PART I/II

SUPPLEMENTAL TECHNICAL REPORT,LAND USE AND EXISTING CONDITIONS SUMMARY

City of Haskell, Texas

Municipal Solid Waste Transfer Station

Haskell County, Texas

6/10/2021

Prepared by

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STATE OF TEXAS

KEN MARTIN

44025

REGISTERED

PROFESSIONAL ENGINEER

8/9/21

Contents

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
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GLOSSARY

Abbreviations and Terminology

ANSI	American National Standards Institute
ASTM	American Society for Testing Materials
CHC	County Historic Chairperson
EPA, USEPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map (FEMA)
MGD	Million Gallons Per Day
NEPA	National Environmental Policy Act
NRCS	National Resource Conservation Service
NPS	National Park Service
OSHA	Occupational Safety and Health Administration
PE	Polyethylene (pipe material)
PVC	Poly Vinyl Chloride (pipe material)
RD	Rural Development (USDA)
RUS	Rural Utility Service (USDA)
SCADA	Supervisory Control and Data Acquisition System
SHPO	State Historic Preservation Officer (THC)
TCEQ (formerly TNRCC)	Texas Commission of Environmental Quality
TDHCA	Texas Department of Housing & Community Affairs
TDS	Total Dissolved Solids
THC	Texas Historic Commission
TCEQ	Texas Commission on Environmental Quality
TNRIS	Texas Natural Resource Information System (TWDB)
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCTCOG	West Central Texas Council of Governments
WWTP	Wastewater Treatment Plant

PART I SUPPLEMENTAL TECHNICAL REPORT

The Haskell Transfer Station is proposed for a Type V Registration Facility located in Haskell County, Texas. It will be located at the landfill, which is owned and operated by the City of Haskell, which lies approximately 3.8 miles East of the city. This will provide transfer operations for the City of Haskell, Haskell County, and infrequently, the surrounding counties.

The proposed transfer station will be inside the currently permitted property boundary and may utilize the undeveloped southern portion of the property. A gatehouse, scales, and earthmoving equipment are already staged on the permitted area.

The overall property consists of gently undulating grasslands with no canopy cover or woody vegetation. The property generally slopes to the north towards Red Creek located in the northernmost portion of the property. The permit boundary has been formed to avoid the creek and FEMA designated floodplain.

The City of Haskell has owned the property for over 30 years; therefore, no transactions will need to take place to expand the landfill permit boundary.

SECTION 1.0 INTRODUCTION

The City of Haskell proposes to develop and operate a Type V Municipal Solid Waste (MSW) Transfer Station on the existing landfill site and on an adjacent 58.71 acres of land located in Haskell County, Texas. This transfer station will be located approximately 4 miles East of Haskell on US Highway 380 Drawing I/II-1 – Site Location Map. The transfer station will provide service for residences, businesses, and industries in the Haskell area. In addition, the transfer station will accept waste from municipal, private, and public haulers from surrounding communities and counties. The transfer station will accept municipal solid waste, and special wastes as authorized by the Texas Commission on Environmental Quality (TCEQ) and as defined in Section 2.2.2. Parts I/II of this permit application have been prepared consistent with 30 TAC §330.59 and §330.61. In accordance with 30 TAC §330.57(c)(2), Parts I and II have been combined. Section 2, General Information, presents an overview of the project and a detailed transfer station description as well as the types of waste that will be accepted at the transfer station. The remaining portions of Parts I/II of this application present information on specific existing conditions on and around the site and matters of the entities involved in the application process. Drawings referenced throughout this document are provided at the end of Parts I and II.

SECTION 2.0 GENERAL INFORMATION

2.1 Project Overview

The City of Haskell is currently operating under Texas Commission on Environmental Quality (TCEQ) rules a Type 1AE and Type IVAE landfill. The City will be closing the Type IAE and Type IV AE landfill as the current capacity is expended. The City is proposing to add a registration for a transfer station to the existing MSW landfill #1604B and on land that the City owns adjacent to the South of the existing landfill. The surface waters in the area are a known source for a high saline contribution to the waters of the State. The elevation of the transfer station is 1482 above MSL to 1490 above MSL. The city of Haskell has a population of approximately 3,195. This is below the requirement in 330.9 (b) (1) a municipality with a population of less than 50,000; Latitude and longitude is 33.173296 and -99.645219 degrees.

2.1 Properties and Characteristics of Waste (330.61 b)

The City of Haskell's Type V transfer station shall receive waste from the following sources: residential, commercial, sludges from municipal wastewater treatment plants that do not contain free liquids, Class III Industrial wastes, compost feedstocks, and special wastes as authorized by the TCEQ, waste consistent with brush, construction or demolition waste, and rubbish.

Special wastes as authorized by the TCEQ and industrial solid wastes if any, consistent with brush, construction, or demolition waste, and rubbish will be accepted .

Special wastes that are soils contaminated by petroleum products, crude oils, or chemicals in concentration greater than 1,600 milligrams per kilogram total petroleum hydrocarbons or contaminated by constituents of concern that exceed concentrations listed in §335.521(a)(1), will not be accepted. The City of Haskell's Municipal Solid Waste Type V transfer station will not receive regulated hazardous wastes.

Special wastes and industrial solid wastes if any, consistent with brush, construction or demolition waste, and rubbish will be accepted at the Type V transfer station.

Typically, all refuse received will be transported off-site within 48 hours with the exception of holidays and weekends. During holidays and/or weekends, the refuse may be temporarily stored at the site not to exceed a time period of 72 hours. All waste will be transported to an authorized landfill facility. Initially the City of Abilene landfill will be utilized. Sorted non-putrescible recyclable materials will be stored in containers on-site until recycled.

The refuse may be temporarily stored at the site, on the tipping floor, for a time period not to exceed 48 hours, except holidays and weekends. If stored, the municipal solid waste will be in the processing building or in a securely covered transfer trailer located within the building or parked in the designated parking area outside the building, so as not to attract vectors, cause odors around the storage area, or be susceptible to wet weather.

The City of Haskell Municipal Solid Waste Type V transfer station may not receive regulated hazardous waste.

The following parameter limitations are in effect at this site:

- Regulated Hazardous Waste other than from Conditionally Exempt Small Quantity Generators (CESQG) may not be accepted. Municipal hazardous waste from a CESQG may be accepted; provided the generator provides a certification that it generates no more than 220 pounds of hazardous waste per calendar month. The presence or characteristic of any material meeting the definition of a regulated hazardous waste is a limiting parameter for waste disposal or processing.

- Polychlorinated Biphenyls (PCBs) wastes, as defined under 40 Code of Federal Regulations (CFR), Part 761, is a limiting parameter for waste disposal or processing.

- Special wastes that are soils contaminated by petroleum products, crude oils, or chemicals in concentrations greater than 1,500 milligram per kilogram total petroleum hydrocarbons or contaminated by constituents of concern that exceed concentrations listed in Table 1, § 335.521(a)(1) limiting parameter for waste disposal or processing.

- The presence of radioactive materials [30 TAC Chapter 336], except as authorized in Chapter 336 or that are subject to an exemption of the Department of State Health Services, is a limiting parameter for waste disposal or processing. [30 TAC §330.15(e)(9)]

- Lead acid storage batteries will not be intentionally or knowingly accepted for disposal.

- Do-it-Yourself (DIY) used motor vehicle oil will be intentionally or knowingly accepted for disposal as a limiting parameter for waste disposal or processing.

- Used-oil filters from internal combustion engines will not be intentionally or knowingly accepted for disposal limiting parameter for waste disposal or processing.

- Whole used or scrap tires will not be accepted for disposal or disposed as a limiting parameter for waste disposal or processing.

- Items containing chlorinated fluorocarbons (CFCs), such as refrigerators, freezers, and air conditioners, will only be accepted at the site if the generator or transporter provides written certification that the CFC has been evacuated from the unit and that it was not knowingly allowed to escape into the atmosphere limiting parameter for waste disposal or processing.

- Liquid waste (any waste material that is determined to contain "free liquids" as deemed by EPA Method 9095 (Paint Filter Test), as described in "Test Methods for Evaluating Solid Wastes, Physical chemical Methods" (EPA Publication Number SW-846)) is a limiting parameter for waste disposal or processing.

These will not be disposed of unless it is:

  - Bulk or non-containerized liquid waste that is:
    - household waste other than septic waste; or
  - Contained liquid waste; and
    - the container is a small container similar in size to that normally found in household waste;
    - the container is designated to hold liquids for use other than storage; or the waste is a household waste.

- Regulated Asbestos Containing Materials will not be disposed as a limiting parameter for waste disposal or processing.

- Industrial Class 1 Waste will not be disposed as a limiting parameter for waste disposal or processing.

See also Part IV Site Operating Plan and Part III Site Development Plan.

2.2 Waste Volume Projections

The City of Haskell transfer station will serve individuals, businesses, and communities in Haskell County and surrounding Texas counties. 2010 Census data shows the population of Haskell County as 5,899. There is one access gate. General duty collection truck as well as private vehicles bring material through the gate to the transfer station. The waste collected is generally household and commercial waste including putrescible material, packaging material, and general city trash as defined in 30 TAC § 330.3 (27), (56) and (64).

Based on population, the maximum annual waste acceptance rate at the City of Haskell's Municipal Solid Waste Transfer Station for the next five years is estimated as follows:

Year	Estimated Maximum Annual Waste Acceptance Rate
1	10,400 tons
2	10,400 tons
3	10,400 tons
4	10,400 tons
5	10,400 tons

Based on the former used of a (20 tons/day (IAE) + 20 tons/day (IVAE)) x 260 working days/year = 10,400 tons/year

SECTION 3.0 EXISTING CONDITIONS SUMMARY (30 TAC § 330.61 (a)

3.1 Existing Conditions

The Haskell Transfer Station is proposed as a Type V Municipal Solid Waste Transfer Station Facility located in Haskell County, Texas. The site is in northwest-central Texas within the province known as the Abilene Haskell Rolling Plains. The site is situated near a basin divide between two tributaries of Red Creek located to the North and South. The 160 acre property owned by the City of Haskell currently contains the 1604B landfill. The northern section of the 160 acre site is undeveloped and acts as mitigation to flooding. There are no issues associated with 330.61 (h) – (o). These items are separately addressed in the remainder of this document.

The existing landfill is currently operational with the existing waste footprint nearing total capacity and preparing for closure.

SECTION 4.0 MAPS (30 TAC §330.59 (c)

Attached general county map with a one-half inch to one mile scale and a TXDOT county map series at a scale of 1: 72,224. See Attachment I/10 general county map. And Attachment I/9 TXDOT county map.

SECTION 5.0 LANDOWNERS' MAP AND LIST

1.	CHARLES BURNETT 6400 US HWY 380E HASKELL TX 79521	2.	CARL AND DARLENE HOPKINS 1904 N. 1ST ST. HASKELL TX 79521	3.	BRUCE KING, ROCK KING AND VERNON DAV 121 NE JOHNSON AVE. BURLESON TX 76028

4.	MICHAEL HARTIN 5330 ODNEAL RD. KRUM TX 76249	5.	BRADELY A SEAY HERITAGE TRUST P.O. BOX 429 SANTO, TX 76472	6.	FLAT TOP EIGHT RANCHES PO BOX 1616 ALBANY TX 76430
7.	STEVEN L., STEVEN W., CATHERINE, AND NINA WILHITE 824 OVER RIDGE DR. GRAND PRAIRIE TX 75052				

Mineral Interests

Interest Owner *[from whom inherited]*	**Who Manages/Signs**
San Lorelle, Inc *Lorelle Bailey > Sandra Bailey Wilgus*	**David Wilgus, Pres.** P.O. Box 225629 Dallas, TX 75222-5629
Mary Jane Young, LLC *Lee A. Brownfield*	**Mary Jane Young, LLC,** Manager PO Box 90175 San Antonio, TX 78209
Linda Lee Sacra *Lee A. Brownfield*	**Linda Lee Sacra** PO Box 1732 Roswell, NM 88202
Pamela Jane Crowe *Leta Jane Shirley*	**Pamela Jane Crowe** P.O. Box 278 Buckholts, TX 76518

Nancy Jane Clark *Leta Jane Shirley*	**Nancy Jane Clark** PO Box 445 McKenna, WA 98558
Liza Jane Morell *Leta Jane Shirley*	**Liza Jane Morell** 5002 Wedgefield Rd Granbury, TX 76049
John Brownfield Shirley *Leta Jane Shirley*	**John Brownfield Shirley** 117 Idle Creek Trail Abilene, TX 79602
Jerry Bailey Family, LLC *Laurine Bailey > BHK Partnership*	**Jerry G. Bailey ,** Manager 1713 28th St Lubbock, TX 79411
D M Minerals, LLC *Laurine Bailey/ Joe Ann Hardey > BHK Partnerhsip* 1. Becky Hardey 2. Lon Hardey	**D M Minerals, LLC** Becky Hardey, Designated Manager 15995 Indian Rd. La Conner, WA. 98257
Jay Anthony Hardey *Laurine Bailey/ Joe Ann Hardey > BHK Partnerhsip*	**Jay Anthony Hardey** 435 Emerald Way Weatherford Texas 76085
Grant Hardey *Joe Ann Hardey*	**Joseph Grant Hardey** 435 Emerald Way Weatherford, TX 76085
Garrett Hardey *Joe Ann Hardey*	**James Garrett Hardey** 435 Emerald Way Weatherford Texas 76085
Grayson Hardey	**Jay Grayson Hardey**

Joe Ann Hardey	435 Emerald Way Weatherford, TX 76085
Amanda Grace Hardey *Joe Ann Hardey*	**Amanda Grace Hardey** 435 Emerald Way Weatherford, TX 76085
Brownfield Whitewood, LLC Anna Lisa deBoisblanc Barton David de Boisblanc *Laurine Bailey/Laura Lou Karlen*	**Anna Lisa de Boisblanc & Barton David de Boisblanc** Managers 400 North Ervay #518 Dallas, TX 75201
B. Walton Allen Investments, Ltd. *R.W. Allen > Bobbie W. Allen*	**B. Walton Allen Investments, Ltd.** c/o B.W. Allen Management Services, LLC, Sharon Bibeau, Secretary/Treasurer 113 Copperleaf Road, Lakeway, Texas 78734
Kenneth Allen Davis *Ettadell Smith*	**Kenneth Allen Davis** 3850 Whitehall Dr. Dallas, TX 75229
Smith Mineral Interest LLC *Ettadell Smith*	**Joe D. Smith, Manager** 2908 CR 6475 Neodosha, KS 66757
Wingerd Family Farms, LLC *Marion Woodruff / LM Wingerd Trust*	**Lou Anne Jameson, President** PO Box 10 Matador, TX 79244
Donald Ray Copeland, LLC	**Donald Ray Copeland,** Manger 203 Tanglewood

[Lenore Copeland & Lal Copeland Estate Trust]	Athens, TX 75751
Gary Michael Copeland *[Lenore Copeland & Lal Copeland Estate Trust]*	**Gary Michael Copeland** 4549 Titus Circle, Plano, TX 75024
Angeline C. Eddleman, LLC *[Lenore Copeland & Lal Copeland Estate Trust]*	**Angeline C. Eddleman LLC** Angeline C. Eddleman, Manager 3333 Allen Parkway Unit 3003 Houston, TX 77019
Stephen Lynn Brownfield	**Stephen Lynn Brownfield** P. O. Box 1002 Whitewright, TX 75491
Dark Moon, LLC *[Estate of Richard L. Brownfield]*	**Dark Moon, LLC** **Stephen Lynn Brownfield,** Manager P.O. Box 1023 Whitewright, TX 75491
Stanolind Operating Corp. **1206 W IH20 20** **Monahans, Texas 79756**	**North American Life Insurance** 8501 W. Higgins Rd, Chicago, IL 60631

SECTION 6.0 AERIAL PHOTOGRAPH

6.1 Aerial Photograph is in Appendix I/II 1.

SECTION 7.0 LAND-USE AND IMPACT ON SURROUNDING AREA (30 TAC § 330.61 (d), (g) & (h))

7. 1 LAND USE ANALYSIS (30 TAC § 330.61(G) & (H) (1)-(4)) & (6)

The Haskell Transfer Station site is located in a rural area, outside any city limits or ETJ; therefore, it is not zoned under any governmental jurisdiction. The site lies approximately three (3) miles east of the City of Haskell ETJ. The site does not require approval as a nonconforming use or a special permit from the local government.

The facility is consistent with the provisions of §330.561 for coastal areas. The facility is not located within the areas as defined in 30 TAC §335.584(b)(3)-(4).

Land uses within one mile of the City of Haskell MSWLF are predominately farming and ranching. The land lying to the north of the site is "bottom" land of Red Creek, with moderate mesquite growth and intermixed native range grasses. Cultivated tracts abut the landfill on the south and west sides. Unimproved pasture land abuts the east and north sides of the landfill and mostly describes the majority of the surrounding area within a one mile radius of the property.

Growth trends within 5 miles are declining in the area of the landfill and have been since the 2000 Census was taken. The decline may be largely due to the decreased oil and farming activity in the region; however, this trend may reverse as new technologies concerning shale oil and gas extraction have made sparked new interest in West Texas oil and gas plays.

There are no residences or business establishments within one mile of the landfill facility. The nearest residence is located approximately 2 miles away to the north. A small rural church and cemetery are located approximately 3 miles north of and slightly east of the landfill site. The nearest developed areas with churches and residents is four miles to the west in the City of Haskell. There are no historic sites or structures, archaeological significant sites, or site having exceptional aesthetic quality within four miles of the site. A roadside park on US Highway 380 is located two miles east of the site.

Proximity to Residents and Other Uses
30 TAC §330.61(h)(4)

The proximity to residences and other uses (e.g., schools, churches, cemeteries, historic structures and sites, archaeologically significant sites, sites having exceptional aesthetic quality, etc.) within 1 mile of the facility, as well as an approximate number of residences and commercial establishments, including the distances and directions to the nearest residences and commercial establishments, are presented.

(1) Schools
There are no schools located within 1 mile of the facility.

(2) Licensed Day Care Facilities
No licensed day care facilities are found within 1 mile.

(3) Churches
There are no churches in the vicinity of the site.

(4) Hospitals
No hospital is located within 1 mile of the facility,

(5) Cemeteries
There are no cemeteries located within 1 mile of the facility.

(6) Historic Structures and Sites, Archeologically Significant Sites, and Sites having Exceptional Aesthetic Quality
No known historic structures and sites, archeologically significant sites, and sites having exceptional aesthetic quality are located within 1 mile of the facility.

(7) Recreational Areas
No recreation areas are withing 1 miles.

(8) Wells, springs and Surface Water Bodies
Red Creek is inside of the original 160 acre property on the North side of the existing landfill. (within 1 mile of the facility). There are no known springs within 1 mile. There three wells within 1 mile not already plugged or unused (Part I/II Appendix I/II 3 Part I/II Appendix I/II 3 Geology Report).

(9) Residential
The historic town of Haskell is located approximately 4 miles West on US 380. Established residential communities located there not as dense and there are no residences within 1 mile.

(10) Commercial and Industrial
The general lack of growth has not led to significant growth in that corridor within 1 mile of the landfill. It is still entirely rural and agricultural.

There are no known pipelines, underground utilities, or electrical transmission line easements across this site. No solid waste unloading, storage, disposal, or processing operations shall occur within any easement, buffer zone, or right-of-way that crosses the facility. No solid waste disposal shall occur within 25 feet of the center line of any utility line or pipeline easement but no closer than the easement, unless otherwise authorized by the executive director. All pipeline and utility easements shall be clearly marked with posts that extend at least six feet above ground level, spaced at intervals no greater than 300 feet. Land Use Map, see Appendix I/II 2.

Any other information requested by the executive director shall be made available.

Facility layout map in accordance with 330.61 (d) can be found in Part III Attachment 1.

7.2 WATER WELLS WITHIN 500 FEET (30 TAC § 330.61 (H) (J)) AND ONE -MILE (30 TAC 305.45 (A)(6)(A)

A water well search was performed by Jacob & Martin for water wells located within 500 feet and one-mile of the proposed site. This water well search indicates no existing known water wells within 500 feet of the proposed site boundary. The one-mile search is provided as part of the Geology/Soil Boring Report, Appendix I/II 3 Water Well Map.

7.3 ABANDONED OIL AND WATERWELLS (30 TAC§ 330.61 (L))

There are no known existing water wells situated within the existing landfill permit boundary or on the 160 acre property. If water wells are discovered on the Site, the City of Haskell will provide the TCEQ with written certification within 30 days of discovery that these wells have been properly capped, plugged, and closed in accordance with all applicable rules and regulations of the commission or other state agency.

Jacob & Martin also performed a search for existing or abandoned oil and natural gas wells within the property boundary. Based on this search, there are no known existing or abandoned on-site crude oil or natural gas wells, or other wells associated with mineral recovery that are under the jurisdiction of the Railroad Commission of Texas. There is no record of any oil and gas activity on the property. There was one wildcat lease on the original 160 acre site.

There is one dry hole located within the existing landfill permit boundary. The well was plugged on May 22, 1985 by E.P. Operating Company. The well was drilled to a depth of 5,575 ft bgs. No surface evidence of the well has been observed. Texas Railroad Commission data shows that the well was successfully plugged, other information concerning the well is not readily available.

This well report is also provided as part of the Geology/Soil Boring Report in Appendix I/II 3.

If any oil or natural gas wells are discovered within the site, the City of Haskell will provide written notification to TCEQ of their location. If any discovered well is within the waste disposal footprint or may impact operations of the transfer station, the City of Haskell will provide the TCEQ with written certification within 30 days of discovery that these wells have been properly capped, plugged, and closed in accordance with all applicable rules and regulations of the Railroad Commission of Texas.

SECTION 8.0 TRANSPORTATION (3 0 TAC § 3 3 0. 6 1 (i))

Consistent with §330.61(i)(1) through (4), information related to the availability and adequacy of access roads, data on the existing and expected vehicular traffic on access roads within one mile of the facility during the expected site life of the facility, and projected volume of traffic expected to be generated by the facility on the access roads within one mile of the facility has been obtained/developed and considered. Confirmation of coordination with the Texas Department of Transportation (TxDOT), Abilene District, is included in Appendix I/II 4

8.1 Availability and Adequacy of Roads

The primary access roads to the Haskell Landfill are US Highway 380 and Ranch Road 618 (RR 618), both located just south of the site. US 380 is a two lane divided asphalt highway with paved shoulders and RR 618 is a two land divided asphalt highway without paved shoulders. The Texas Department of Transportation (TXDOT) is responsible for maintenance of both roads. These roads are readily available and adequate to satisfy all current and projected demands required by the landfill. There is no substantial increase in vehicle traffic expected on US380 or FM 618 associated with the proposed transfer station. Assuming that the waste inflow volume will continue to increase at a slow linear rate in accordance with growth trends in Haskell, the total vehicle traffic on US380 associated with the transfer station is estimated to have a minor increase in vehicles per day over the life of the landfill. This may include transfer trucks, collection trucks and small vehicles, as well as landfill employee vehicles. This estimate of traffic is dependent on the method of waste transport (i.e., direct haul vs. use of transfer trailers), the use of the transfer station by small vehicles, as well as market dynamics of the waste collection and hauling business.

The site entrance is shown on the Part III Attachment 1A. The entrance is a graded and maintained dirt roadway. The scales are located far enough away from US 360 to prevent landfill traffic from backing up on the highway near the entrance.

8.2 Volume of Vehicular Traffic on Access Roads

The Texas Department of Transportation performs annual traffic counts to determine Annual Daily Traffic (AADT) information on TXDOT maintained roads. Twenty-four-hour counts, with truck and seasonal factors are applied. The table below shows the TXDOT reported data for average daily traffic along state roads within 1 mile of the Haskell MSW landfill from 2015 to 2017:

ROAD	2015	2016	2017	2037 Estimated AADT
US 380 E of FM 618	736	563	582	820
FM 618	90	144	111	160
US 380 W of FM 618	627	1018	845	1070

*Abilene District TXDOT Traffic Maps 2015 - 2017

The City of Haskell MSW landfill operates two trash hauling trucks, each with a twenty (20) cubic yard capacity to move waste. The volume of vehicular traffic on access roads within one mile of the facility is estimated to be no more than ten (10) loads per day per each of these 20 CY hauling trucks. Additional usage is estimated to be no more than ten (10) loads per day of light-duty traffic customers. Existing and projected demands placed on the existing transportation infrastructure are easily satisfied and do not represent cause for any capital improvements to be made. US 380 holds a Functional Classification Code of 4, defining it as a major roadway, as such can handle weights associated with trash hauling trucks coming to and from the site.

