ponds and lift stations previously scheduled for shut-down.

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VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION

Implementation of the "No Action" alternative will not require the irreversible or irretrievable commitment of additional resources due to construction. Resources already committed, including labor and fuel, are essentially lost. However, the inplace lines could be removed and reused if so desired.

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IX. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed action will not alter the land use in this sparsely populated area and will not affect long-term productivity.

Population increases within the project area could eventually require the future development of rural land; however, the decision not to fund the city's project could delay urbanization and any adverse impacts to water quality in the Little River watershed.

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