8.3 Airport Impact

The nearest airport is the Haskell Municipal Airport, which is located approximately (4) miles from the Haskell MSW Landfill. The method of operation used at the existing Haskell MSW landfill (such as prompt cover of all waste material and the elimination of watering points) should, to a large extent, limit the bird hazard to airplanes flying in the area.

A buffer zone of approximately 1500 to 2000 feet will be maintained between the transfer station, and the adjacent private property on the east, south, and west side of the site. On the north side of the site, a much greater buffer zone (approximately 2500') is maintained because of Red Creek. On all sides of the existing property an access inspection road is constructed around the permitted areas.

In accordance with §330.545, the existing landfill does not currently encroach within 10,000 feet of any airport runway end used by turbojet aircraft or within 5,000 feet of any airport runway end used by only piston-type aircraft. As §330.545(b) describes, the landfill and proposed transfer station are located within a six-mile radius of the Haskell Municipal Airport that can be used by turbojet or piston-type aircraft. Notification letters (Appendix I/II 5) have been sent to the Federal Aviation Administration and the City of Haskell Municipal Airport indicating a planned lateral expansion of the Haskell MSW landfill that has been discontinued.

SECTION 9.0 GENERAL GEOLOGY AND SOILS STATEMENT (30 TAC §330.63(b), (d) & (e)

9.0 Waste management unit design

A general discussion of the geology and soils of the site has been prepared.

General Geology and Soils Statement

The soil conditions on-site have been evaluated and the geologic conditions of the area discussed with a geologist. It is determined that the soil conditions and geologic conditions at the City of Haskell City MSW Landfill #1604B Type I AE and Type IV AE landfills are stable for the purpose for which the transfer station are proposed. There are no on-site or local geologic or human-made features or events (both surface and subsurface).

9.1 General Geology

The proposed transfer station site lies within the outcrop of the Vale Formation of the Clear Fork Group. These Permian deposits are exposed in gently west-northwestward dipping strata in narrow, successively younger belts from east to west across Haskell County. The County lies on the eastern border of the major salt accumulation beds in West Texas. The Permian sediments are commonly referred to as the 'red beds' due to their primary color.

The Pease River Group is exposed west of the existing landfill and consists largely of sandstone, gypsum and shale. The San Angelo sandstone, lower most formation of the Pease River Group, rests disconformably upon the formations of the Clear Fork Group. Below and outcropping to the east of the Clear Fork Group occurs the Wichita Group which consists chiefly of massive fossiliferous limestone beds.

The Clear Fork Group is divided into three formations: the Choza, Vale, and Arroyo in descending order. Generally, all these formations are composed of shales with relatively thin layers of limestone, dolomite, sandstone, gypsum and marl. The shales are usually not distinguishable, and the formations are mapped based on prominent limestone and dolomite beds[1]. A correlation table is found on the following page.

[1] McAtee, Win, Geologist, Trinity Engineering Testing Corporation. Geotechnical Investigation of Haskell Regional Landfill. December 1990.

STRATIGRAPHIC CHART OF GEOLOGY IN HASKELL COUNTY, TEXAS

SYSTEM	SERIES	GROUP	FORMATION
PERMIAN	LEONARD	PEASE RIVER	BLAIN GYPSUM
			SAN ANGELO SANDSTONE
		CLEAR FORK	CHOZA
			BULLWAGON DOLOMITE
			VALE (HASKELL LANDFILL)
			STANDPIPE LIMESTONE
			ARROYO
		WICHITA	LUEDERS
	WOLFCAMP		CLYDE
			BELLE PLAINS
			ADMIRAL
			PUTNAM
			MORAN
	PENNSYLVANIAN ORDOVICIAN CAMBRIAN PRECAMBRIAN		

9.2 General Soils

The United States Department of Agriculture, Natural Resources Conservation Service, General Soil Maps of Texas indicates that the site is located on clay loam soils mostly in the Tillman and Vernon associations. Data indicates that these soils are well drained with no real frequency of flooding or ponding.

9.3 Fault Areas

To remain consistent with §330.61(j)(2) and §330.555, a Geotechnical Investigation was conducted by Trinity Engineering Testing Corporation (Appendix C). The study did not indicate the presence of surface faults that would impact the landfill. The TWDB Water Data interactive database was also referenced, the nearest Faultline to the facility is 19.2 miles to the Southeast in Throckmorton County.

No known or recorded faults in the proposed area. No active fault is known to exist within 1/2 mile of the site. There are no know areas experiencing withdrawal of crude oil, natural gas, sulfur, etc., or significant amounts of groundwater that could produce the possibility of differential subsidence or faulting that could adversely affect the integrity of landfill liners. No solid waste disposal shall be accomplished within a zone of influence of active geological faulting or differential subsidence because active faulting results in slippage along failure planes, thus creating preferred seepage paths for liquids. A study would be conducted to include the below items if subsidence or faulting was determined:

(1) structural damage to constructed facilities (roadways, railways, and buildings);

(2) scarps in natural ground;

(3) presence of surface depressions (sag ponds and ponded water);

(4) lineations noted on aerial maps and topographic sheets;

(5) structural control of natural streams;

(6) vegetation changes;

(7) crude oil and natural gas accumulations;

(8) electrical spontaneous potential and resistivity logs (correlation of subsurface strata to check for stratigraphic offsets);

(9) earth electrical resistivity surveys (indications of anomalies that may represent fault planes);

(10) open cell excavations (visual examinations to detect changes in subsoil texturing and/or weathering indicating stratigraphic offsets);

(11) changes in elevations of established benchmarks; and

(12) references to published geological literature pertaining to area conditions.

9.4 Seismic Impact Zones

The seismic impact zone as defined by §330.557 is an area with a 10 percent or greater probability that the maximum horizontal acceleration in lithified earthen material, expressed as a percentage of the earth's gravitational pull, will exceed 0.10g in 250 years. Based on a review of the USGS seismic maps of the area, the site is not located within a seismic impact zone.

9.5 Unstable Areas

The determination of potential unstable areas at the site is based on site observation and a review of existing documentation for the site by a licensed professional engineer and geologist. Based on this review, the foundation conditions and the geologic formations are stable. In addition, there is no evidence to suspect mass movement of natural foundations of earthen material on or in the vicinity of this site. No foundation problems exist at the site. Based on site observation, and review of the Trinity Engineering Testing Corporation Geotechnical Investigation of the site, the site is not located in an unstable area and the integrity of the site is not expected to become impaired by natural or human-induced events or forces. Based on information from existing geological and geotechnical data (reference: Bureau of Economic Geology, University of Texas at Austin), unstable areas due to poor foundation conditions, areas susceptible to mass movement, salt domes, or karst terrain do not exist at, or immediately adjacent to the Site. Therefore, additional engineering measures for unstable areas do not need to be incorporated. This determination was also based on information provided as part of the Geology/Soil Boring Report Appendix I/II 3.

SECTION 10.0 GROUNDWATER AND SURFACE WATER STATEMENTS (30 TAC § 330.61 (k) and 30 TAC § 330.63 (c))

10.1 Groundwater

Groundwater quantities are available from several different geologic formations in Haskell County. The principal shallow aquifer is from the basal sands and gravels of the Seymour Formation which lies above the Clear Fork Group. This strata is mapped as a major aquifer in north central Texas by the Texas Water Development Board. The Seymour formation generally produces good quality water suitable for drinking purposes. Mapping from TWDB shows the aquifer to not cover the site of the landfill.

Groundwater observations performed by Trinity Engineering Testing Corporation show that piezometer and open boring water data reveal that groundwater does exist within the shale strata at the existing landfill. The groundwater typically flows toward the northeast; however, a topographic divide in the southern section of the site apparently influences some water movement toward the south and southeast. Water level measurements during the study period show that groundwater occurs at a depth between 9 to 27 feet below the ground surface. The source of shallow groundwater is believed to be from surface recharge on the outcrop of materials at the site. Local groundwater variations may also be influenced by the thickness and type of surface soils, and the ponding of surface water.

Site studies also show that deeper groundwater does exist on the site between 30 and 40 feet below ground surface. See Appendix 3 for more information on groundwater conditions.

Consistent with the provisions of §330.549 related to groundwater, the facility is not located within the recharge zone of the Edwards Aquifer as identified in 30 TAC Chapter 213.

10.2 Surface Water

Consistent with §330.61(k)(2), a discussion of surface water at and near the site has been developed.

The existing Haskell MSW Landfill and proposed transfer station site is located in the Brazos River drainage basin of Texas. The proposed transfer station location will be near to the geographic center of the 160 acres. Red Creek traverses the far northern end of the property from west to east. The landfill permit boundary is located south of the creek approximately 250 feet. All areas where surface water leaves the property are along the north-northeastern boundary. The existing permitted area has surface water discharged by way of a natural swale that drains to the north of the permitted boundary. This outfall location is used for sampling of stormwater as required by the landfill's TPDES permit. The proposed transfer station will have minimal impact on surface water.

10.4 Stormwater Permitting

The existing landfill facility has been covered under TPDES Permit No. TXR05O812 under general permit TXR050000. The facility and proposed transfer station have been designed to prevent the discharge of pollutants into waters of the state and the U.S., as defined by the Texas Water Code and the Clean Water Act. Haskell MSW Landfill will amend their Stormwater Pollution Prevention Plan to include the new transfer station area. All liquids resulting from the operation of this facility shall be disposed of in a manner that will not cause surface water or groundwater pollution. This facility shall provide for the treatment of wastewaters resulting from waste management activities and from cleaning and washing in compliance with the storm water permit. Owners or operators shall ensure that storm water and wastewater management is in compliance with the regulations of the commission

Stormwater runoff from the developed landfill and proposed transfer station will be conveyed through perimeter drainage channels that discharge into detention basins prior to discharging offsite as overland flow. The surface water drainage system for the developed landfill is designed in accordance with 30 TAC §330.63(c). Stormwater will be conveyed from the landfill property into natural drainage features, into Red Creek.

Liquids resulting from the operation of the transfer station will be disposed of in a manner that will not cause adverse impact to surface waters or ground water. The transfer station is being designed to prevent discharge of pollutants into waters of the State or waters of the United States, as defined by the Texas Water Code and the Federal Clean Water Act, §402, as amended, respectively. Consistent with TCEQ requirements, a Notice of Intent (NOI) will be submitted to the TCEQ and a Stormwater Pollution Prevention Plan will be developed prior to the commencement of operations to obtain coverage under the Texas Pollutant Discharge Elimination System (TPDES) General Permit, TXR050000 for Stormwater Discharges associated with Industrial Activity. In addition, an NOI will be submitted the TCEQ and a Stormwater Pollution Prevention Plan will be developed prior to construction to obtain coverage under the TPDES General Permit, TXR150000 for Stormwater Discharges Associated with Construction Activity.

The City will obtain appropriate approvals or permits that may be required by local agencies for connection to a sanitary sewer or installation of an on-site domestic wastewater management system as such time as they are available.

The City of Haskell MSWLF #1604B and proposed transfer station meet the requirements of the NPDES Permit No. TXR050000 (TXR05P871) under the following sections of the Site Development Plan and Site Operating Plan.

A. All storm water control facilities shall be checked on a quarterly basis and repaired as needed.

B. Fuel berms shall be checked quarterly and repaired as required.
No fueling shall occur during storm events.

C. All measures contained in the Site Development and Site Operating Plans shall be maintained as required under their guidelines first, then with this SWP3 as additional requirements to those measures.

D. Potential pollutants which could pose a threat to storm runoff are as noted below and shall be revised within 30 days of any significant change as to the addition of any other possible pollutants;

   a. Oil collection station (landfill)
   b. Fuel storage (landfill)
   c. Construction debris cells (landfill)
   d. All other waste cells (landfill)
   e. Animal pits (landfill)

E. Storm Water Runoff routes will follow drainage patterns as shown in Part III Appendix 1

F. Site maps are covered in Attachments #1 of Part III

G. As of the time of writing of this Plan no reportable spills have occurred at this site within the past five years. This plan will be amended every time a reportable spill occurs within this facility.

H. Storm water runoff sampling shall occur during any runoff event at the runoff exit point located at the boundary of the Northeast comer of the landfill #1604B. Sampling records shall be kept with the Site Operating Plan Book for Landfill #1604B.

I. Sampling tests shall occur within the first 30 minutes of a storm discharge. The sample method shall be Grab Sample and the following tests are required for the sample taken; Iron-mg/L, TSS-mg/L and hazardous metals testing. The results are to be kept with the Site Operating Plan along with chain of custody forms used by the City and the Lab.

SECTION 11.0 FLOODPLAIN AND WETLAND STATEMENT (30 TAC § 330.61(m))

11.1 Floodplains

Consistent with §330.61(m)(1) and §330.547, the 100-year floodplain has been evaluated for the Haskell proposed transfer station located at the existing landfill.

The Federal Emergency Management Agency (FEMA) has prepared a Flood Insurance Rate Map (FIRM), for the area in and around the Haskell Landfill. These maps show that the landfill is not located within the 100-year floodplain. The landfill will not restrict the flow of the 100-year floodplains in the area, nor would it reduce the temporary storage capacity of the floodplain, or result in the washout of solid waste. See Floodplain Map Appendix 18.

11.2 Wetlands

In accordance with §330.61(m)(2) and (3) and §330.553, a wetlands determination and identification has been conducted for the site and confirmed with the US Army Corp of Engineers. The USACE performed a review of project information revealing that water features, potential waters of the US, and/or waters of the US are not present on site. Thus, the expansion will occur only on upland. If any situation occurs that affects a wetland, then compliance with Nationwide Permit 12 will be required during construction.

The work was conducted to identify areas subject to jurisdiction under Section 404 of the Clean Water Act. There are no applicable local ordinances or laws related to wetland areas.

The site was analyzed for the presence of wetlands and streams that meet the definition as defined by the Corps of Engineers Wetland Delineation Manual. The site does not contain any wetlands that meet the requirements of hydrology, hydric soils, or hydric plants. USGS topographic maps show one depression in the permit area located on the far eastern boundary of the site. This depression does not contain any hydric significance and only holds water during periods of extreme flooding. The depression is not located adjacent to a water of the U.S. and would not be considered jurisdictional even if it contained more hydric indicators. No direct, indirect, or cumulative effects to wetlands will result by the proposed improvements. The construction and operation of the municipal solid waste landfill unit or recovery operation shall not:

(A) cause or contribute to violations of any applicable state water quality standard;

(B) violate any applicable toxic effluent standard or prohibition under the Clean Water Act, §307;

(C) jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of a critical habitat, protected under the Endangered Species Act of 1973; and

(D) violate any requirement under the Marine Protection, Research, and Sanctuaries Act of 1972 for the protection of a marine sanctuary.

The Haskell MSW Landfill and transfer station property is not located in any wetlands or waters of the U.S.

SECTION 12.0 PROTECTION OF ENDANGERED OR THREATENED SPECIES (30 TAC § 330.61(n))

As outlined in §330.61(n) and §330.551, an evaluation of endangered or threatened species at or near the site has been conducted.

See coordination letters to the US Fish and Wildlife Service and the Texas Parks and Wildlife Department (with attachments) Appendix I/II Correspondence C3 and C7. These letters address the TCEQ regulations listed above, noting, "There are no record of rare, threatened or endangered species within 1.5 miles in the TNDD. The site is not in an area designated as critical habitat nor does the site provide suitable habitat for any federally-listed species. Construction and operation of the landfill will not endanger critical habitat or for any listed threatened or endangered species, nor will the site damage any suitable habitat for any federally-listed species.

The Texas Natural Diversity Database reveals no recorded instances of protected or endangered species at the site. The IPaC Trust Report shows no critical habitat for endangered or threatened species.

In view of the above, consistent with 30 TAC §330.61(n), it is concluded that the development and operation of this transfer station will not result in the destruction or adverse modification of the critical habitat of endangered or threatened species, or cause or contribute to the taking of threatened or endangered species or result in adverse impact to critical habitat of threatened or endangered species. Directions were given to ensure the state-listed Texas Horned Lizard is protected. See attached Biological Assessment (Appendix I/II 9).

Based on the evaluation by Jacob Martin LLC, in accordance with §330.551(a) the facility and the operation of the facility would not result in the destruction or adverse modification of the critical habitat of endangered or threatened species and would not cause or contribute to the harming or taking of any endangered or threatened species.

SECTION 13.0 LEGAL DESCRIPTION (30 TAC § 330.59(d)(1) &(d)(2)

A-408 WILLOUGHBY, L. SUR NO. 55 TRACT 1 - 160.0 ACRES Volume 416 Page 781

Part I Attachments 2,3,4,and 5.

Property Owner Affidavit Part I/II Appendix 11

SECTION 14.0 METES AND BOUNDS SURVEY

Both of the property and facility are in Attachments for Part I: I/2, I/3 , I/4 and I/5

SECTION 15.0 LEGAL AUTHORIT Y (30 TAC § 330.59(e)) & (h)

The applicant, the City of Haskell, is an incorporated city in the State of Texas since 1907 as a General Law Type A city. The city has an estimated population of approximately 3,195, based on current estimates. Under Texas Law, the City has the responsibility to provide for the management of solid waste generated by residents and businesses, and has the authority per jurisdiction of the city charter as the County seat of Haskell County and a General Law Type A city. The City is a General Law city under Local Government Code Section 51 and has no other charter. The city operates no other facilities in any other states. The City has operated the prior and existing landfills at this site since the early 1990s as MSW #1604. The City is not delinquent on any fees to the TCEQ.

SECTION 16.0 EVIDENCE OF COMPETENCY (30 TAC § 330. 59(f))

16. 1 CITY OF HASKELL

The applicant, the City of Haskell, currently owns and operates a Type 1AE MSW Landfill, TCEQ Permit No. MSW-1604B. The existing landfill has been operated by the City with revisions and amendments since prior to 1998. The City has a long track record of successfully operating a municipal solid waste landfill, including responding to TCEQ call-ins such as the SOP changes in 2008.

The competency of the City of Haskell to operate the proposed transfer station is evidenced by the City's operating history, over 20 years of operating Site 1604B. The City of Haskell has no financial interest in any solid waste facility any other state, territories. or countries.

16.2 THE CITY OF HASKELL KEY PERSONNEL

As with Site 1604B, the proposed transfer station will be administered within the City's Public Works Department. Key personnel include the following: City Manager and landfill operation staff; See also Attachment I/13.

- Winston Stephens, Public Works Director for the City, has over 6 years of experience in managing and operating landfills, in his time with the City. Mr. Stephens is responsible for managing all of the Public Works operations in the city including public water, waste water and solid waste. He provides experience and oversight of the Solid Waste department. He is also licensed in water distribution, water treatment and several other TCEQ licensed operations with almost 500 hours of continuing courses.

- Colton Pittman has worked at the landfill for over 6 years. He has taken the MSW Class A and B courses. He has passed the license exam and has a Class A license. He is the on-site operator . As that is of record, he is overseeing the operation, responsible for managing landfill staff, equipment maintenance, day-to-day operation of the landfill, regulatory compliance, community relations, and related activities.

- Ross Warington is the current Gate Keeper. He has had the TEC training in waste screening and has been with the City for over 4 years.

- Jim Smith is an equipment operator who has worked at the landfill in the past and is currently in his third year working for the City.

The City of Haskell will ensure that a transfer station employee is employed, and serves as the Solid Waste Facility Supervisor as defined in 30 TAC 30.207(2). The transfer station manager will have the requisite managerial and technical qualifications to assure that the City's proposed MSW facilities comply with TCEQ requirements arid is trained in the practical aspects of the design, operation, maintenance and supervision of a solid waste facility according to standards, rules or orders established by the TCEQ. These qualifications include the following:

- Education and/or Experience — A minimum of the required four or five years related experience and/or training, or equivalent combination of education and experience, for a A or B license.
- Language Skills — Ability to read and interpret documents such as safety rules, operating and maintenance instructions, and procedure manuals. Ability to write routine reports and correspondence.

16.3 EQUIPMENT TO BE DEDICATED TO THIIS FACILITY

Sufficient equipment will be provided to conduct site operations in accordance with the transfer station design and conditions and will include the following minimum number and types of equipment:

Table 3 summarizes the equipment used at the facility. The equipment type, number, size and function are also included.

Table 3 Transfer Station **Facility Equipment List**

Equipment Type	Number (Minimum)	Typical Size	Function
Diesel Tank	2	500 gallons	Equipment fuel
Road Grader or Maintainer	1	Various sizes	Grinding of excess road
Front Loader or skid steer load	1	Cat 930 or 252 or equivalent	Movement on tipping floor
Dump Truck	1	15 cu yd Mack or equivalent	Hauling of needed material across site.

The equipment requirements for this landfill will be based on anticipated solid waste volume and field conditions consistent with 30 TAC §330.127. The Director of Public Works, with input from transfer station personnel, will routinely assess the equipment needed to maintain compliance with the TCEQ regulations and make adjustments, as appropriate.

Backup Provision:

In the event of equipment repairs or during equipment maintenance periods, the facility will obtain equipment from other facilities, contractors, or local rental companies to avoid interruption of waste services.

16.4 OTHER PERMITS /AUTHORIZATIONS

Consistent with 30 TAC §305.45(a)(7), the following table lists all permits or construction approvals that the City of Haskell will apply for related to the proposed landfill. Construction and operation of the landfill will comply with 30 TAC Chapter 330 Subchapter U and 330. 55 (a) and all air authorizations will be coordinated with TCEQ Air Permits Division.

PERMIT PROGRAM	LANDFILL APPLICABILITY
(A) Hazardous Waste Management Program under the Texas Solid Waste Disposal Act	N.A.
(B) Underground Injection Control Program under the Texas Injection Well Act	N.A.
(C) National Pollutant Discharge Elimination System Program under the Clean Water Act and Waste Discharge Program under Texas Water Code, Chapter 26	See Note 1
(D) Prevention of Significant Deterioration Program under the Federal Clean Air Act (FCAA)	N.A.
(E) Nonattainment Program under the FCAA	N.A.
(F) National emission standards for hazardous air pollutants preconstruction approval under the FCAA	N.A.
(G) Ocean dumping permits under the Marine Protection Research and Sanctuaries Act	N.A.
(H) Dredge or fill permits under the FCAA	N.A.
(I) Licenses under the Texas Radiation Control Act	N.A.
(J) Subsurface area drip dispersal system permits under Texas Water Code, Chapter 32	See Note 2
(K) Other Environmental Permits	See Note 3

Notes:

1. See Parts I/II, Section 10, related to compliance with the Texas Water Code and the Federal Clean Water Act. Storm Water Permit

2. An on-site sanitary sewage system serves the employees and visitors of the City's solid waste facilities.

3. The City will complies with the Standard Air Permit Certification consistent with Chapter 330, Subchapter U.

4. N.A.: not applicable

SECTION 17.0 APPOINTMENTS (30 TAC § 330.59(g))

17.1 The owner or operator shall provide documentation that the person signing the application meets the requirements of §305.44 of this title (relating to Signatories to Applications). If the authority has been delegated, provide a copy of the document issued by the governing body of the owner or operator authorizing the person that signed the application to act as agent for the owner or operator. All delegated signatory authority will meet the stated requirements.

17.2 305.44 (3) For a municipality, state, federal, or other public agency, the application shall be signed by either a principal executive officer or a ranking elected official. For purposes of this paragraph, a principal executive officer of a federal agency includes the chief executive officer of the agency, or a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., regional administrator of the EPA).

(b) A person signing an application shall make the following certification: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

All delegated signatory authority will meet the stated requirements. Anyone other than the Mayor of Haskell City will show authorization by the Mayor and City Council.

SECTION 18.0 COUNCIL OF GOVERNMENTS (30 TAC § 330.61(p)) AND TEXAS HISTORICAL COMMISSION (30 TAC § 330.61(o))

As outlined in §330.61(p), Parts I and II of this application were submitted for review to the West Central Texas Council of Governments to determine compliance with the regional solid waste plan. Since the Haskell MSW proposed transfer station is not located within any city limits, there is not an appropriate local government solid waste plan and review process (Haskell County Judge correspondence in support). Documentation of coordination with the West Central Texas Council of Governments is located in Correspondence Listing C6 (notification and delivery of Parts I and II).

Consistent with §330.61(o), a request for review was submitted to the Texas Historical Commission through eTRAC (202101848)documenting compliance with the Natural Resource Code, Chapter 191, Texas Antiquities Code (for the proposed lateral expansion of the landfill prior to changing directions to utilize a transfer station). No archeological survey is needed. However, if cultural materials are encountered during project activities, work should cease in the immediate area; work can continue where no cultural materials are present. Please contact the THC's Archeology Division at 512-463-6096 to consult on further actions that may be necessary to protect the cultural remains. The review letter and documentation can be found in Appendix 12 and Correspondence Listing C4.

LIST OF PREPARERS

Names of Persons Contributing

- Ken Martin – Professional Engineer (Jacob Martin, LLC)
    - Document Review
- Kirt Harle – Professional Engineer (Jacob Martin, LLC)
    - Drainage Plan
- David Hudson – Environmental Scientist (Jacob Martin, LLC)
    - Authored Environmental Report

HASKELL MSW TRANSFER STATION

Part I/II Appendices

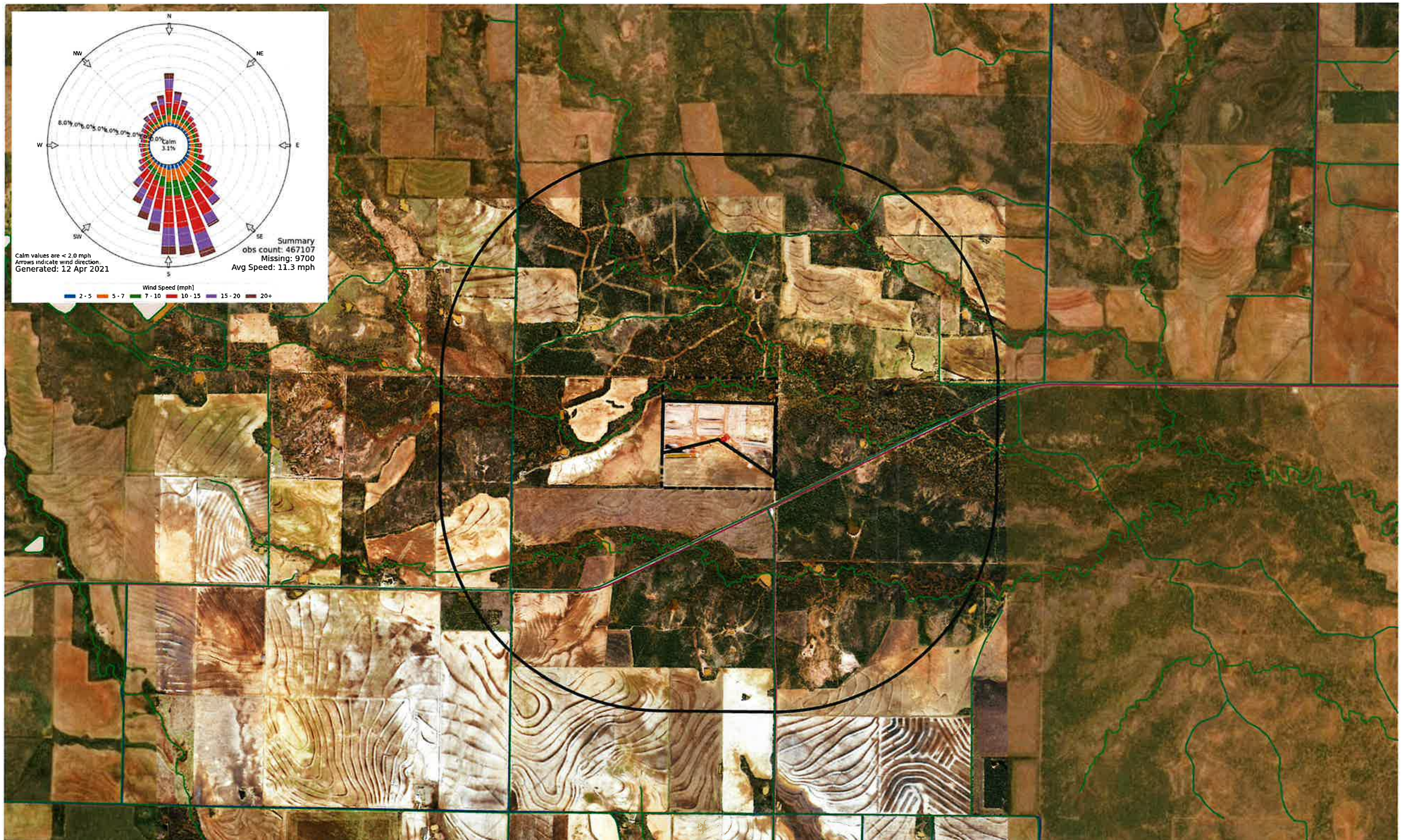
Appendix #1

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8/9/21

Attachment 1-1
August 2 2021

TABLE OF CONTENTS

KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8/9/21



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LEGEND

- Landfill Boundary
- Benchmark
- Fenced Boundary
- Property Boundary
- ONE MILE BUFFER
- Transfer Station

Proposed Transfer Station
Part I/II Appendix 1 Page 1-3
June 15 2021
Revision:
Latitude:33.1734445°
Longitude:-99.6451909°
Benchmark: 1479.13'

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

Aerial Map 2018 NAIP

Haskell Transfer Station

JACOB | MARTIN
FIRM# - F2448

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #2

STATE OF
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER
8-9-21

Attachment 2-1
August 2, 2021

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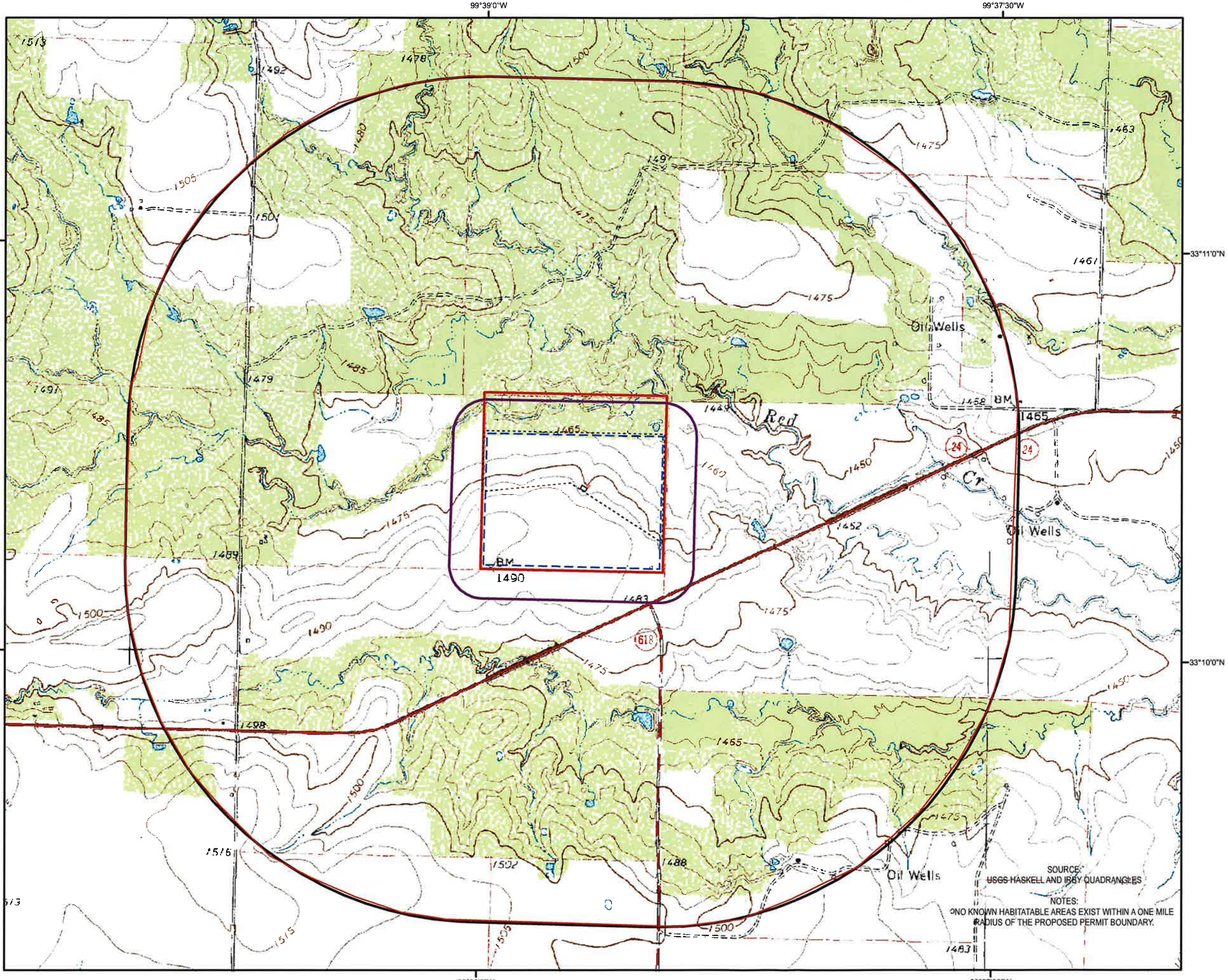
STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER
8-9-21



N
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0 1,000 2,000 Feet

LEGEND

- 500' BOUNDARY
- ONE MILE BOUNDARY
- LAND BOUNDARY
- FENCED BOUNDARY
- LANDFILL BOUNDARY
- TRANSFER STATION

HASKELL COUNTY
TEXAS

GENERAL LAND USE	
OPEN LAND	98 %
WATER BODIES	1 %
ROADWAYS	1 %

Proposed Transfer Station
Part II Appendix 2 Page 2-3
June 15 2021
Revision:
Latitude:33.1734445°
Longitude:-99.6451909°
Benchmark: 1479.13'

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

Haskell Transfer Station

JACOB & MARTIN, LTD.
CONSULTING ENGINEERS
3465 CURRY LANE, ABILENE, TX 79606
325-695-1070
1508 SANTA FE DR., STE. 203, WEATHERFORD, TX 76086
817-594-9880

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #3

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8/9/21

Attachment 3-1
August 2, 2021

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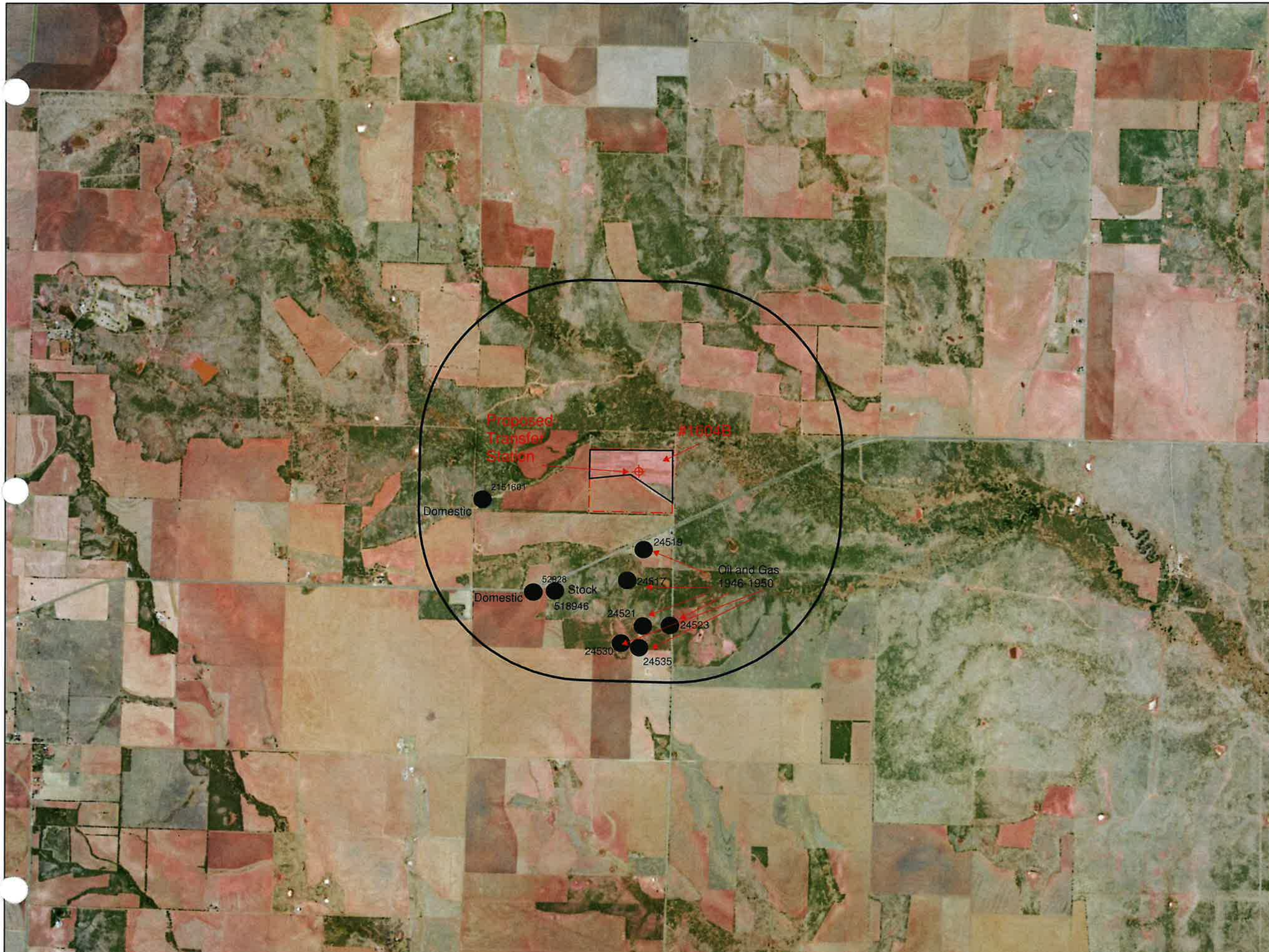
Boring/Geology Report

Attachment# - Page #

KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8/9/21



N
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0 0.25 0.5 1 Miles

LEGEND

Transfer Station
LANDFILL BOUNDARY
PROPERTY BOUNDARY
WATER WELL
ONE MILE BUFFER
BENCHMARK

HASKELL COUNTY
TEXAS

1). Aerial Map Hosted from ESRI Website.
2). There are no springs located within one mile of the permit boundary.
3). Water wells identified from the online state records.
4). The well lcoation provided by coordinates identified in TWDB documents and drilling reports.

Appendix I/II 3
October 30, 2020
Revision:
Page 3 Water Wells & Springs
Benchmark
Latitude:33.1734445°
Longitude:99.6451909°
Benchmark: 1479.13'

KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8/19/21

WATER WELLS & SPRINGS MAP

HASKELL MUNICIPAL LANDFILL
CITY OF HASKELL, TX
MAJOR AMENDMENT

JACOB|MARTIN
FIRM# - F2448
3465 Curry Ln
Abilene Tx, 79606
(325)695-1070

Trinity Engineering Testing Corporation

GEOTECHNICAL INVESTIGATION
HASKELL REGIONAL LANDFILL
HASKELL, TEXAS

FOR

JACOB & MARTIN, INC.

ABILENE, TEXAS

AND

THE CITY OF HASKELL

HASKELL, TEXAS

DECEMBER, 1990

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Page

GEOTECHNICAL INVESTIGATION

HASKELL REGIONAL LANDFILL

HASKELL, TEXAS

INTRODUCTION

GENERAL: This investigation was requested by Mr. Kenneth Martin, P.E. of Jacob and Martin, Inc., in May, 1990. Mr. Robert Baker, City Manager of Haskell authorized our work on June 27, 1990.

A proposal for the boring plan and general scope of investigation was sent to Mr. Wayne Lee, Bureau of Solid Waste Management at the Texas Department of Health on July 24, 1990. This investigation was performed according to soil data requirements in the Texas Department of Health's Municipal Solid Waste Management Regulations (Reference 1) and oral recommendations by Mr. Wayne Lee on August 16, 1990.

PURPOSE: This investigation will be included as Attachment No. 11 - Soils Report in the permit application performed by Jacob and Martin, Inc. The primary purpose of this investigation is to provide prudent information regarding subsurface characteristics and recommendations for site development. Since municipal waste disposal sites have the potential to contaminate shallow groundwater systems, it is imperative to understand the subsurface characteristics of the proposed site.

LOCATION: The project site concerns an existing 65 acre Type II Municipal Solid Waste Site (Permit No. 1604) located approximately four miles east of Haskell, Texas in Haskell County (Plate I). The City of Haskell proposes to convert the Type II Landfill into a 160 acre Type I Municipal Solid Waste Site.

OPERATION: Trench disposal techniques have been previously utilized in the permitted section of the site. Currently, several trenches have been excavated which lie between filled trench areas (see Plate IV). Typically, trench depth has been about 20 to 25 feet.

The proposed operation of the Type I Landfill will utilize an area fill method. It is expected that maximum excavation depths will be about 30 feet.

METHOD: The following services were developed to complete this report:

1. Background Data - Research of available publications pertaining to the regional geology and groundwater characteristics of the area.

2. Subsurface Drilling - Recovery of relatively undisturbed samples at the site in order to establish site stratigraphy and lithology.

3. Groundwater Evaluation - Document groundwater conditions and install temporary piezometers to evaluate seasonal groundwater fluctuations. Selected groundwater samples were collected for analytical testing.

4. Laboratory Investigation - Classification and permeability testing to evaluate insitu and liner material suitability characteristics.

5. Site Assessment - Evaluation of collected data regarding applicable regulatory requirements and site development recommendations.

FIELD EXPLORATION

DRILLING METHOD: Subsurface materials at the 160 acre tract were investigated by 24 core borings; 4 borings were drilled to a 100 foot depth, 10 borings were drilled to a 50 foot depth, and 10 borings were drilled to a 35 foot depth. The boring locations are shown on Plate IV in Appendix I. The borings were staked in the field by the author and surveyed by Jacob and Martin, Inc.

The drilling procedure for this investigation generally involved recovering undisturbed or representative samples continuously from the borings using the following methodology:

1. Continuous hydraulic pushing through cohesive soils using a 24-inch length by a 3-inch diameter steel tube sampler, until refusal;

2. Advancing the boring through shale or hard rock materials by rotary drilling using a 4.5-inch wing bit or an NWD-size double tube core barrel.

Generally, each boring was advanced utilizing dry methods (compressed air) until high moisture conditions in the soils prevented efficient advancement. At the end of each Log of Boring (Appendix II), the depth is noted when water as a drilling fluid was utilized.

SAMPLING METHOD: All samples were retrieved from the individual samplers in the field, classified and identified according to boring number and depth. Push-tube samples and NWD-size core samples of 4-inch length or greater were sealed in plastic or aluminum foil to minimize moisture changes. All samples were arranged in core boxes and transported to the laboratory for further analysis. The samples will be stored for 3 months in the laboratory following completion of this investigation unless notified otherwise.

GROUNDWATER OBSERVATIONS: During the drilling operation, groundwater observations were conducted to aid in the evaluation of the subsurface conditions. Bore holes were left open and bailed of drilling fluids to facilitate well development and help determine static groundwater elevations. Following field operations open bore holes were plugged with bentonite. Appendix III contains groundwater measurements taken between July 12 and November 7, 1990. Notes at the bottom of the Logs of Boring summarize the approximate static water levels evaluated for each boring location.

PIEZOMETER INSTALLATION: At nine of the boring locations shown on Plate IV, temporary piezometers were installed in order to measure groundwater levels for several seasons prior to finalizing the groundwater protection plan. Piezometer wells vary between 25 and 60 feet in depth. Three of the wells were designed to evaluate water conditions of the deeper strata isolated below the water table; the remaining wells were completed or sealed above the water table.

Piezometers consist of 2 inch diameter schedule 40 PVC slip jointed pipe with hand cut screen sections. Pea gravel was back-filled around the pipe annulus and bentonite pellets or bentonite grout was utilized to seal the annulus. A surface concrete slab was constructed around each piezometer in order to seal the hole from surface water contamination. Piezometers were reported to the Texas Water Well Drillers Board as required by State law. Appendix III includes Piezometer Well Data Sheets summarizing the design of each well.

FIELD PERMEABILITY TESTS: Addition and/or recovery slug tests were performed in Piezometer Nos. B-5, B-12 and B-16 in order to determine the hydraulic conductivity at each well. These tests were performed by causing an instantaneous introduction or removal of water in the piezometer and recording the water level recovery with time. Hydraulic conductivity was calculated using the Hvorslev method in which a homogeneous, isotropic and infinite medium under water table conditions is assumed (Reference 2). An example calculation and graphical results are presented in Appendix III.

LABORATORY INVESTIGATION

MATERIAL CLASSIFICATION: All samples of subsurface materials retrieved from the borings were examined and classified in the laboratory. Atterberg limit and minus 200-mesh sieve tests were performed on selected representative samples to determine physical properties and to establish potential permeability characteristics. Results of these tests, along with in-situ moisture contents, are summarized on Plate V. Laboratory classification of the subsurface materials were performed by applying the "Unified Soil Classification System".

Careful inspection of the recovered samples were performed regarding lithology, hardness, moisture, color, texture and the occurrence of discontinuities such as slickensides or fractures. Typical soil/rock classification and drilling symbols, weathering and soil structure characteristics are explained on the attached 'Key Used on Logs of Boring' at the front of Appendix II.

RELATIVE CONSISTENCY: During the logging process, push-tube samples were subjected to pocket penetrometer tests to evaluate the relative consistency of the cohesive soils. The pocket penetrometer readings are shown on the Logs of Boring under the column labeled "N-Blows per Foot". Readings shown as "4.5+" indicate that the dynamic range of the device was exceeded. In general, as the pocket penetrometer readings increase, the unconfined compressive strength increases.

RQD DETERMINATIONS: The quality of the NWD-sized core return was examined through use of the Rock Quality Designation (RQD). Characteristics concerning fractures and discontinuities in the consolidated materials are represented by the RQD. The RQD is a modified core recovery ratio which is determined by adding the lengths of NWD-sized core samples at least four inches long and dividing the sum by the length of the core run. The ratio is expressed as a percentage. Results of the RQD measurements are shown on the right side of the Logs of Boring.

ANALYTICAL TESTS: Groundwater samples were collected in accordance with Municipal Solid Waste Regulations from the piezometers located within approximately 200 feet of existing solid waste buried at the site. Groundwater samples were initially collected from Piezometers B-5, B-6, B-9 and B-10 on September 5, 1990. On November 7, 1990 additional groundwater samples were collected from Piezometers B-3, B-6 and B-9. Samples were submitted to consulting analytical laboratories for chemical analysis. Heavy metals, inorganic constituents and various other parameters were evaluated to help assess background values and the geochemical nature of the shallow groundwater. Appendix III contains the results of the chemical analysis and tables for comparing the values to established Environmental Protection Agency drinking water standards.

SAMPLE PERMEABILITY TESTS: Flexible wall, back-pressure head permeability tests were conducted on various undisturbed cohesive soils, siltstones, shales, and a remolded composite sample. Laboratory permeability test results are subject to various testing parameters including sample size, sample orientation, testing time, hydraulic gradient and confining pressure. Testing parameters were designed to limit excessive pressures and evaluate steady state conditions.

Samples were selected with the intention of showing the range of possible hydraulic conductivities for intact consolidated shales or siltstones and samples with fractures or discontinuities. Horizontally and vertically oriented samples were tested to determine permeability characteristics of side and bottom landfill areas.

A permeability test was also conducted on a remolded composite sample collected from material excavated from the active waste area to evaluate the suitability of these materials for liner construction. The composite sample was compacted to approximately 95 percent of maximum density and slightly above optimum moisture conditions. Moisture-density relationships for the composite soil sample and Permeability Data Sheets are reported in Appendix IV. Plate VI summarizes laboratory permeability test results.

APPLICABLE TEST STANDARDS: The following test standards were used for this investigation:

a. Unified Soil Classification System: ASTM D 2487-83
b. Atterberg Limit Tests: ASTM D 4318-84
c. Minus 200-Mesh Sieve Tests: ASTM D 1140-71
d. Moisture Content Tests: ASTM D 2216-80
e. Compaction Test: ASTM D 698-78
f. Pressure Head Permeability Test: Corps of Engineers Design Manual EM-1110-2-1906

GEOLOGIC INVESTIGATION

PHYSIOGRAPHY: Haskell County lies in northwest-central Texas within the province known as the Abilene Haskell Rolling Plains. The high rolling plains generally rise in elevation toward the west. The study site lies within the Brazos River Drainage Basin.

The study site is situated near a basin divide between two tributaries of Red Creek located to the north and south (Plate I). Generally, land surface slopes gently toward the northeast where a small intermittent creek transverses the property. Maximum elevation relief is about 33 feet at the site based on the topographic survey map prepared by Jacob & Martin, Inc.

LANDUSE: The land surrounding the existing solid waste activities are currently being utilized for cropland and rangeland. Most of the land area is cultivated and terraced (Photograph 1 and 2). A northern section of the site is covered with thick grasses, and scattered small mesquite and hackberry trees (Photograph 3). A shallow stock tank is located near the northeast corner of the rangeland area (Photograph 4). Another small water tank lies to the east of the existing waste area. The landfill site is bordered on all sides by cropland or rangeland.

CLIMATE: Climate directly affects the surface and groundwater hydrology of a site, and therefore influences the site suitability for shallow waste disposal. Haskell County has a semiarid to subhumid environment with an annual rainfall of 23 inches. Seventy-five percent of the precipitation occurs between April and October (Reference 4) when the mean air temperatures are also the highest. Rainfall data from the Weather Bureau Field Office in Haskell for the months during this investigation indicated that current precipitation amounts in the area are relatively close to the historical monthly averages.

REGIONAL GEOLOGY: The stratigraphic sequence of rocks in the study vicinity are shown on Plate II. Geologic publications (References 3 and 4) and subsurface material characteristics indicate the proposed landfill site lies within the outcrop of the Vale Formation of the Clear Fork Group. These Permian deposits are exposed in gently west-northwestward dipping (approximately 50 feet per mile) strata in narrow, successively younger belts from east to west across the county (Reference 4). Haskell County lies on the eastern border of the major salt accumulation beds in west Texas. The Permian sediments are commonly referred to as the 'red beds' due to their primary color.

The Pease River Group is exposed west of the study site and consists largely of sandstone, gypsum and shale. The San Angelo sandstone, lower most formation of the Pease River Group, rests disconformably upon the formations of the Clear Fork Group. Below and outcropping to the east of the Clear Fork Group occurs the Wichita Group which consists chiefly of massive fossiliferous limestone beds (Reference 4).

The Clear Fork Group is divided into three formations: the Choza, Vale and Arroyo in descending order (Reference 5). Generally, all these formations are composed of shales with relatively thin layers of limestone, dolomite, sandstone, gypsum and marl. The shales are usually not distinguishable, and the formations are mapped based on prominent limestone and dolomite beds.

The Bullwagon Dolomite Member of the Vale Formation is believed to occur west of the landfill site. The Vale Formation overlies the Standpipe Limestone or Rainy Limestone Member of the Arroyo Formation. The Vale Formation at the study site consists of typical Permian red beds composed largely of shales interbedded with thin limestone and siltstone layers. The reddish brown shales contain irregular splotches or circular spots of greenish or grayish color.

Plate III is a geology map of the project vicinity which shows that a large area near the site is overlain by the Seymour Formation. These Pleistocene sediments consist of clays, silts, sands and gravels deposited on an uneven erosional surface of the Permian shales. The Seymour Formation is between 30 and 60 feet thick in Haskell County (Reference 6).

GEOLOGIC HISTORY: Rocks of the Permian age, deposited approximately 300 million years ago, are represented by various depositional environments including fluvial, deltaic, channel fill and tidal flats (Reference 7). It is believed that sediments of the Clear Fork Group were deposited primarily within a broad, restricted, shallow sea that was receding toward the west. The Permian sediments were probably derived from red residual soils in the upland plains and Quachita Mountains located to the east of the basin (Reference 8).

The massive weight of sediments and cementing processes slowly lithified the materials into a consolidated rock. Irregular fractures and slickensides present throughout the Permian red beds are probably the result of tectonic stresses (Reference 9). The irregular gray spots may be due to saline fluids causing a reduction of the iron oxides (Reference 8). Geologic literature review did not identify any evidence of past or present faulting in the area. Review of several aerial photographs did not identify any lineations believed to be associated with faulting.

REGIONAL HYDROGEOLOGY: Groundwater quantities are available from several different geologic formations in Haskell County. The principal shallow aquifer is from the basal sands and gravels of the Seymour Formation which lies above the Clear Fork Group. This strata is mapped as a major aquifer in north central Texas by the Texas Department of Water Resources (Reference 10). Plate III identifies the numerous shallow wells within the City of Haskell developed in the granular Seymour sediments. The Seymour Formation generally produces good quality water suitable for drinking purposes. Production rates in the Seymour Aquifer are reported between 50 to 1300 gallons per minute (Reference 4).

Permian sediments have widely variable groundwater characteristics due to their various lithologies. The San Angelo Sandstone Formation, the Bullwagon Dolomite Member of the Vale Formation, the Standpipe Limestone Member of the Arroyo Formation, and the Lueders Formation are the geologic strata most likely to yield suitable shallow groundwater (See Plate II). All these units are exposed to the east or west of the study site.

Wells more than 150 feet deep in the Permian sediments are unlikely to yield potable water (Reference 11). Regional groundwater flow in the Permian beds generally follow the westward dipping strata (Reference 11). The main source of recharge to the sediments is precipitation on the outcrop, therefore, as groundwater moves down dip, it typically becomes highly mineralized with increasing depth.

Regionally, groundwater is found in the shales of the Clear Fork Group and similar Permian red beds (Reference 6). Fresh to moderately saline water occurs within the 'fractures in friable red clay' and in the relatively thin limestone, dolomite or sandstone beds (Reference 4). However, the shale beds generally yield small quantities of water of poor quality. Groundwater in the red beds usually becomes highly mineralized with increasing depth and is commonly suitable only for livestock purposes. In Jones County, there are 3 wells developed in shales of Clear Fork Group which yield about 100 gallons per minute, but most wells in the shales yield only a few gallons per minute (Reference 11).

A water well search of plotted wells within 1 mile of the project site was performed by Geosource, Inc. This search located one livestock well identified on Plate III as Well No. 6. The well report form and an analytical statement for this well is included in Appendix V. During the field work, one abandoned livestock well was found near the southeast corner of the study tract (Plate IV). Another abandoned well was identified several hundred feet north of the tract (Plate IV). Data concerning these abandoned wells are also reported in Appendix V.

SITE STRATIGRAPHY AND MATERIAL CHARACTERISTICS

GENERAL SITE STRATIGRAPHY: Specific types and depths of subsurface materials are shown on the Logs of Boring in Appendix II. West-east and north-south cross sections (Plates VII and VIII) illustrate the general stratigraphy based on the recovered materials.

Surface soils vary from 1.5 feet to over 13.5 feet in thickness overlying the primary shales at the site. Plate VIII shows that the residual surface clays generally become thicker toward the northern section of the site. The average thickness of the surface soils based on the borings are about 6 feet.

The primary shales of the Vale Formation were found in all the borings to their termination depths. A drillers' log of the wildcat well located on the site indicates that the Vale Formation is approximately 260 feet thick below the landfill (Appendix V). The oil well log indicates that thick sequences of limestone, shale and dolomite primary underlie the site to a depth of 5575 feet. Also included in Appendix V is a written certification of the plugging method used in the abandoned oil well. It should be noted that the surface plug extends down to a depth of only 19 feet.

SOIL CLASSIFICATION: Plate V summarizes the Atterberg limit, minus 200-mesh sieve, moisture content and classification results of representative soils recovered from the borings. Surface soils vary considerably in engineering properties, but are typically composed of brown to reddish brown medium plasticity silty or sandy clays.

In a few scattered areas, the top horizon consists of high plasticity dark brown to brown clays which grade into the underlying silty clays. The silty clays often grade directly into the underlying primary shales; however, in some areas an intermediate layer of clayey sand with gravel occurs. The granular materials in the soils are generally composed of caliche or calcareous particles.

PRIMARY FORMATION: The reddish brown shales that underlie the landfill site have relatively consistent engineering properties. Generally, the shales consist of medium plasticity clays with a hard consistency. Natural moisture content typically appears to decrease with depth. The shales are consolidated clays and could possible be defined as mudstones due to the lack of a fissile texture in many samples. However, upon drying, the cores typically break more readily in horizontal layers.

Calcium carbonate and/or silicon is evidently a cementing agent in the shales and has resulted in relatively high strength characteristic. Some of the shales could be classified as marls or calcareous shales exhibiting very high strengths. Variable calcium content probably affects the plasticity indexes evaluated on Plate V. Mechanical crushing and repeated drying the shale samples were necessary to break apart the clays for the minus 200-mesh sieve tests.

Relatively thin, poorly cemented siltstone and hard limestone beds occur scattered throughout the shale stratum. Occasional conglomerate beds also occur. Cross sections indicate that these beds are laterally discontinuous. Limestone beds are typically only a few inches thick. Siltstone beds are usually about 6 inches to 1 foot thick with a maximum thickness of about 4 feet. Photograph 5 shows a 2 foot thick conglomerate bed steeply dipping along a side wall of a trench at the site.

Since the shales were oxidized materials at the time of deposition, there is no definite color change due to weathering as is often observed in other shale formations. However, inspection of the recovered samples indicate that desiccation cracks, fractures and bedding planes are more prevalent in the upper 30 feet of the sediments. RQD evaluations show that the upper 30 feet have an average value of 29 percent compared with a 41 percent average in core samples between 30 and 60 and 60 and 100 feet.

Irregular breakage planes, fractures and slickensides are present in most of the shale samples recovered. The discontinuities are typically 'hair line' cracks without any mineral infilling or discoloration. Photograph 6 shows the irregular nature of the fractures present in the shales at a depth of about 20 to 25 feet.

PERMEABILITY TESTS: Laboratory permeability tests are summarized on Plate VI. Test results indicate that hydraulic conductivities vary significantly in the shales that were tested. Intact shale samples showed the lowest permeability values ranging between 4.5x10E-8 to 8.6x10E-10 centimeters per second (cm/sec). Static conditions (equal inflow vs. outflow) were generally difficult to establish in these samples. There was not observable consolidation or swelling of these intact shales, yet there was an increase in moisture content which suggests that the clay matrix is unsaturated.

Seven shale samples were tested in the permeameter which exhibited fractures transversing the cores. Results show that some fractures in the shales increase the permeability significantly compared to the intact shales. However, some fractured shales remain relatively impermeable. Hydraulic conductivities ranged between 2.0x10E-5 to 4.2x10E-8 cm/sec in the fractured shales tested.

Two siltstone samples were tested in the permeameter which indicated the vertical permeability is relatively low. However, it is believed that horizontal permeability in these materials would be significantly higher due to their definite layered texture.

Field permeability results also indicated variable hydraulic conductivities exist in the insitu materials at the site. Piezometer Nos. B-12 and B-16 each responded well and recovered nearly completely within 100 minutes. Piezometer No. B-5 showed almost no response over a period of 100 minutes (Appendix III). The calculations resulted in a range of hydraulic conductivities from 2.1x10E-5 cm/sec in B-12 to 4.7x10E-5 cm.sec in B-16. The hydraulic conductivity for Piezometer No. B-5 could not be calculated due to lack of response; however, it can be assumed to be much lower than Piezometer Nos. B-12 or B-16.

A laboratory permeability test was also conducted on a remolded sample consisting of representative material collected from a site excavation. The moisture/density curve and remolded sample was performed with the site material without further processing in order to help simulate actual liner compaction techniques. The laboratory permeability test and classification tests indicate that most of the shales and surface soils at the site would be acceptable liner material.

SUBSURFACE WATER CONDITIONS

SHALLOW GROUNDWATER: Groundwater observations during the drilling operation, piezometer and open boring water data reveal that groundwater does exist within the shale strata at the landfill site (Appendix III). The groundwater table contour map (Plate IX) shows that the hydraulic gradient generally follows the topographic contours shown on the site plan. Flow lines on the map show that the local direction of water movement is generally toward the northeast. However, a topographic divide in the southern section of the site apparently influences some water movement toward the south and southeast.

Groundwater data observations collected between July 12 to November 7, 1990 show that spatial and temporal distributions occur in the unconfined shallow groundwater system. During periods of increased precipitation or drought, the groundwater table may be expected to vary considerably. Water level measurements during the study period show that groundwater occurs at a depth between 9 to 27 feet below the ground surface.

Groundwater flow is probably influenced significantly by the heterogeneous nature of the fracture permeability in the shales, and the variable character of siltstone, limestone and conglomerate beds found at the site. Groundwater systems dominated by fracture flow are particularly difficult to characterize.

The source of shallow groundwater is believed to be from surface recharge on the outcrop of materials at the site. Local groundwater variations may also be influenced by the thickness and type of surface soils, and the ponding of surface water at the site.

Utilizing Darcian principles, the average linear velocity can be roughly predicted by multiplying the hydraulic conductivity times the hydraulic gradient and dividing by the effective porosity. Assuming conservative hydraulic conductivities and effective fracture porosities of the shales, and based on measured field hydraulic gradients, it can be estimated that lateral groundwater velocity is probably less than 1 foot per year.

DEEP GROUNDWATER: Based on Piezometer Nos. 5 and 10 which were isolated in shale strata between 30 and 40 feet, groundwater also occurs at these greater depths. Groundwater measurements in these piezometers are consistent with the surrounding water elevations. Publications on regional groundwater characteristics in the Permian shales also indicate that water typically occurs throughout the strata. As discussed previously, groundwater recharge in the deeper strata, particularly in the more permeable sediments, would occur where the westward dipping strata outcrop on the surface.

Groundwater flow conditions at the site are probably influenced by the occurrence of more permeable siltstone strata. It is expected that lateral flow through these sediments is greater than the vertical or lateral flow within the shales. The siltstone layers may serve as layered semi-confined water bearing units within the unconfined system. Observations during the drilling of B-4 showed a rapid water level rise upon encountering the siltstone layer at 34 feet.

GROUNDWATER QUANTITY: Specific pumping tests were beyond the scope of this investigation to determine the specific yield and transmissivities of the water bearing strata. However, based on bailing operations, permeability test results and classification of the subsurface materials, the amount of water within the sediments is relatively small. In Piezometer No. 6, the most productive well, the yield is at least about 1 gallon per minute. In the event that excavations encounter groundwater, significant dewatering problems are not expected due to the relatively low permeabilities of the shales and siltstones.

GROUNDWATER QUALITY: Groundwater quality within shale type strata are typically relatively poor with high total dissolved solids (TDS), sulphates, carbonates, sodium and calcium constituents. Groundwater samples collected from Piezometer Nos. B-3, B-5, B-6, B-9 and B-10 were analyzed for various parameters and the results generally indicated a highly mineralized water characteristic of shale environments (Appendix III).

The groundwater quality is very poor in the wells tested. Groundwater could be classified as a brackish, high sulfate, high chloride and high bicarbonate type water. Constituent levels significantly exceed maximum concentration limits for drinking water standards established by the EPA (See Appendix III) for arsenic, selenium, chlorides, fluoride, sulfates and TDS. Furthermore, the constituent levels of arsenic and selenium exceed recommended concentration limits for livestock, and the TDS, arsenic, boron, fluoride and selenium levels exceed the recommended concentrations for irrigation of crops. Repeat testing in several of the piezometers generally resulted in similar results; however, selenium concentrations were found to be non-detectable in the second analysis.

Analytical results show chemical values that vary widely between the sampled wells. Upgradient testing (B-3) indicates that the high inorganic constituents found in the piezometers near the existing landfill are naturally occurring chemical properties of the groundwater. There is no definite pattern to the high constituent levels and well location, in relation to the existing solid waste. It is known that under certain conditions, naturally occurring arsenic can exceed limits specified in drinking water standards. High arsenic levels may also be related to past agricultural practices at the site. High levels of selenium can also naturally exist in appreciable concentrations in rocks such as shale (Reference 2).

Groundwater samples from Piezometer Nos. B-6 and B-9 were tested for several volatile organics (laboratory test EPA #602) in order to determine if previous landfill activities could have contaminated the groundwater. Analytical results (Appendix III) show that detectable concentrations of benzene, ethyl benzene and toluene existed in the sampled water. Constituent levels were very low (5.35 to 9.60 parts per billion) which could indicate diluted concentrations of leachate. Volatile organic compounds are commonly found in solvents, degreasers, paints, paint thinners, and in some household cleaners.

SITE EVALUATION AND DEVELOPMENT

GENERAL SITE SUITABILITY: Site suitability depends on many interrelated parameters including landuse, climate, topography, hydrology and geology. There are also nongeohydrologic factors significant in landfill siting such as social, economic, demographic and landuse, but these factors are beyond the scope of this report.

The subsurface material characteristics and hydrologic conditions have both favorable and unfavorable properties at this site which should be considered for planning site development. The relatively shallow water table and generally fractured consolidated shales are potential disadvantages. However, the low hydraulic gradients and expected flow rates, the limited storage capacity and generally poor quality of the subsurface water are positive aspects. Furthermore, visual inspection of the recovered core, laboratory and field permeability test results indicate that most of the existing discontinuities in the shales, particularly at greater depths, have very low or non-transmissive properties. Existing trenches at the site have not encountered any sidewall groundwater seepage problems, even though the trench depths are below projected groundwater levels. It may be that due to the low transmissivity of the shales, the groundwater is evaporating before seeping out.

The relatively shallow groundwater conditions and permeability characteristics of the insitu materials at this site are the primary considerations in the engineering design of the waste containment areas. Laboratory and field permeability testing, and characteristics of recovered materials indicate that the upper 30 feet of sediments generally would not satisfy the hydraulic conductivity requirement of 1.0x10E-7 cm/sec. Permeability in the insitu materials decreases with depth, due to the decreasing number of fractures and the closing of relative apperture spacing in the shales. However, there remains evidence that at least some shale fractures and siltstones at greater depths would exhibit permeabilities greater than 1.0x10E-7 cm/sec.

The relatively low hydraulic conductivities and the poor water quality of the shale materials suggest the water bearing strata could be classified as an aquitard rather than an aquifer. Based on the tested water samples, it is questionable if natural groundwater at the site would be suitable for any purposes. Relatively low hydraulic gradients and permeabilities, and poor groundwater quality indicate long groundwater residence time and very slow velocity rates. There are no known productive aquifers below the landfill site, and existing deeper water bearing strata could be expected to have poor quality characteristics. Evidently, the Abilene Landfill site located northeast of the City has successfully operated in similar red beds of the Clear Fork Group.

REGULATORY REQUIREMENTS: The suitability of this site for use as a sanitary landfill should be evaluated with respect to the Texas Health Departments regulations. The following paragraphs present selected Health Department regulations which may be applicable to the proposed Type I landfill site:

Sec. 325.74 (b) (5) (D) (ii)

" . . . A facility shall be designed so as not to contaminate the groundwater beyond the boundaries of the site . . . "

" . . . The minimum acceptable protection separating solid waste from groundwater or perched water shall be a naturally occurring barrier of in-situ soil or a man-made liner which provides the protection of three feet of soil with a coefficient of permeability of no more than 1.0 x 10-7 centimeters per second . . . "

" . . . Constructed liner thickness shall not be less than three feet even when soil with a coefficient of permeability of less than 1.0 x 10-7 centimeters per second is used. A protective cover of at least one foot of soil shall be provided for all constructed liners. As an alternative, the one foot on protective soil cover may be omitted if the constructed liner thickness is at least 3 1/2 feet. In-situ liners shall be at least four feet in thickness or three feet with a one-foot protective cover . . . "

Sec. 325.74 (b) (5) (D) (iii) (III)

" . . . Proposed procedures shall be shown when overexcavation and recompaction are required for impermeable soils containing fissures, cracks, joints, bedding planes . . . "

Sec. 325.74 (b) (5) (D) (iii) (IV)

" . . . If groundwater is encountered in the disposal excavations, or in cases where excavations extend below the seasonal high water table, materials with a weight equivalent to one foot of compacted clay liner for every two feet of static water head encountered shall be used as a basis for construction of a liner between the deposited solid waste and the groundwater. The total thickness of the liner shall consist of three feet of soil with a permeability of no more than 1.0 x 1.0 x 10-7 centimeters per second . . . plus an additional thickness of other soil as described above . . . "

" . . . Pressure release systems may be used to reduce the amount of liner support construction . . . "

Based on regulatory requirements, the landfill site will require a constructed liner or scarified/recompacted materials over most of the site. It is possible that the Texas Department of Health may consider certain groundwater and material insitu characteristics at the site and allow some divergence from the usual standards concerning constructed liner requirements. However, the following recommendations are based on the literal interpretation of the regulations.

AREA EXCAVATIONS: Materials at the site are expected to be readily excavated using the existing equipment at the landfill. The upper soil zones should be stockpiled separately for final cover material. The upper, more weathered shales should also be stockpiled in areas not to interfere with future excavations, for use as liner and cover material.

SIDE LINER CONSTRUCTION: Side liners, at least three feet thick, will have to be constructed in excavation areas along the fractured shales and soil exposures to isolate potential seepage groundwater and to contain potential leachate within the waste contaminant area. Recompacted onsite soils and clays should serve as suitable liners. Side liners may have to be keyed into the underlying shales a minimum of two feet.

It is suggested that the depth of excavations remain in the unsaturated zone above the seasonal high water table. Otherwise, side liners may be required to be thicker due to hydraulic head. Above-ground berms could be constructed in order to extend the height of waste placed above natural grade.

Since groundwater was encountered at the landfill site, a pressure release system might be considered. An engineered groundwater collection system could be designed to help prevent seepage water from entering the excavation and used to reduce static water head occurring in weathered materials exposed along landfill boundaries. If a method such as this is utilized, three feet of impervious liner material should be used, and then one foot of protective cover.

BOTTOM LINER REQUIREMENTS: Based on regulatory requirements, material characteristics and groundwater conditions, it is recommended that the shale materials be scarified and recompacted in place on the bottom of excavations. This measure will further insure that any leachate generated in the waste disposal area will be contained within the boundaries of the site.

It is possible that in some areas the insitu shales may provide as a satisfactory liner based on independent liner evaluations. A determination will have to be made in each waste excavation concerning the permeability characteristics of the shales. However, my understanding is that Texas Department of Health policy will basically require constructed liners at all new permit sites, regardless of the groundwater conditions.

FINAL COVER: Municipal Solid Waste Regulations require that 2 to 2.5 feet of final cover must be placed over completed solid waste areas. Most soils and shale materials at the site will be suitable for the first 1.5 feet of compacted cover. This section should be constructed similar to side or bottom liner areas. It is recommended that an additional 12 inches of top soil capable of sustaining shallow rooted vegetation cover the compacted layer to help retain moisture.

LINER EVALUATION: Liner material evaluation and liner design and construction must be in accordance with the Texas Department of Health Bureau of Solid Waste Management Technical Guide No. 3. Construction of competent liners requires that the quality of materials meet or exceed the specified quality and that the installation procedures produce a material of the specified characteristics. In recognition of this, a quality assurance program must be developed. This program specifies the types, methods and frequencies of tests, which would be implemented during construction. Technical Guide No. 3 is a model for this Soil Liner Quality Control Plan (SLQCP) and constitutes the minimum recommended program level.

It is through tests and inspections at the time of construction that these crucial requirements are met. Soil Liner Evaluation Reports (SLER) must be completed according to the SLQCP for each constructed or insitu liner section.

MONITOR WELL PROGRAM: By regulation, the municipal landfill should have as a minimum one upgradient and two downgradient monitor wells. Due to the large size of the site, the multi-directional flow and the hydrogeologic setting, it is recommended that at least eight monitor wells be completed during the lifetime of the site.

Installation of monitor wells can be phased to provide adequate contaminant detection based on the operation plan and sectorized fill layout. Tentative monitor well placement is shown on Plate IX. Monitor wells designated as M-1 and M-2 would serve as the initial downgradient wells located at the edge of fill containment areas. M-3 and M-4 would provide upgradient and background groundwater quality data for comparison purposes. As the site is developed, the additional monitor wells could be installed adjacent to the fill sections.

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Completely screened intervals to a depth of 40 feet should provide an adequate vertical sampling interval. Ideally, each monitor well should intercept a siltstone layer since these horizons are believed to contribute significantly to lateral flow.

The existing piezometers should not be utilized for permanent monitor wells. The temporary piezometers will have to be removed and bentonite plugged according to regulations. It is suggested that groundwater measurements be taken at least two or three times a month until summer, 1991. Daily readings following a large rainfall event until 24 hour static levels are established may provide some insight to groundwater recharge and flow.

Respectively submitted,

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REFERENCES

1. Municipal Solid Waste Management Regulations, Texas Department of Health, Bureau of Solid Waste Management, 1100 West 49th Street, Austin, Texas 78756, July 1983.

2. Freeze, Alan R. and John A. Cherry, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1979.

3. American Association of Petroleum Geologist, Geological Highway Map of Texas, H. B. Renfro Memorial Edition, Tulsa, Oklahoma.

4. Ogilbee, William and F. L. Osborne, Jr., Groundwater Resources of Haskell and Knox Counties, Texas, Texas Water Commission, Bulletin No. 6209, Aug. 1962.

5. Sellards, E. H., Adkins, W. S. and Plummer, F. B., The Geology of Texas, Vol. 1, Stratigraphy, The University of Texas, Bulletin No. 3232, 1981.

6. Gordan, C. H., Geology and Underground Waters of the Wichita Region, North Central Texas, U. S. Geological Survey Paper #317, 1913.

7. Smith, Gary E., Depositional Systems, San Angelo Formation, Permian, North Texas, Bureau of Economic Geology, University. of Texas at Austin, Report of Investigation No. 80, 1974.

8. Baker, Charles L., Depositional History of the Red Beds and Saline Residues of Texas Permian, University. of Texas, Bulletin No. 2901, 1929.

9. Yelderman, Joseph C., Oral Communication, Baylor Dept. of Geology, Waco, Texas, Sept. 1990.

10. Texas Department of Water Resources, Water for Texas, A Comprehensive Plan for the Future, Vol. 1, November, 1984.

11. Winslow, A. G., and others, Water Resources of Jones County, Texas, Texas Board of Water Engineers, Bulletin No. 5418, Dec. 1954.

Trinity
Engineering Testing
Corporation

December 27, 1990

Jacob & Martin, Inc.
3465 Curry Lane
Abilene, Texas 79606
Attn: Mr. Ken Martin

Reference: Geotechnical Investigation
Haskell Regional Landfill
Haskell, Texas

Dear Mr. Martin:

Enclosed please find one (1) copy of our report for the referenced project. Two copies have been sent to Mr. Robert Baker. This is a final copy, and if any corrections are necessary, they will be made by addendum or page.

We appreciate the opportunity to be of service to your company. Please feel free to call if you have any questions concerning this report.

Sincerely,

TRINITY ENGINEERING TESTING CORPORATION

Win McAtee

Win McAtee, Geologist
Waco Engineering Division

WM/ph

Enclosure

Trinity Engineering Testing Corporation

APPENDIX I

PHOTOGRAPHS

PLATES I TO IX

NORTH

AERIAL PHOTO
HASKELL LANDFILL
Attachment #4

Photograph 1 - Southward view across south-central portion of the landfill site. Piezometer No. B-6 is located in the approximate middle of the picture.

Photograph 2 - Northward view taken from next to the active area trench.

Photograph 3 - Southward view taken from near Boring No. 18 showing the grassland and scattered small trees in the low lying area of the tract.

Photograph 4 - Southward view taken from on top of the stock tank dam. The active landfill area is along the horizon in the distance.

Photograph 5 - View of the conglomerate bed exposed along the active area trench. The conglomerate is composed of loosely cemented gravel and sand.

Photograph 6 - Closeup View of exposed trench side wall showing the typical characteristics of fractures in the red beds.

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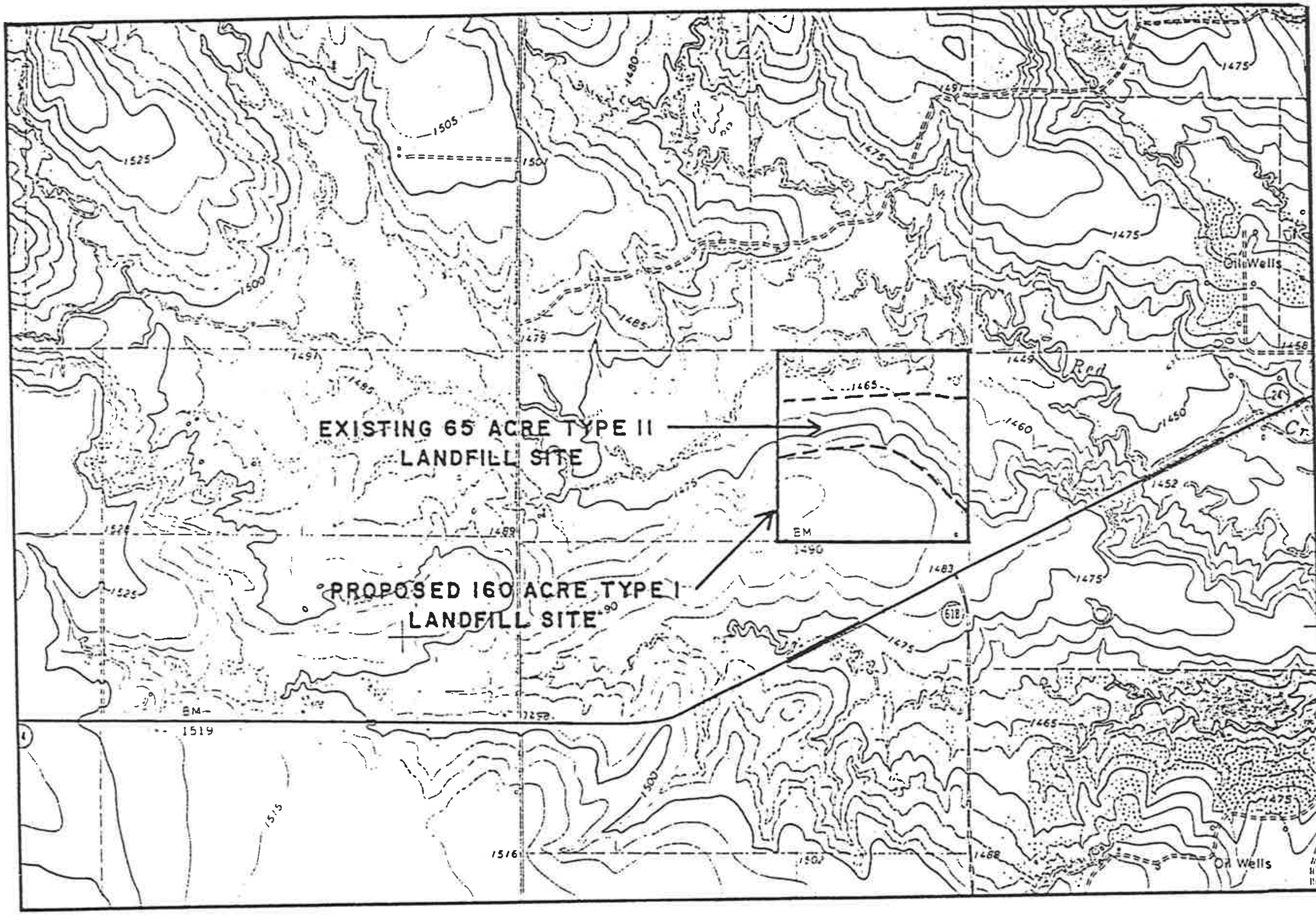
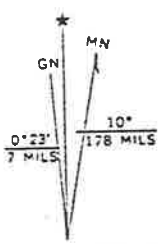


MAP SOURCE: U.S.G.S. - HASKELL SHEET



UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL

HASKELL REGIONAL LANDFILL
SEPTEMBER, 1990

PLATE I

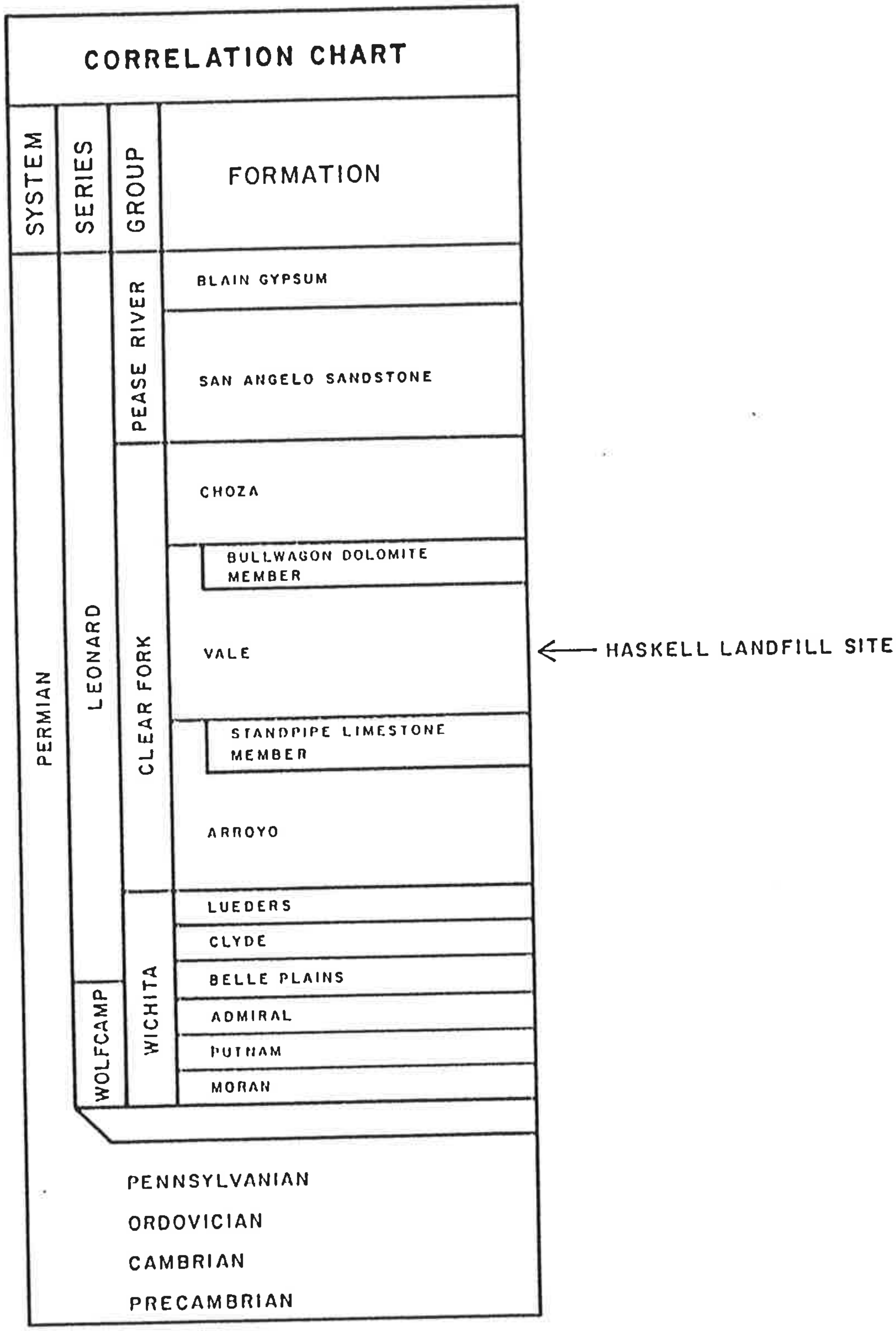
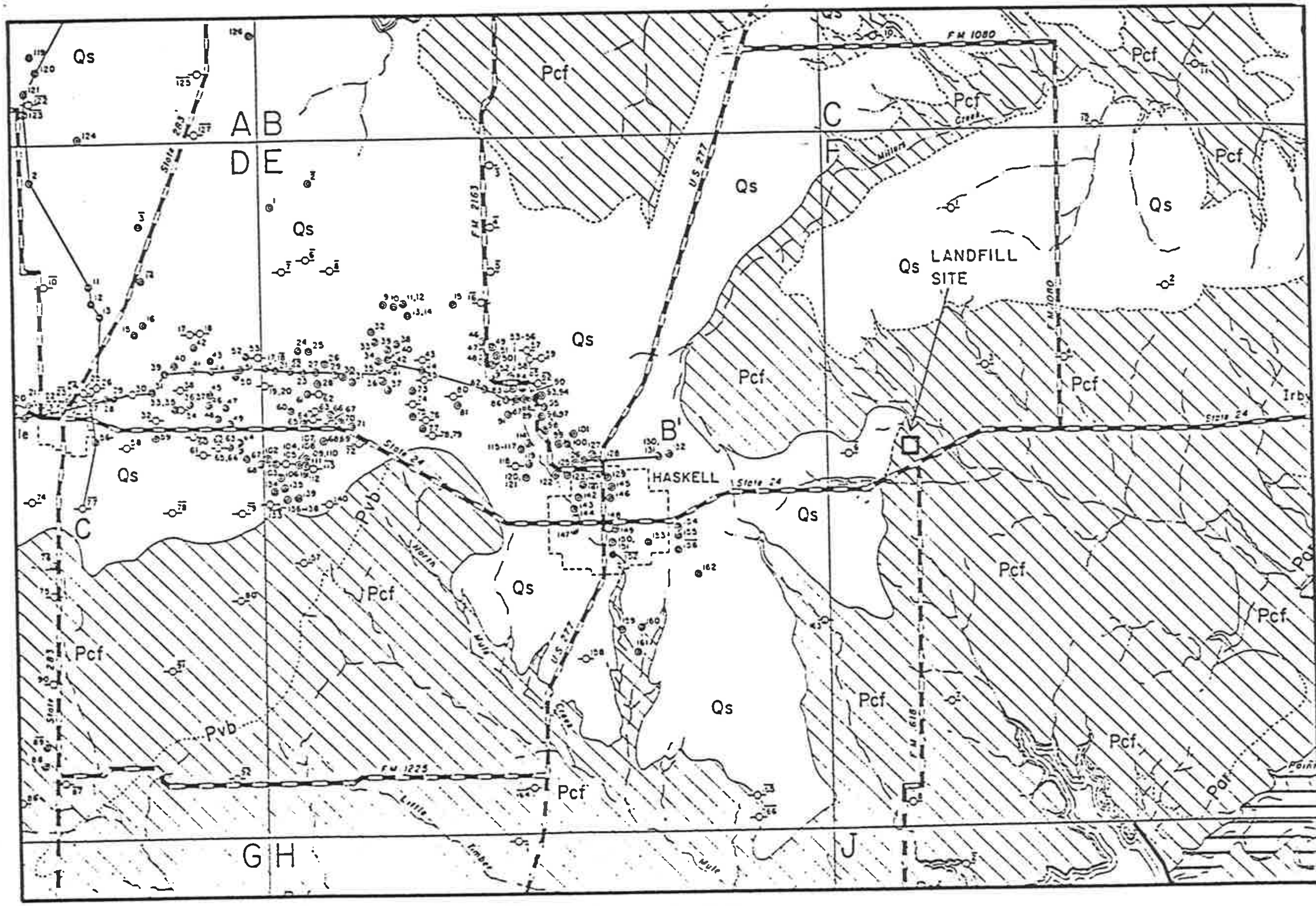


PLATE II STRATIGRAPHIC CHART OF GEOLOGY IN HASKELL COUNTY, TEXAS

Trinity Engineering Testing Corporation



ADAPTED FROM T.W.C. BULLETIN 6209

LEGEND:

- Qs – SEYMOUR FORMATION
- Pcf – CLEAR FORK GROUP (undifferentiated)
- Pvb – BULLWAGON MEMBER
- Por – RAINY LIMESTONE MEMBER
- -o- – WINDMILL WELL
- ◎ – 3 H.P. PUMP WELL

GEOLOGY MAP

HASKELL REGIONAL LANDFILL

PLATE III

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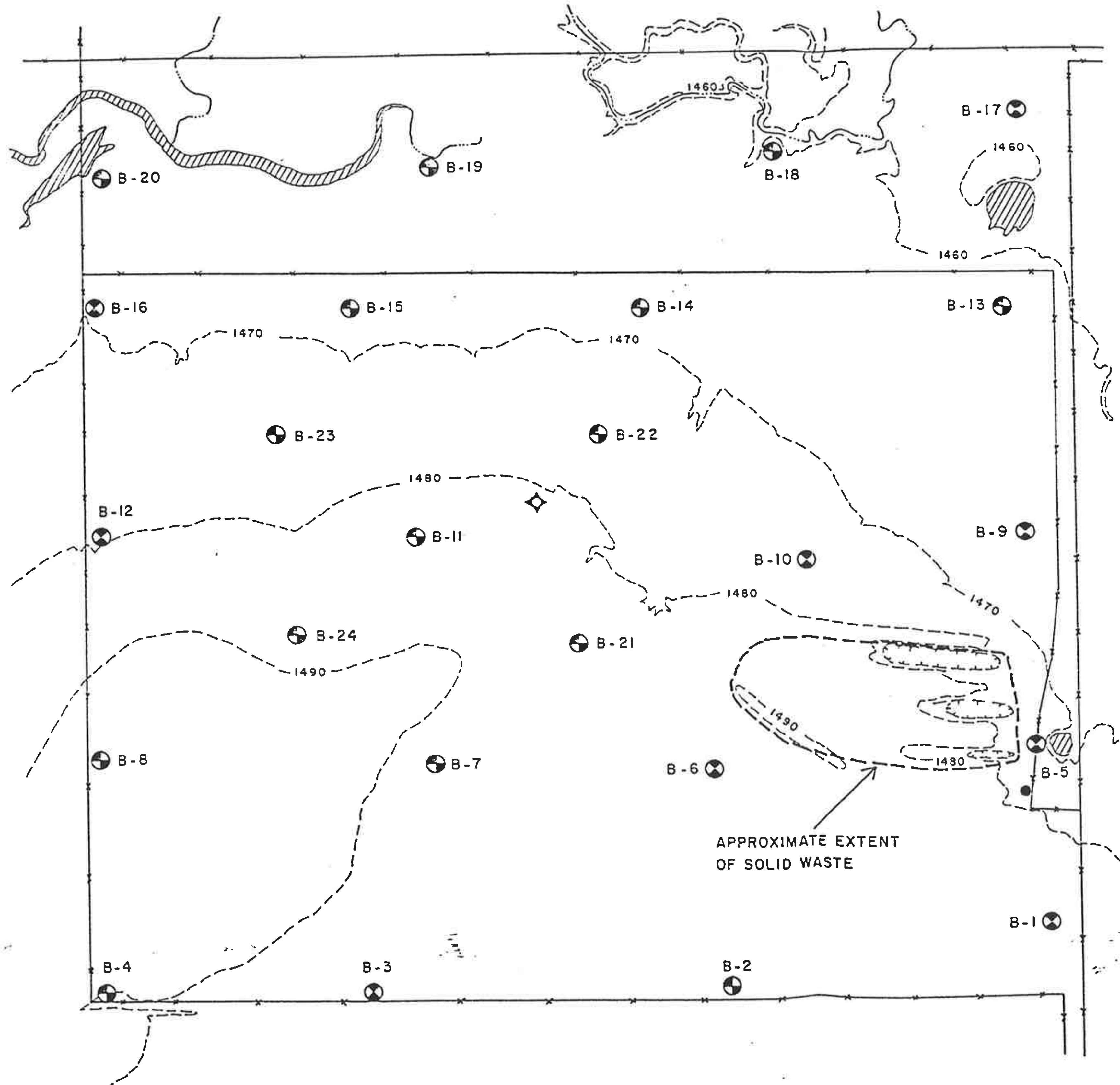


LOCATION OF BORINGS

HASKELL REGIONAL LANDFILL

SEPTEMBER, 1990

LEGEND:

- BORING
- PIEZOMETER
- OIL WELL
- WATER WELL
- SURFACE WATER
- FENCE
- CREEK

SCALE FEET

0 100 200 300 400 500

PLATE IV

Trinity Engineering Testing Corporation

HASKELL SANITARY LANDFILL

HASKELL, TEXAS

SUMMARY OF SOIL CLASSIFICATION TESTS

Boring No.	Depth (ft.)	LL (%)	PI (%)	-200 (%)	% Moisture	USC	Material Description
1	90.0-92.0	37	21	100	7	CL	Reddish Brown Shale
2	1.5- 3.0	58	43	93	15	CH	Dark Reddish Brown Clay
3	44.0-44.5	37	21	100	9	CL	Reddish Brown Shale
4	81.5-82.0	57	32	95	15	CH	Reddish Brown Shale
5	24.2-25.0	43	24	98	13	CL	Reddish Brown Shale
6	33.0-34.5	42	21	99	10	CL	Reddish Brown Shale
7	16.0-17.8	40	26	88	12	CL	Reddish Brown Shale
8	13.2-13.8	37	22	73	13	CL	Reddish Brown Shale w/sand
9	48.6-50.0	48	27	92	13	CL	Reddish Brown Shale
10	15.0-16.0	40	24	97	11	CL	Reddish Brown Shale
11	36.6-37.8	45	27	98	11	CL	Reddish Brown Shale
12	48.0-49.5	48	30	99	11	CL	Reddish Brown Shale
13	18.0-19.0	44	25	95	12	CL	Reddish Brown Shale
14	29.8-30.2	41	24	99	11	CL	Reddish Brown Shale
15	3.0- 4.5	50	36	94	17	CL-CH	Reddish Brown Clay

LL = Liquid Limit   PI = Plasticity Index   (-)200 = Percent Passing #200 Mesh Sieve
MC = Moisture Content   USC = Unified Soil Classification

PLATE V

Sheet 1 of 2

Trinity Engineering Testing Corporation

HASKELL SANITARY LANDFILL

HASKELL, TEXAS

SUMMARY OF SOIL CLASSIFICATION TESTS

Boring No.	Depth (ft.)	LL (%)	PI (%)	-200 (%)	% Moisture	USC	Material Description
16	19.0-20.0	37	23	91	11	CL	Reddish Brown Shale
17	7.5- 9.0	30	19	44	13	SC	Reddish Brown Clayey Sand
18	43.1-44.0	49	28	98	12	CL	Reddish Brown Shale
19	23.0-24.0	34	20	96	10	CL	Reddish Brown Shale
20	0.0- 1.5	--	--	44	5	SC	Reddish Brown Clayey Sand
20	64.0-65.0	44	28	99	9	CL	Reddish Brown Shale
21	21.5-22.0	47	28	96	14	CL	Reddish Brown Shale
22	6.0- 7.5	44	24	98	17	CL	Reddish Brown Shale
23	32.6-33.4	42	27	96	11	CL	Reddish Brown Shale
24	25.0-25.7	41	22	86	8	CL	Reddish Brown Shale
*	--	42	24	--	--	CL	Reddish Brown Silty Shale

* Composite sample from active area trench (Standard Proctor)
LL = Liquid Limit PI = Plasticity Index (-)200 = Percent Passing #200 Mesh Sieve
MC = Moisture Content USC = Unified Soil Classification

PLATE V

Sheet 2 of 2

Trinity Engineering Testing Corporation

HASKELL SANITARY LANDFILL

HASKELL, TEXAS

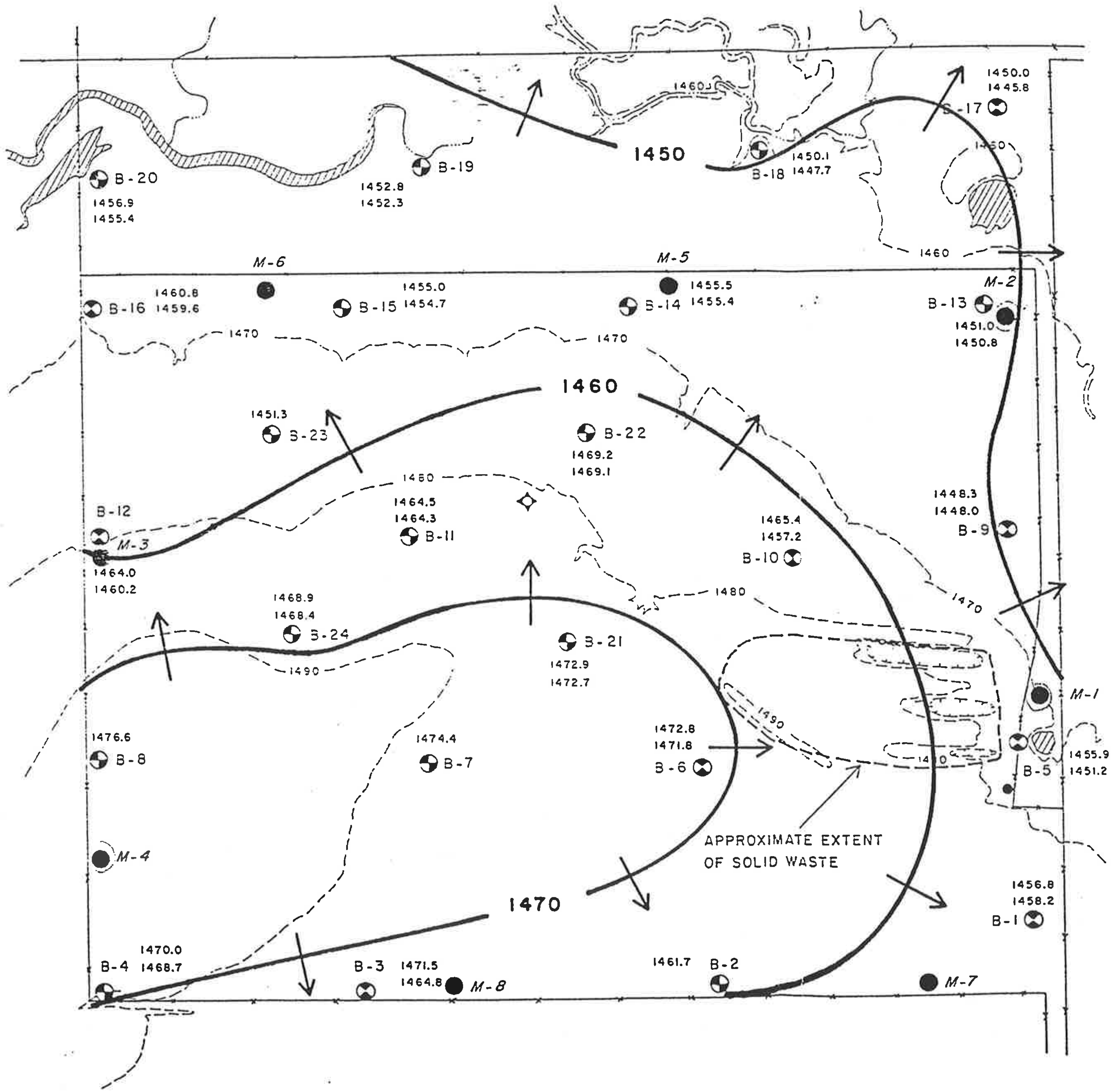
SUMMARY OF PERMEABILITY TEST

Boring No.	Depth ft.	Initial Moisture Content %	Final Moisture Content %	Initial UDW Lbs/ft.	Pressure Head, psi	Hydraulic Conductivity cm/sec	Material Description
--	--	16.3	17.3	108.3	5	4.5×10^{-8}	Reddish Brown Shale*
1	7.5- 9.0	13.6	16.1	119.7	5	1.2×10^{-5}	Reddish Brown Shale (Fractured)
2	22.2-22.9	10.6	11.0	136.9	5	5.2×10^{-9}	Reddish Brown Shale
4	12.5-13.0	10.3	11.3	133.8	5	8.6×10^{-10}	Reddish Brown Shale
4	26.0-27.0	10.8	11.6	129.3	5	4.2×10^{-8}	Reddish Brown Shale (Vertical Fracture)
7	26.0-27.6	12.2	12.9	134.2	5	8.6×10^{-8}	Reddish Brown Shale (Fractured)
12	35.0-35.8	13.2	13.5	128.6	5	1.9×10^{-7}	Gray Siltstone
13	18.0-19.0	13.4	14.3	128.4	5	4.2×10^{-7}	Reddish Brown Shale (Fractured)**
14	8.0- 8.5	11.1	15.4	126.9	5	8.1×10^{-8}	Gray Siltstone
14	21.1-21.5	11.9	13.4	124.4	5	8.7×10^{-7}	Reddish Brown Shale (Fractured)
16	6.0- 7.5	11.5	15.8	121.2	5	1.7×10^{-6}	Reddish Brown Shale (Fractured)
17	7.5- 9.0	17.7	19.4	113.1	5	1.0×10^{-6}	Reddish Brown Sandy Clay (Fractured)
17	56.5-58.0	11.2	11.4	134.3	5	4.6×10^{-9}	Reddish Brown Shale
18	16.6-17.7	12.1	13.1	124.1	5	2.0×10^{-5}	Reddish Brown Shale (Fractured)

* Composite, Remolded sample - 95% U.D.W. and optimum moisture (ASTM D 698)

** Sample oriented horizontal

PLATE VI



WATER TABLE CONTOUR MAP

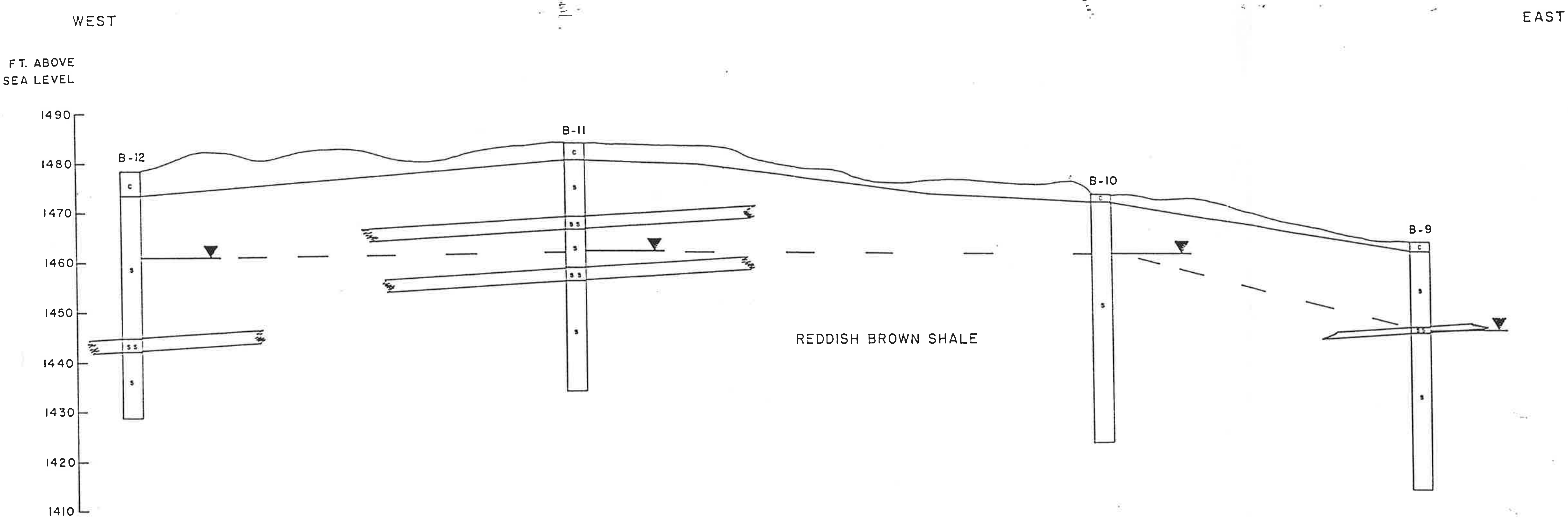
HASKELL REGIONAL LANDFILL
SEPTEMBER, 1990

LEGEND:

- BORING
- PIEZOMETER
- OIL WELL
- WATER WELL
- SURFACE WATER
- FENCE
- CREEK
- WATER TABLE CONTOUR
- FLOW DIRECTION
- PROPOSED MONITOR WELL
- 1465.7 / 1460.3 MAXIMUM & MINIMUM WATER ELEVATIONS BETWEEN 7/12/90 AND 9/24/90

SCALE FEET
0 100 200 300 400 500

Trinity Engineering Testing Corporation



LEGEND: c — CLAY
s — SHALE
ss — SILTSTONE
▼ — WATER TABLE

HORIZONTAL SCALE — 1" = 200'
VERTICAL SCALE — 1" = 20'

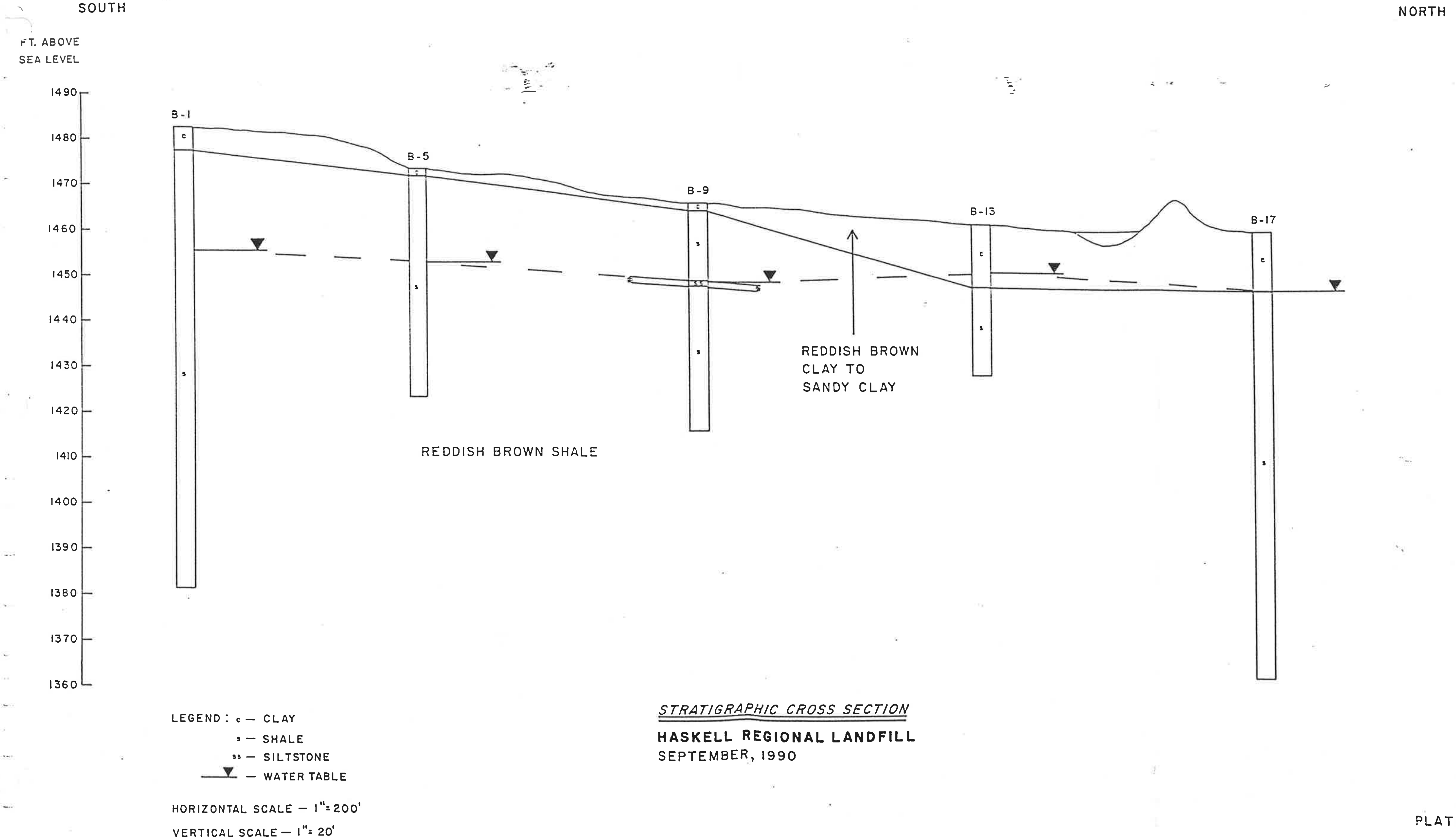
STRATIGRAPHIC CROSS SECTION

HASKELL REGIONAL LANDFILL

SEPTEMBER, 1990

PLATE VII

Trinity Engineering Testing Corporation



STRATIGRAPHIC CROSS SECTION

HASKELL REGIONAL LANDFILL

SEPTEMBER, 1990

PLATE VIII

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APPENDIX II

LOGS OF BORING

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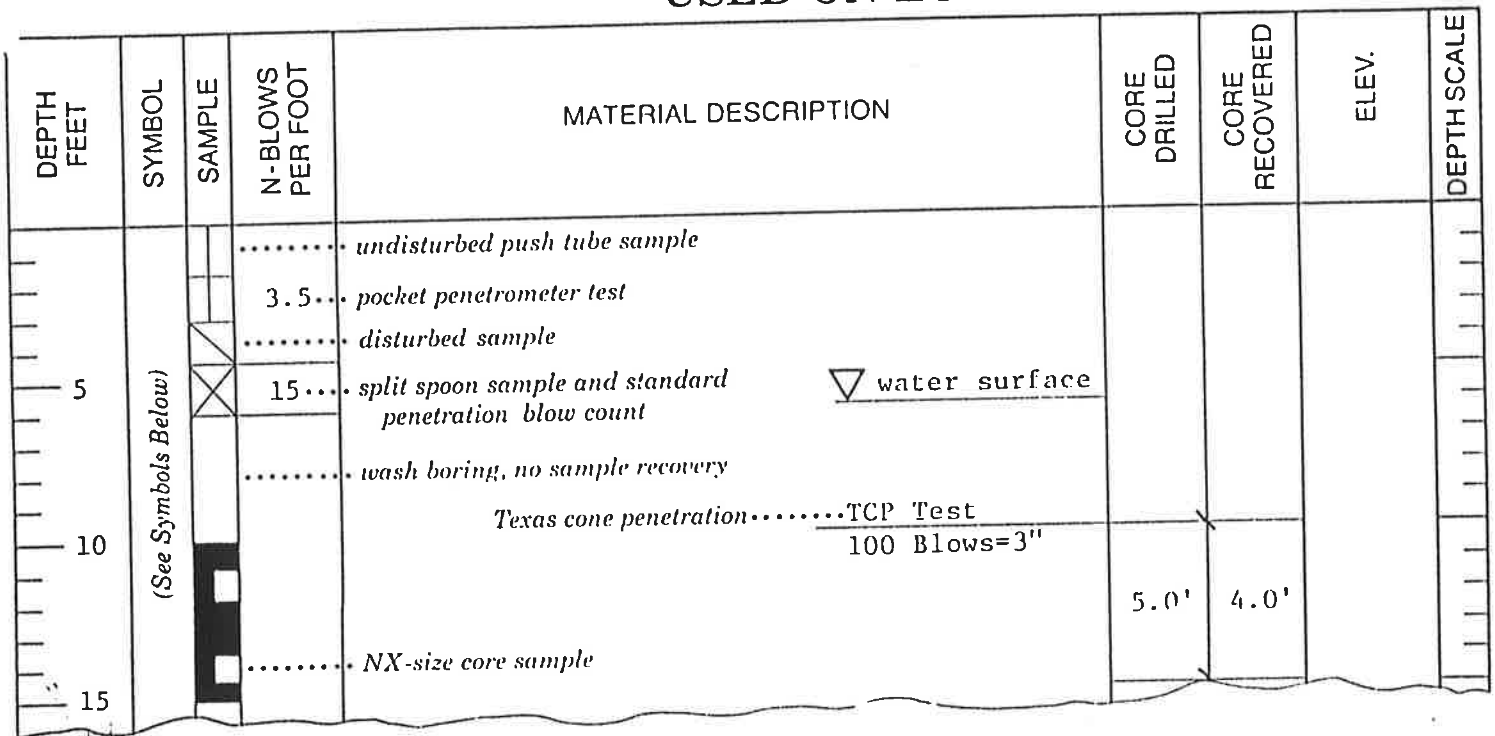
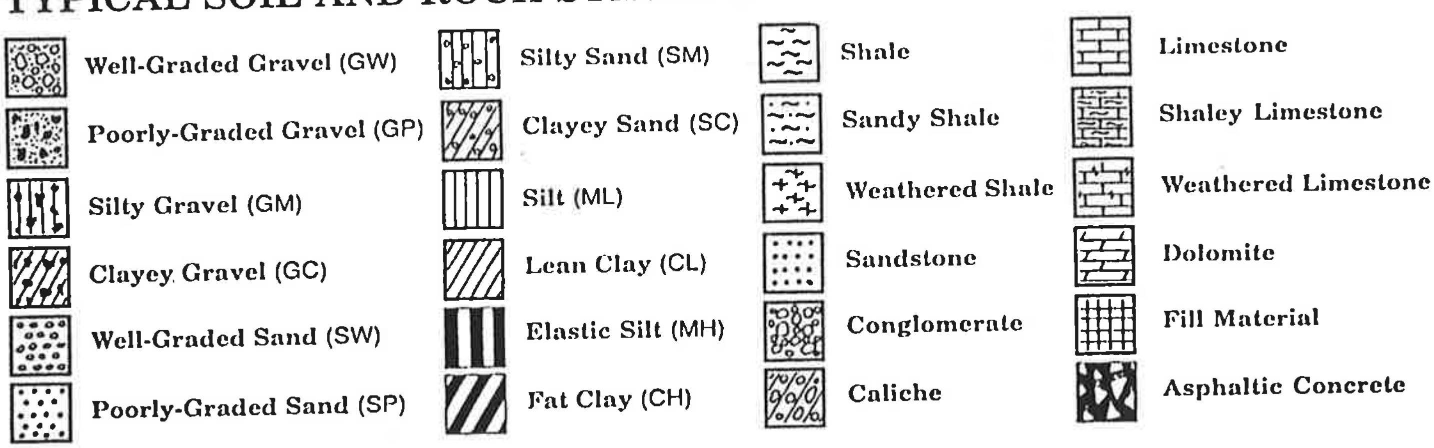
EXPLANATION OF SYMBOLS AND TERMS USED ON LOGS OF BORINGS



TYPICAL SOIL AND ROCK SYMBOLS



DEGREE OF WEATHERING

Unweathered .. Rock in its natural state without visible sign of decomposition or discoloration

Slightly Weathered .... Slight discoloration without visible sign of decomposition

Weathered .... Complete discoloration with zones of slightly decomposed rock

Severely Weathered .... Complete discoloration and decomposition, approaching soil texture and appearance

SOIL STRUCTURE

Calcareous .... Containing calcium carbonate

Slickensided ... The presence of planes of weakness having a slick and glossy appearance

Fissured ...... Breaks along definite planes of fracture with little resistance to fracturing

Laminated .... Alternating thin layers or lenses of varying material or color

Interbedded ... Alternating layers of varying material

The Log of Boring is a representation of the subsurface materials at the specific boring location and within the depth explored. The transition between strata may be gradual and variations in material types and depths between borings can be expected. Water level observations represent those conditions at the time of exploration and may vary with time and location on the site.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/10/90 **Type:** Core **Boring No:** 1

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1482.8	DEPTH SCALE
			4.5+	Tan Clayey Sand				
			4.5+ 4.5+	Reddish Brown Sandy Clay with calcareous particles				
5				Reddish Brown Shale (fractured)	5.0 (0%)	1.2		
10					5.0 (0%)	1.1		
15					5.0 (42%)	2.6		
20–25					10.0 (8%)	6.2		
30–35					10.0 (19%)	5.6		
40				Log of Boring continued . . .				

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

'roject: Haskell Sanitary Landfill

Location: Haskell, Texas   Date: 7/10/90   Type: Core   Boring No: 1

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (0%)	6.5		
50					3.0 (0%)	0.0		
55								
					5.0 (10%)	4.1		
60								
65					10.0 (35%)	9.9		
70								
75					10.0 (54%)	9.9		
80				Log of Boring continued . . .				

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/10/90 **Type:** Core **Boring No:** 1

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
85, 90, 95				Reddish Brown Shale (fractured)	5.0 (38%)	4.7		
					5.0 (0%)	2.7		
					10.0 (49%)	7.9		
100				Total Depth of Boring = 100.0 feet				

Note: Boring was advanced 53.0 feet below the ground surface prior to using drilling fluid, and groundwater was encountered at that depth. Static water level established at 26.0 feet within 24 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/2/90 **Type:** Core **Boring No:** 2

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1485.9	DEPTH SCALE
			4.5+	Dark Reddish Brown Clay				
			4.5+					
			4.5+	Reddish Brown Silty Clay with calcareous nodules				
5			4.5+					
			4.5+	Reddish Brown Shale (fractured)				
			4.5+					
10			4.5+	1" gray siltstone layer				
15				1" gray siltstone layer	10.0	8.5		
20					(14%)			
25					8.0	7.8		
30					(71%)			
35					10.0	5.7		
					(22%)			
40				Log of Boring continued . . .				

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/2/90 **Type:** Core **Boring No:** 2

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (74%)	9.4		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 11.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level established at 24.2 feet within 24 hours after bailing.

TESCO Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/2/90 **Type:** Core **Boring No:** 3

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1488.5	DEPTH SCALE
			4.5+ 4.5+	Dark Brown to Brown Silty Clay				
			4.5+	Reddish Brown Silty Clay				
5			4.5+	Reddish Brown Silty Clay with scattered gravel				
10			4.5+ 4.5+	Reddish Brown Shale (fractured)				
15					5.0 (40%)	4.4		
20				4" gray limestone layer	10.0 (0%)	2.5		
25								
30				5" gray siltstone layer	10.0 (26%)	5.5		
35				1" gray siltstone layer				
40								

Log of Boring continued . . .

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/2/90 **Type:** Core **Boring No:** 3

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (50%)	9.6		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 20.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 23.7 feet within 24 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/13/90 **Type:** Core **Boring No:** 4

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1490.0
0–6	4.5+ 4.5+ 4.5+ 4.5+	Reddish Brown Silty Clay			
6	4.5+	Reddish Brown Shale (fractured)			
9–19			10.0 (0%)	3.2	
19–29			10.0 (10%)	7.3	
29		— 1" gray siltstone layer			
29–39			10.0 (29%)	8.9	
34–35		Gray Siltstone (laminated)			
35–40		Reddish Brown Shale (fractured) — 2" gray siltstone layer			
40		Log of Boring continued . . .			

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/13/90 **Type:** Core **Boring No:** 4

DEPTH FEET	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED
45	Reddish Brown Shale (fractured)	10.0	9.4
	Gray Siltstone (laminated)		
50	Reddish Brown Shale (fractured)	(37%)	
55		10.0	7.8
		(22%)	
60		5.0	1.0
		(0%)	
65			
70		10.0	8.8
		(41%)	
75			
80			

Log of Boring continued . . .

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/13/90 **Type:** Core **Boring No:** 4

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
				Reddish Brown Shale (fractured)	10.0 (28%)	8.7		
85					5.0 (0%)	0.0		
90								
95					10.0 (63%)	9.6		
100				Total Depth of Boring = 100.0 feet				
				Note: Boring was advanced 65.0 feet below the ground surface prior to using drilling fluid, and groundwater was encountered at 34.0 feet. Static water level established at 22 feet within 24 hours after bailing.				

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 9/3/90 **Type:** Core **Boring No:** 5

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1473.2	DEPTH SCALE
0			4.5+	Reddish Brown Clay				
			4.5+	Reddish Brown Shale (fractured)				
5			4.5+					
10–20					10.0 (22%)	4.8		
20–30					10.0 (45%)	7.8		
30–40					10.0 (25%)	5.3		
40				Log of Boring continued . . .				

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 9/3/90 **Type:** Core **Boring No:** 5

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45 50				Reddish Brown Shale (fractured)	10.0 (55%)	7.8		
				Total Depth of Boring = 50.0 feet				
				Note: Boring was advanced 10.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level established at 21.0 feet within 7 days after bailing.				

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/8/90 **Type:** Core **Boring No:** 6

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1487.3
	3.5	Reddish Brown Clay			
	2.5				
	4.5	Reddish Brown Sandy Clay with gravel			
5	4.5+	4" gray sand layer			
	4.5+	Reddish Brown Shale (fractured)			
	4.5+				
10	3.5	6" gray siltstone layer			
15					
		2" gray siltstone layer	10.0	5.4	
20		2" gray siltstone layer			
			(23%)		
25					
			10.0	9.1	
30					
			(52%)		
35		Total Depth of Boring = 35.0 feet			

Results of pocket penetrometer tests (N-blows column)

Note: Boring was advanced 20.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 14.5 feet 2 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/8/90 **Type:** Core **Boring No:** 7

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1489.4
	2.5 4.5+ 4.5+	Reddish Brown Clay with limestone particles			
5	3.5	Reddish Brown Clayey Sand			
10		Reddish Brown Shale (fractured)			
		Gray Siltstone (laminated)			
15		Reddish Brown Shale (fractured)	10.0 (40%)	7.7	
20		Gray Conglomerate			
25		Reddish Brown Shale (fractured)	10.0 (42%)	9.9	
30		—1" gray siltstone layer	5.0 (68%)	4.3	
35		Total Depth of Boring = 35.0 feet			

Results of pocket penetrometer tests (the N-blows column values)

Note: Boring was advanced 20.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 15.0 feet within 5 days after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/10/90 **Type:** Core **Boring No:** 8

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1491.4
0–3			4.5+ 4.5+	Reddish Brown Clay			
3–8.5			4.5+ 4.5+	Reddish Brown and Tan Silty Clay with scattered gravel			
8.5–19.5				Reddish Brown Shale to Shale with sand (fractured) — thin gray siltstone seam	10.0 (34%)	7.9	
19.5–20.5				Gray Siltstone (laminated)			
20.5–35				Reddish Brown Shale to Shale with sand (fractured) — 6" gray siltstone layer	5.0 (0%) 10.0 (0%)	4.6 0.0	

Total Depth of Boring = 35.0 feet

Results of pocket penetrometer tests

Note: Boring was advanced 25.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 14.8 feet within 5 days after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/22/90 **Type:** Core **Boring No:** 9

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1465.9
0–1	4.5+	Reddish Brown Clay			
1–5	4.5+ 4.5+ 4.5+	Reddish Brown Shale (fractured)			
10–15			10.0	9.2	
17		— 4" gray siltstone layer	(46%)		
20–25			10.0	7.9	
28			(46%)		
30–35			10.0	8.6	
38			(57%)		
40		Log of Boring continued . . .			

N-blows per foot values are results of pocket penetrometer tests.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/22/90 **Type:** Core **Boring No:** 9

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (61%)	9.9		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 30.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 17.7 feet within 7 days after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 9/5/90 **Type:** Core **Boring No:** 10

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1475.6
0	4.5	Reddish Brown Clay			
1		Gray Clayey Sand			
2–5	4.0 4.5+ 4.5+	Reddish Brown Shale (fractured)			
9–19			10.0 (22%)	7.3	
19–29			10.0 (81%)	9.0	
30		—thin limestone layer			
29–39			10.0 (53%)	7.9	
40		Log of Boring continued . . .			

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 9/5/90 **Type:** Core **Boring No:** 10

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (25%)	4.8		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 10.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 12.3 feet within 7 days after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/14/90 **Type:** Core **Boring No:** 11

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1485.6
0–3	4.5+ 4.5+	Reddish Brown Sandy Clay with scattered gravel			
3–14	4.5+	Reddish Brown Shale (fractured)			
14–16.5		Gray Siltstone (laminated)	10.0	7.8	
			(46%)		
16.5–25		Reddish Brown Shale (fractured) thin siltstone seam thin siltstone seam			
25–27		Gray Siltstone (laminated)	10.0	7.0	
			(22%)		
27–40		Reddish Brown Shale (fractured)	10.0	9.6	
			(73%)		

Log of Boring continued . . .

Results of pocket penetrometer tests (refers to the N-BLOWS PER FOOT column)

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas Date: 8/14/90 Type: Core Boring No: 11

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (55%)	9.5		
50				Total Depth of Boring = 50.0 feet				
				Note: Boring was advanced 6.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 21 feet within 4 hours after bailing.				

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/13/90 **Type:** Core **Boring No:** 12

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1479.2	DEPTH SCALE
0–5			4.5+ 4.5+ 4.5+	Reddish Brown Silty Clay				
5–10				Reddish Brown Shale (fractured)				
10–20					10.0 (47%)	9.3		
20–30				—8" vertical fracture	10.0 (24%)	8.5		
30–40				Gray Siltstone with shale seams (laminated)	10.0 (55%)	9.8		
				Reddish Brown Shale (fractured)				
40				Log of Boring continued . . .				

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/13/90 **Type:** Core **Boring No:** 12

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (89%)	9.8		
50				Total Depth of Boring = 50.0 feet				
				Note: Boring was advanced 6.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level established at 17.4 feet within 3 hours after bailing.				

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/30/90 **Type:** Core **Boring No:** 13

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1461.0	DEPTH SCALE
			4.5+	Reddish Brown Clay to Silty Clay				
			4.5+					
			4.5+					
5			2.5					
			4.5	– becoming blocky				
			4.0					
10			3.5					
			2.0					
			4.5+					
			4.5+	Reddish Brown Shale (fractured)				
15								
			4.5+					
			4.5+					
20								
			1.0					
25					10.0	5.0		
30					(10%)			
				Total Depth of Boring = 33.0 feet				
35								

Results of pocket penetrometer tests (N-blows column)

Note: Boring was advanced 23.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 10 feet within 6 days after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/30/90 **Type:** Core **Boring No:** 14

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1467.5
0–1	3.5	Reddish Brown Clay to Silty Clay			
1–2.5	3.5				
2.5–4	2.5				
4–5.5	3.5				
5.5–7	4.0	becoming blocky			
7–8.5	4.5	Gray Siltstone (laminated)			
8.5–35		Reddish Brown Shale (fractured)	4.0 (25%)	3.2	
			10.0 (16%)	4.5	
			10.0 (47%)	8.6	
35		Total Depth of Boring = 35.0 feet			

Results of pocket penetrometer tests

Note: Boring was advanced 15.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 12 feet within 6 days after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/1/90 **Type:** Core **Boring No:** 15

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1468.5	DEPTH SCALE
			3.0	Reddish Brown Clay to Silty Clay				
			2.0					
			3.0					
5			4.5+	—becoming blocky				
			4.5+					
			4.5+	Reddish Brown Shale (fractured)				
10								
				—6" gray siltstone layer				
15					10.0	8.0		
20					(32%)			
25								
					10.0	6.1		
30					(33%)			
35				Total Depth of Boring = 34.0 feet				

Results of pocket penetrometer tests

Note: Boring was advanced 10.5 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 13.8 feet within 24 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/1/90 **Type:** Core **Boring No:** 16

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1469.7
0–2	4.5+	Reddish Brown Sandy Clay			
	4.5+				
2–5	4.5+	Reddish Brown Sandy Clay with scattered gravel			
5	4.5+				
	4.5+	Reddish Brown Shale (fractured)			
	4.5+				
10	4.5+				
20		1" gray siltstone layer	10.0 (28%)	5.7	
25			10.0 (30%)	6.6	
34		Total Depth of Boring = 34.0 feet			

N-blows per foot: Results of pocket penetrometer tests

Note: Boring was advanced 10.5 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 10.1 feet within 3 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** (started) 7/14/90 **Type:** Core **Boring No:** 17

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1460.0
0–6	4.5+, 4.5+, 4.5+, 3.0	Reddish Brown Silty Clay			
6–10	1.5, 2.0, 4.0	Reddish Brown Sandy Clay to Clayey Sand			
10–13.5	3.5	Reddish Brown Clay with calcareous nodules			
13.5–40	4.5+	Reddish Brown Shale (fractured)			
20–30			10.0 (22%)	6.0	
30–40			10.0 (17%)	4.9	

Log of Boring continued . . .

Results of pocket penetrometer tests (N-BLOWS PER FOOT column)

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/15/90 **Type:** Core **Boring No:** 17

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
40–50				Reddish Brown Shale	10.0 (14%)	5.6		
50–60					10.0 (58%)	9.5		
60–70					10.0 (50%)	7.8		
70–80					10.0 (54%)	9.7		

Log of Boring continued . . .

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/16/90 **Type:** Core **Boring No:** 17

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
				Reddish Brown Shale (fractured) "	10.0	6.0		
85				Gray Conglomerate with shale layers				
90				Reddish Brown Shale (fractured)	(24%)			
				Gray Siltstone with shale layers (laminated)	10.0	9.8		
95				Reddish Brown Shale (fractured)	(75%)			
100				Total Depth of Boring = 100.0 feet				

Note: Boring was advanced 30.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered at 12.0 feet. Static water level was established at 10 feet within 48 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/19/90 **Type:** Core **Boring No:** 18

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1460.5	DEPTH SCALE
			4.5+	Brown Sandy Clay				
			4.5+	Reddish Brown Clay to Silty Clay				
			4.5+					
5			4.5+	Reddish Brown Sandy Clay to Silty Clay with scattered gravels				
			4.5+					
			4.5+					
10			4.5+					
			4.5+	Reddish Brown Shale (fractured)				
15								
20					10.0 (16%)	3.6		
25								
30					10.0 (20%)	5.6		
35								
40				Log of Boring continued . . .				

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/19/90 **Type:** Core **Boring No:** 18

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
				Reddish Brown Shale (fractured)	10.0 (59%)	9.5		
45				—6" gray siltstone layer	5.0 (20%)	2.0		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 15.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 12.8 feet within 20 minutes after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/18/90 **Type:** Core **Boring No:** 19

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1464.9	DEPTH SCALE
			4.5+	Reddish Brown Sandy Clay				
			4.5+					
			3.5	Reddish Brown Clay to Silty Clay				
5			2.5					
			2.0					
			3.0	Reddish Brown Silty Clay with scattered gravel				
10			4.5+	Reddish Brown Shale (fractured)				
			4.5+					
15								
					10.0	6.5		
20					(32%)			
25					4.5 (58%)	4.0		
30								
35					10.0	7.3		
40					(30%)			

Log of Boring continued . . .

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/18/90 **Type:** Core **Boring No:** 19

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (35%)	5.0		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 13.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 12.1 feet within 2 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/16/90 **Type:** Core **Boring No:** 20

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1466.4
0	4.5+	Reddish Brown Sandy Clay			
	4.5+	Reddish Brown Clayey Sand			
5	4.5+	Reddish Brown Shale (fractured)			
	4.5+				
	4.5+				
10–20		2" gray shale layer 4" gray shale layer	10.0 (18%)	5.8	
20–30		4" gray siltstone layer 7" gray siltstone layer	10.0 (36%)	8.3	
30–40			10.0 (41%)	9.0	

Log of Boring continued . . .

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 7/16/90 **Type:** Core **Boring No:** 20

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
40–50				Reddish Brown Shale (fractured)	10.0 (41%)	9.2		
50–60					10.0 (45%)	9.4		
60–70					10.0 (58%)	9.5		
70–80				6" gray conglomerate layer 2" gray conglomerate layer	10.0 (54%)	9.5		
80				Log of Boring continued . . .				

Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** (finish) 7/17/90 **Type:** Core **Boring No:** 20

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
85				Reddish Brown Shale (fractured) — 6" reddish-brown dolomite layer	10.0 (67%)	9.9		
90								
95					10.0 (46%)	8.9		
100				Total Depth of Boring = 100.0 feet				

Note: Boring was advanced 20.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 9.5 feet after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/22/90 **Type:** Core **Boring No:** 21

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1488.7
0–1	2.5	Brown Clay			
1–4	3.5	Reddish Brown Clay with calcareous nodules			
	4.5+				
4–26	4.5+	Reddish Brown Shale (fractured)			
10–20		— 8" gray siltstone layer	10.0 (47%)	9.8	
20–30			10.0 (16%)	7.8	
26–27.5		Gray Siltstone (laminated)			
27.5–35		Reddish Brown Shale (fractured)			
30–35			5.0 (12%)	3.2	

Total Depth of Boring = 35.0 feet

← Results of pocket penetrometer tests

Note: Boring was advanced 6.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 15 feet within 2 hrs. after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/22/90 **Type:** Core **Boring No:** 22

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.
					1486.0
0–1	4.5+	Reddish Brown Sandy Clay			
1–40	4.5+ 4.5+ 4.5+ 4.5+	Reddish Brown Shale (fractured)			
12.5		1" limestone layer			
10–20			10.0 (5%)	3.0	
20–30			10.0 (92%)	9.8	
30–34			4.0 (15%)	3.4	
34–40			10.0 (60%)	9.6	

Log of Boring continued . . .

Results of pocket penetrometer tests (applies to the N-BLOWS PER FOOT column)

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/22/90 **Type:** Core **Boring No:** 22

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	6.0 (0%)	0.0		
50				Total Depth of Boring = 50.0 feet				

Note: Boring was advanced 10.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 16.8 feet within 8 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/23/90 **Type:** Core **Boring No:** 23

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1463.7	DEPTH SCALE
			1.0	Reddish Brown Clay to Silty Clay				
			4.5+					
			4.5+	Reddish Brown Shale				
5			4.5+					
10								
15				— 6" gray siltstone layer	10.0 (28%)	6.8		
20					5.0 (0%)	0.0		
25								
30				— 4" gray siltstone layer	10.0 (16%)	5.5		
				— 2" gray siltstone layer				
35				Total Depth of Boring = 35.0 feet				

Results of pocket penetrometer tests

Note: Boring was advanced 10.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 22.5 feet within 4 hours after bailing.

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/23/90 **Type:** Core **Boring No:** 24

DEPTH FEET	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV. 1489.8
0–2	3.5	Reddish Brown Clay			
2–5	4.5+ 4.5+	Reddish Brown and Tan Silty Clay with scattered gravels			
5–20	4.5+ 4.5+ 4.5+	Reddish Brown Shale (fractured) — 3" gray siltstone layer	10.0 (49%)	7.7	
20–24		Gray Siltstone with shale layers (laminated)	10.0 (34%)	8.8	
24–40		Reddish Brown Shale (fractured) — 2" gray siltstone layer	10.0 (52%)	9.2	

Depth scale: 5, 10, 15, 20, 25, 30, 35, 40

Log of Boring continued . . .

N-blows per foot column: Results of pocket penetrometer tests

Trinity Engineering Testing Corporation

LOG OF BORING

Project: Haskell Sanitary Landfill

Location: Haskell, Texas **Date:** 8/23/90 **Type:** Core **Boring No:** 24

DEPTH FEET	SYMBOL	SAMPLE	N-BLOWS PER FOOT	MATERIAL DESCRIPTION	CORE DRILLED (RQD)	CORE RECOVERED	ELEV.	DEPTH SCALE
45				Reddish Brown Shale (fractured)	10.0 (72%)	9.2		
50				Total Depth of Boring = 50.0 feet				
				Note: Boring was advanced 9.0 feet below				
				Note: Boring was advanced 9.0 feet below the ground surface prior to using drilling fluid, and groundwater was not encountered above that depth. Static water level was established at 21 feet within 4 hours after bailing.				

Trinity Engineering Testing Corporation

APPENDIX III

GROUNDWATER MEASUREMENTS
PIEZOMETER DATA SHEETS
SLUG TEST DATA
ANALYTICAL TEST RESULTS AND
EPA STANDARDS

Trinity Engineering Testing Corporation

GROUNDWATER MEASUREMENTS

Boring No.	Drilled Dry/H_2O Encountered	Bail Depth	Date	H_2O Level	Date
1	53.0/53.0	61.0	7/11/90	26.0	7/12/90
2	11.0	40.0	8/2/90	24.2	8/5/90
3	20.0	40.2	8/2/90	23.7	8/5/90
4	65.0/34.0	58.0	7/13/90	22.0	9/14/90
5	10.0	50.0	9/3/90	17.3	9/5/90
6	20.0	30.0	8/8/90	15.1	(12:00pm) 8/22/90
7	20.0	30.0	8/8/90	15.0	8/13/90
8	25.0	25.0	8/9/90	14.8	8/13/90
9	30.0	23.0	8/22/90	17.9	9/5/90
10	10.0	35.0	(11:50am) 9/5/90	18.4	(2:35pm) 9/5/90
11	6.0	25.0	8/14/90	21.1	9/5/90
12	6.0	25.0	8/13/90	19.0	8/14/90
13	23.0	25.0	7/30/90	10.0	8/5/90
14	15.0	22.0	7/30/90	12.0	8/5/90
15	10.5	20.0	8/1/90	13.8	8/2/90
16	10.5	13.5	8/1/90	12.5	8/2/90
17	30.0/12.0	41.0	7/16/90	10.0	7/18/90
18	15.0	35.0	7/19/90	10.4	7/19/90
19	13.0	16.0	7/18/90	12.6	7/19/90
20	20.0	16.0	7/17/90	11.0	7/18/90
21	6.0	16.0	8/22/90	15.8	9/5/90
22	10.0	25.0	8/27/90	--	
23	10.0	25.0	8/23.90	22.5	8/23/90
24	9.0	25.0	8/23/90	20.9	9/5/90

Trinity Engineering Testing Corporation

Boring No.	Bail Depth	Date	H_2O Level	Date	Bail Depth	Date	H_2O Level	Date
1	35.0	7/12/90	26.0	7/13/90	--		27.0	8/22/90
2	--		24.2	8/6/90				
3	--		23.7	8/6/90	--		18.9	8/22/90
4	--		20.0	8/22/90	30.8	8/22/90	21.3	(10:00am) 9/5/90
5	40.0	(10:20am) 9/5/90	25.8	(2:10pm) 9/5/90	--		21.0	9/12/90
6	3 Well Volumes		15.5	(12:15pm) 8/22/90	--		14.5	(12:15pm) 9/5/90
7	--		15.0	8/14/90				
8	--		14.8	8/14/90				
9	33.0	(11:20am) 9/5/90	28.2	(4:20pm) 9/5/90	--		17.7	9/12/90
10	--		12.3	9/12/90	--		12.3	9/13/90
11	28.5	(12:10pm) 9/5/90	20.3	(4:00pm) 9/5/90				
12	--		16.8	8/22/90	35.0	8/22/90	17.4	(1:10pm) 9/5/90
13	--		10.2	8/6/90				
14	--		12.1	8/6/90				
15	--		13.5	8/5/90				
16	--		9.8	8/22/90	(8/22/90 - 12:55pm) 3 Well Volumes		11.4	(1:07pm) 8/22/90
17	--		13.9	8/22/90	23.5	(2:34pm) 8/22/90	16.0	(2:50pm) 8/22/90
18	--		12.8	8/22/90	15.0	(3:00pm) 8/22/90	12.8	(3:20pm) 8/22/90
19	--		12.1	8/22/90	16.0	(3:30pm) 8/22/90	12.1	(4:50pm) 8/22/90
20	--		9.5	8/22/90	--		9.5	9/5/90
21	3 Well Volumes 9/5/90		16.0	9/5/90				
22	--		16.8	9/5/90	20.0	(9:15am) 9/5/90	16.9	(5:00pm) 9/5/90
23	30.0	(10:45am) 8/23/90	22.5	(4:15pm) 8/23/90				
24	29.5	(1:25pm) 9/5/90	25.2	(3:55pm) 9/5/90	--		21.4	(4:45pm) 9/5/90

Trinity Engineering Testing Corporation

Boring No.	Bail Depth	Date	H_2O Level	Date	Bail Depth	Date	H_2O Level	Date	H_2O Level	Date
1			27.3	9/5/90	--		27.0	9/12/90	27.0	9/13/90
2	--									
3	33.0	8/22/90	17.0	9/5/90	29.5	(12:35pm) 9/5/90	18.8	(3:45pm) 9/5/90	17.0	9/6/90
4	30.0	(10:30am) 9/5/90	21.3	(3:40pm) 9/5/90						
5	--		21.0	9/13/90	--		21.0	9/14/90		
6	3 Well Volumes		14.5	(1:55pm) 9/5/90	--		14.5	9/12/90	14.5	9/13/90
7										
8										
9			17.7	9/13/90	--		17.7	9/14/90		
10	--		12.3	9/14/90						
11	--									
12	3 Well Volumes		21.9	9/5/90	--		17.4	(3:40pm) 9/5/90	17.6 17.6	9/12/90 9/13/90
13										
14										
15										
16	--		10.1	9/5/90	12.1	(1:10pm) 9/5/90	10.1	(3:35pm) 9/5/90	10.1 10.1	9/12/90 9/13/90
17			14.2	9/5/90	--		13.8	9/12/90	13.8	9/13/90
18	--									
19										
20										
21										
22										
23										
24										

Trinity Engineering Testing Corporation

Boring No.	Depth	Piezometer Data Stick-up	Screen	Seal	Bentonite Plug	Notes
1	60.0	1.0	10.0	5.0	--	
2					8/6/90	
3	34.0	2.8	10.0	10.0	--	18.7-9/12/90 18.7-9/13/90
4					9/5/90	
5	50.0	2.0	10.0	40.0	--	
6	35.0	1.3	10.0	10.0	--	Upon bailing H_2O level remained almost static at 15'.
7					8/14/90	
8					8/14/90	
9	34.0	1.0	10.0	5.0	--	
10	40.0	2.5	10.0	30.0	--	Upon bailing H_2O level remained static at about 30'.
11					9/5/90	
12	37.0	2.2	10.0	5.0	--	Upon bailing H_2O level remained static at about 22'
13					8/6/90	
14					8/6/90	
15					8/5/90	
16	25	2.7	5.0	20.0	--	Upon bailing H_2O level remained static at about 14'
17	30	1.5	10.0	5.0	--	
18					8/22/90	
19					8/22/90	
20					9/5/90	Upon bailing H_2O level remained static at about 16'
21					9/5/90	Upon bailing H_2O level remained static at about 16'
22					9/5/90	
23					9/5/90	
24					9/5/90	

Trinity Engineering Testing Corporation

Boring No.	Water Level (7/12/90 to 9/24/90)	H_2O Level	Date
1	26.0-27.6	27.6	11/7/90
2	24.2		
3	17.0-23.7	17.1	11/7/90
4	20.0-22.0		
5	17.3-21.0	20.0	11/7/90
6	14.5-15.5	13.1	11/7/90
7	15.0		
8	14.8		
9	17.6-17.9	16.8	11/7/90
10	10.2-18.4		
11	21.1-21.3		
12	15.8-19.0		
13	10.0-10.2		
14	12.0-12.1		
15	13.5-13.8		
16	8.0-10.1		
17	10.0-14.2	12.0	11/7/90
18	10.4-12.8		
19	12.1-12.6		
20	9.5-11.0		
21	15.8-16.0		
22	16.8-16.9		
23	22.5		
24	20.9-21.4		

Note: Groundwater readings in feet below ground surface

Trinity Engineering Testing Corporation

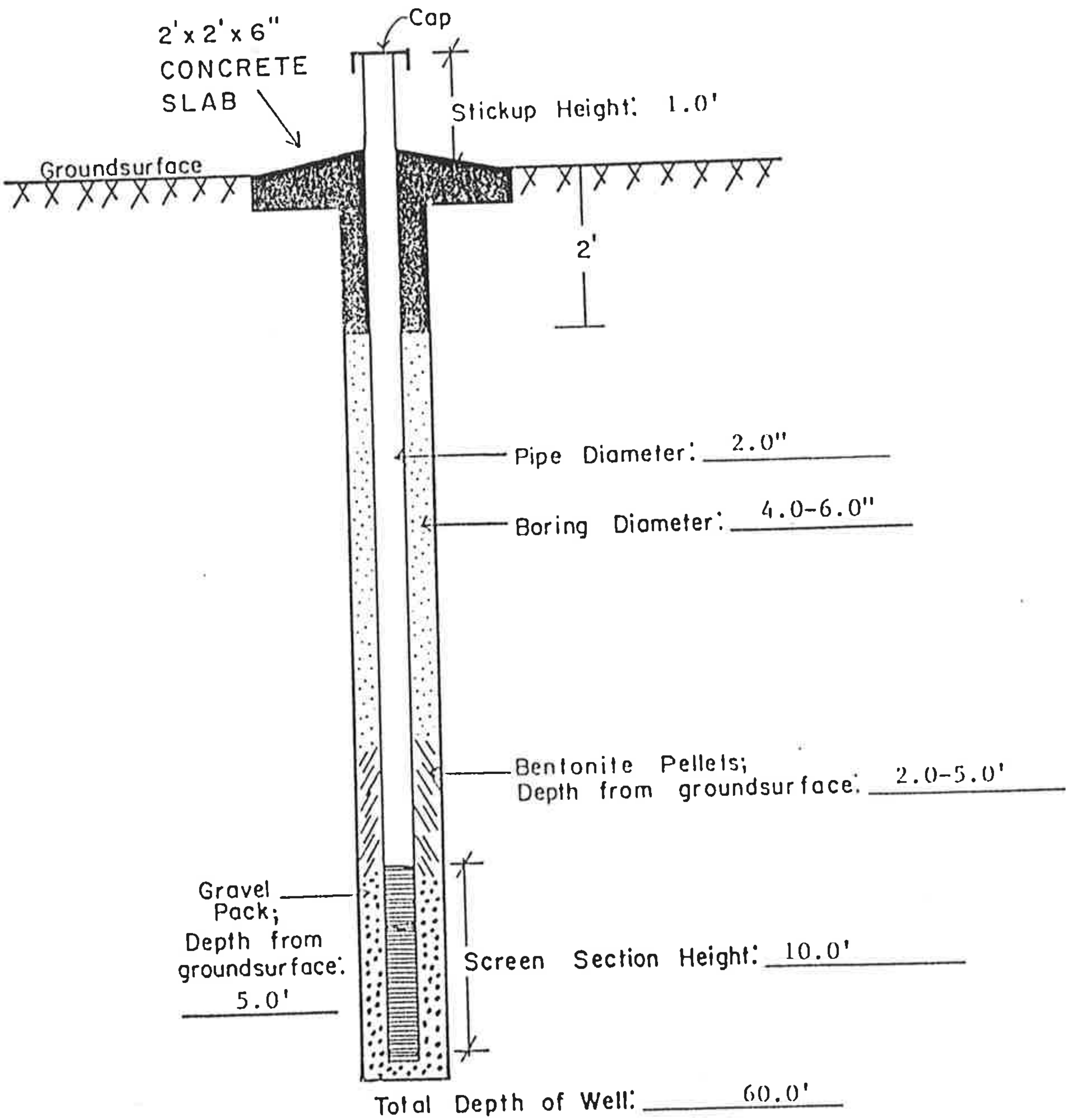
PIEZOMETER WELL DATA SHEET

Piezometer No: B-1

Well Boring Depth: 100.0'

Date Installed: 9/5/90

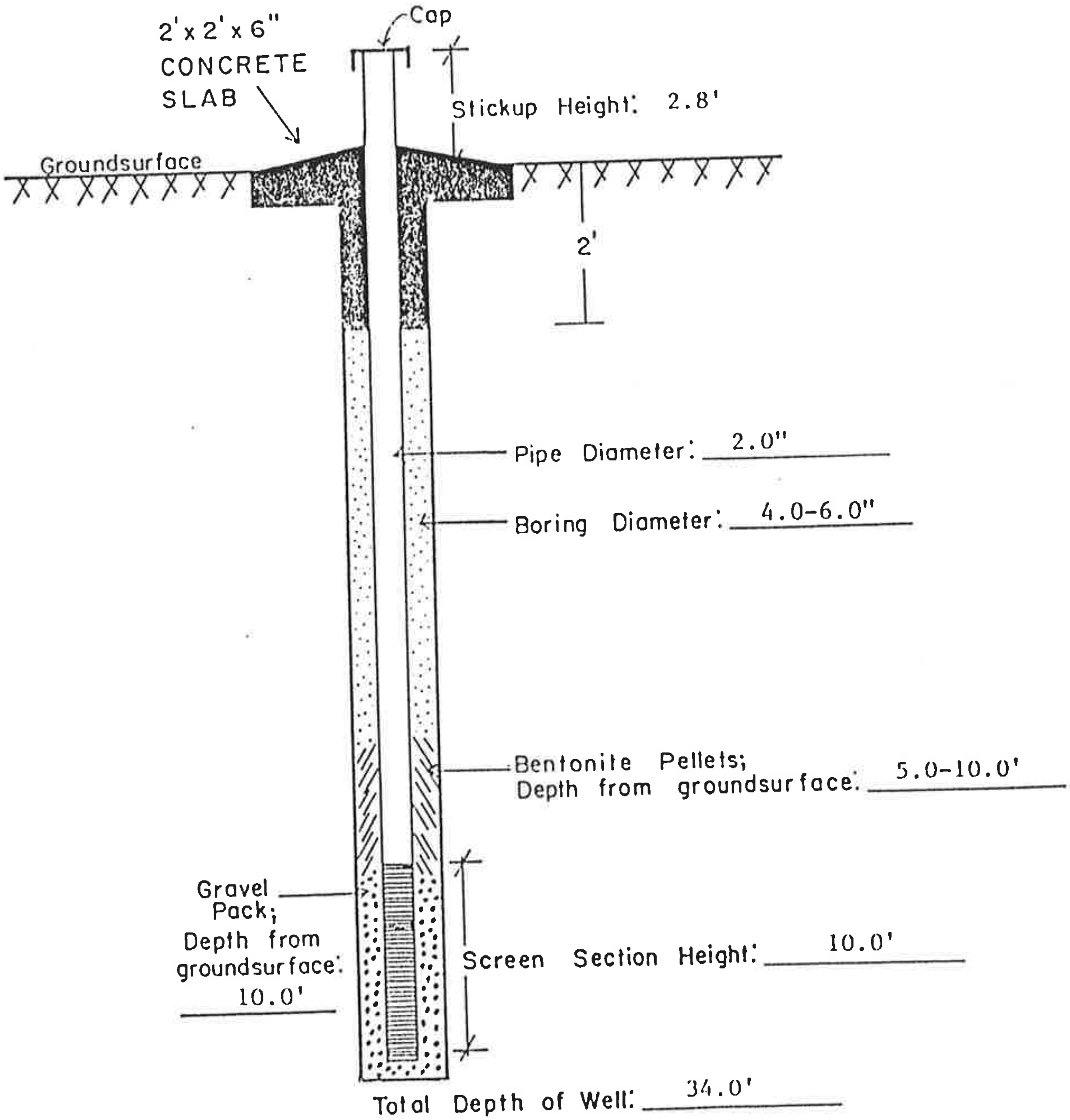
Water Level (groundsurface to water level): 26.0-27.6'



Trinity Engineering Testing Corporation

PIEZOMETER WELL DATA SHEET

Piezometer No: B-3
Well Boring Depth: 50.0'
Date Installed: 9/4/90
Water Level (groundsurface to water level): 17.0-23.7'



Trinity Engineering Testing Corporation

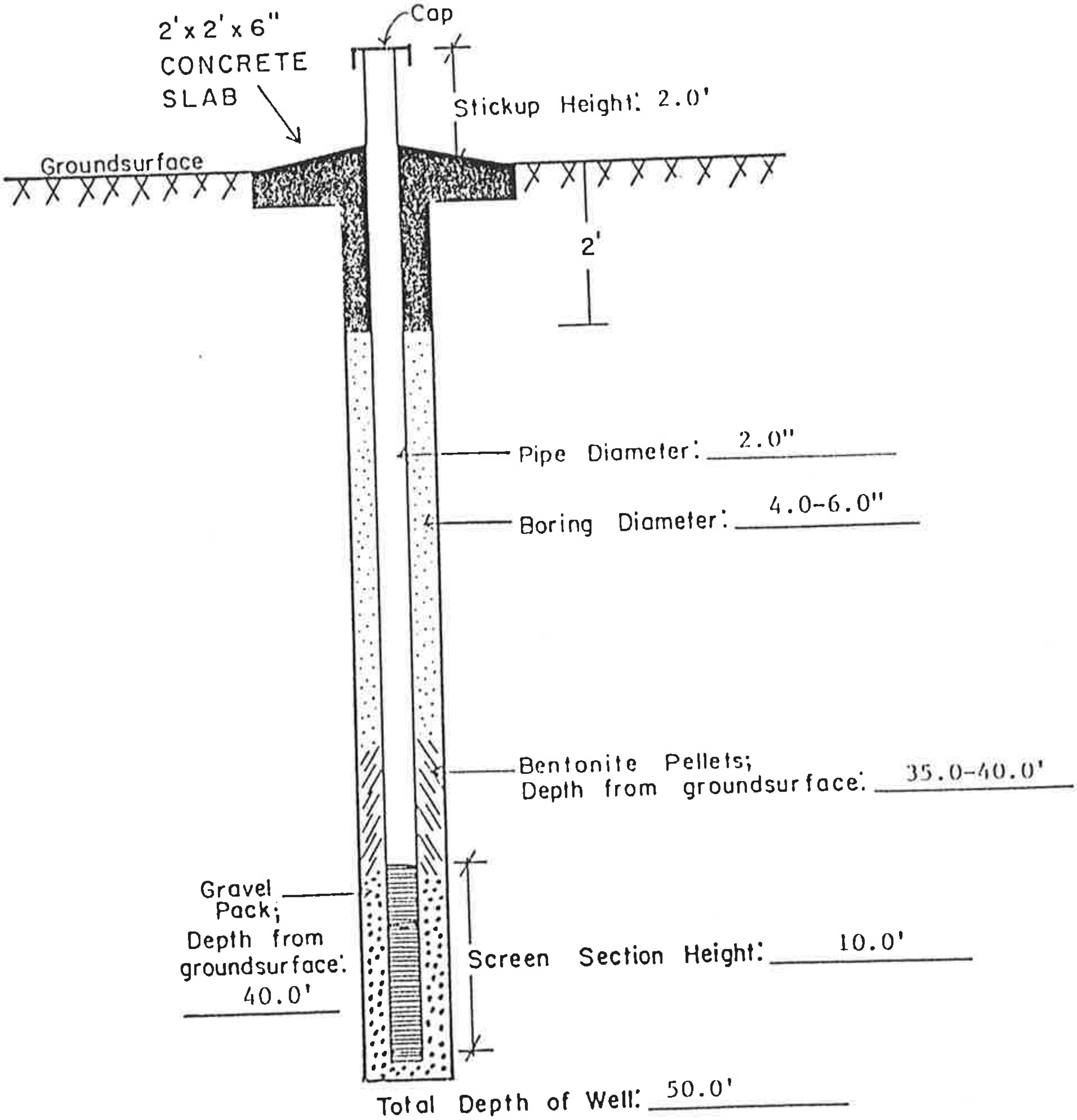
PIEZOMETER WELL DATA SHEET

Piezometer No: B-5

Well Boring Depth: 50.0'

Date Installed: 9/4/90

Water Level (groundsurface to water level): 17.3-22.0'



Trinity Engineering Testing Corporation

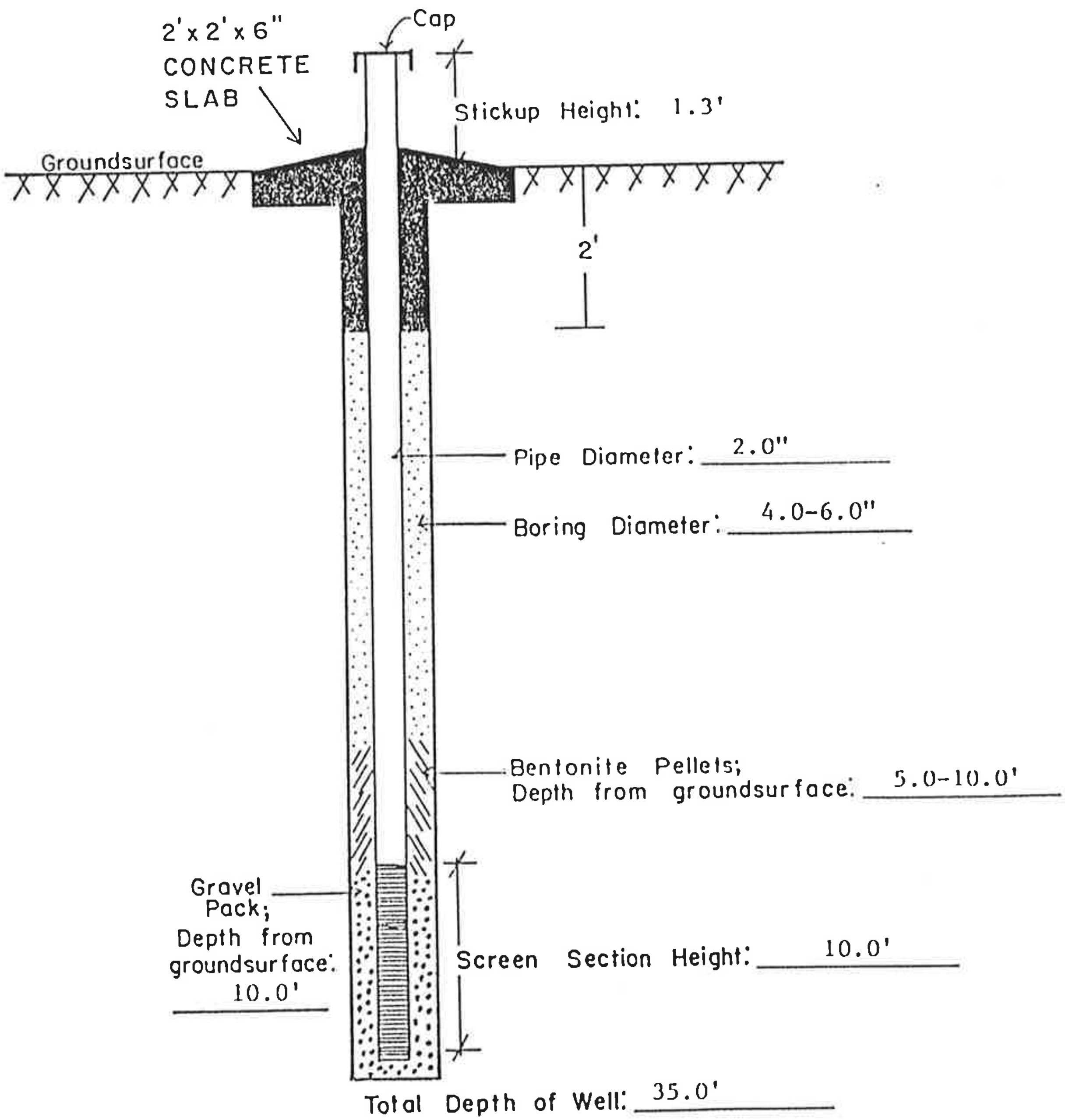
PIEZOMETER WELL DATA SHEET

Piezometer No: B-6

Well Boring Depth: 35.0'

Date Installed: 8/8/90

Water Level (groundsurface to water level): 14.5-15.5'



Trinity Engineering Testing Corporation

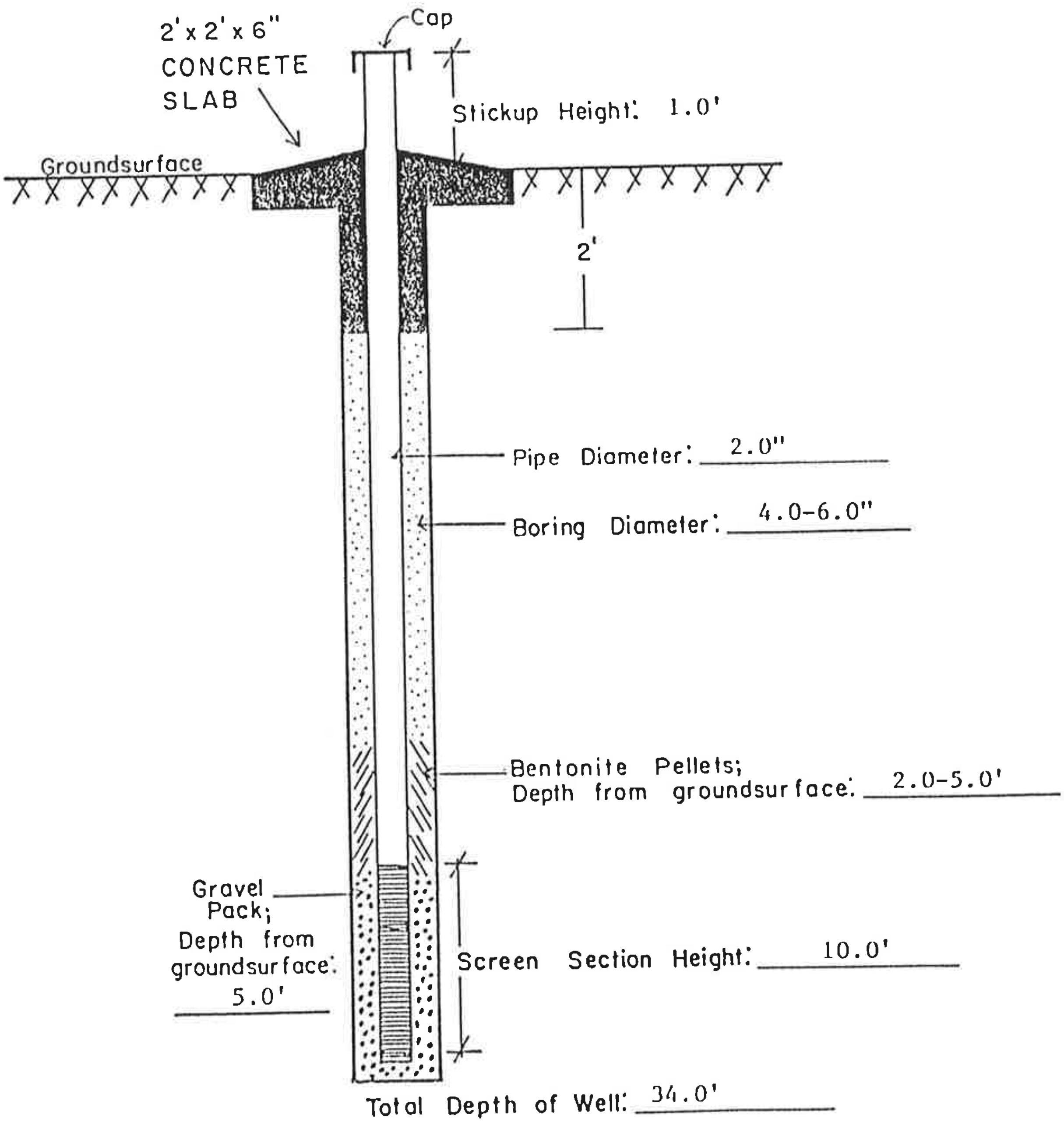
PIEZOMETER WELL DATA SHEET

Piezometer No: B-9

Well Boring Depth: 50.0'

Date Installed: 9/5/90

Water Level (groundsurface to water level): 17.6-17.9'



Trinity Engineering Testing Corporation

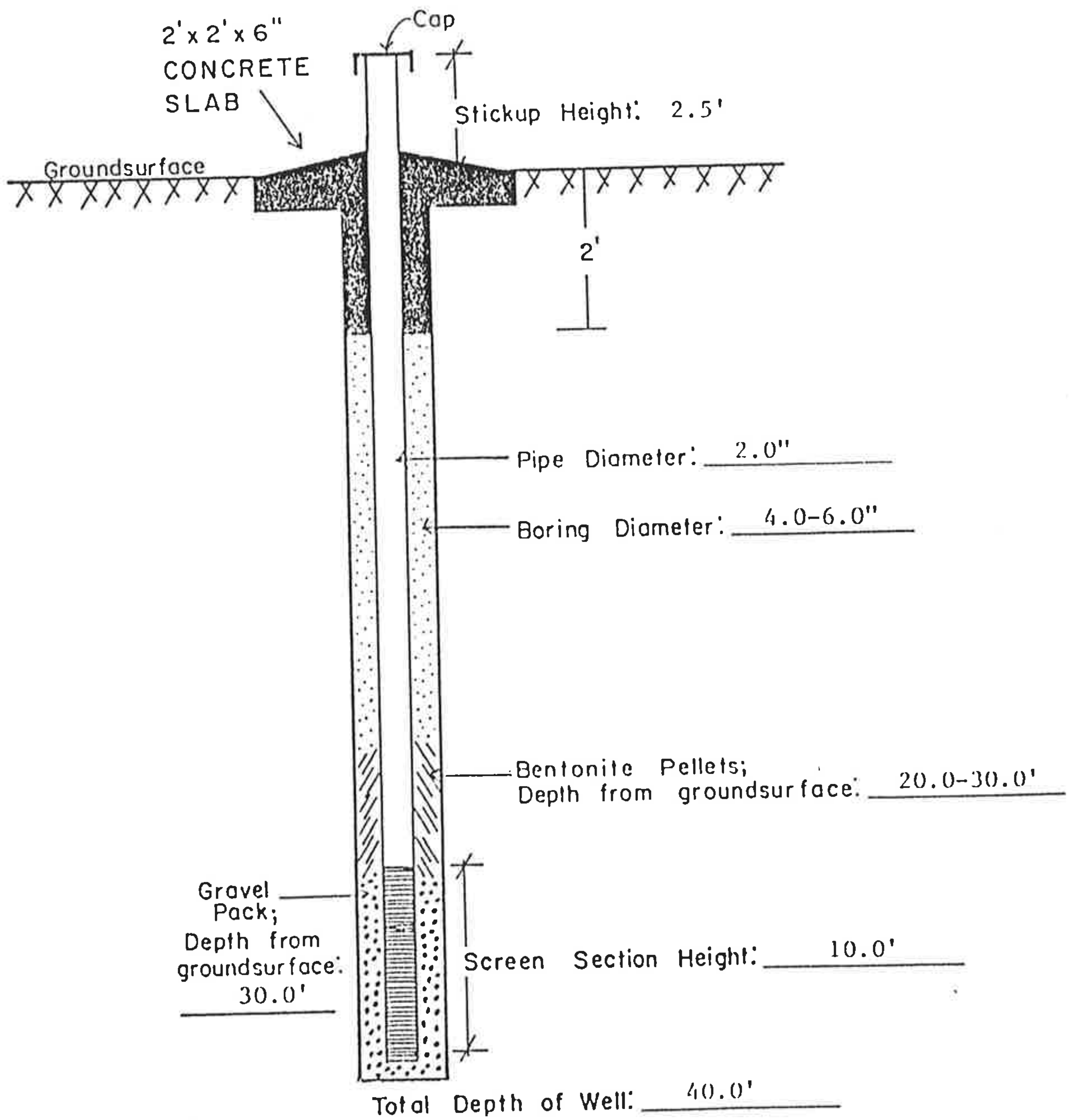
PIEZOMETER WELL DATA SHEET

Piezometer No: B-10

Well Boring Depth: 50.0'

Date Installed: 9/4/90

Water Level (groundsurface to water level): 10.2-18.4'



Trinity Engineering Testing Corporation

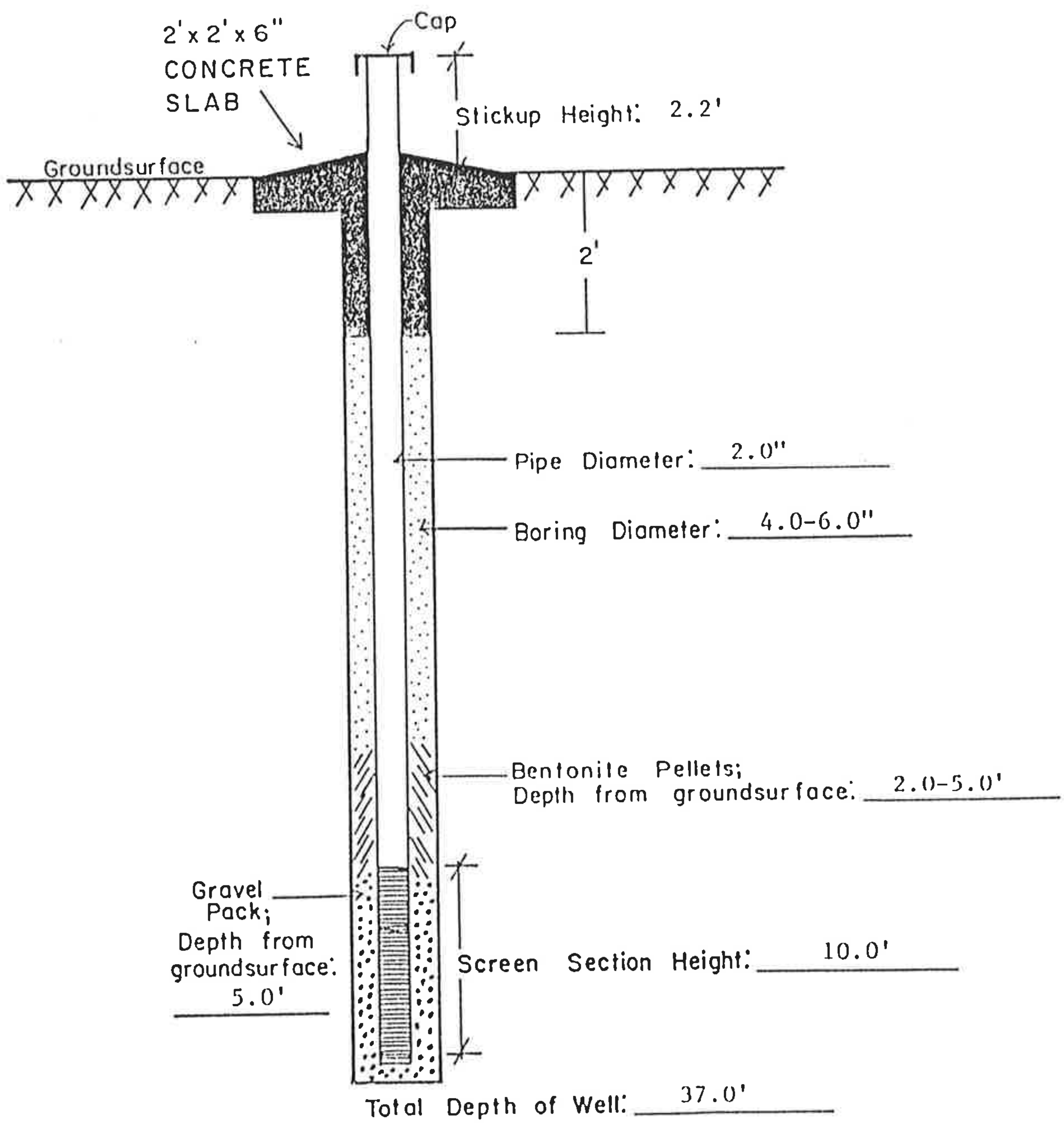
PIEZOMETER WELL DATA SHEET

Piezometer No: B-12

Well Boring Depth: 50.0'

Date Installed: 9/4/90

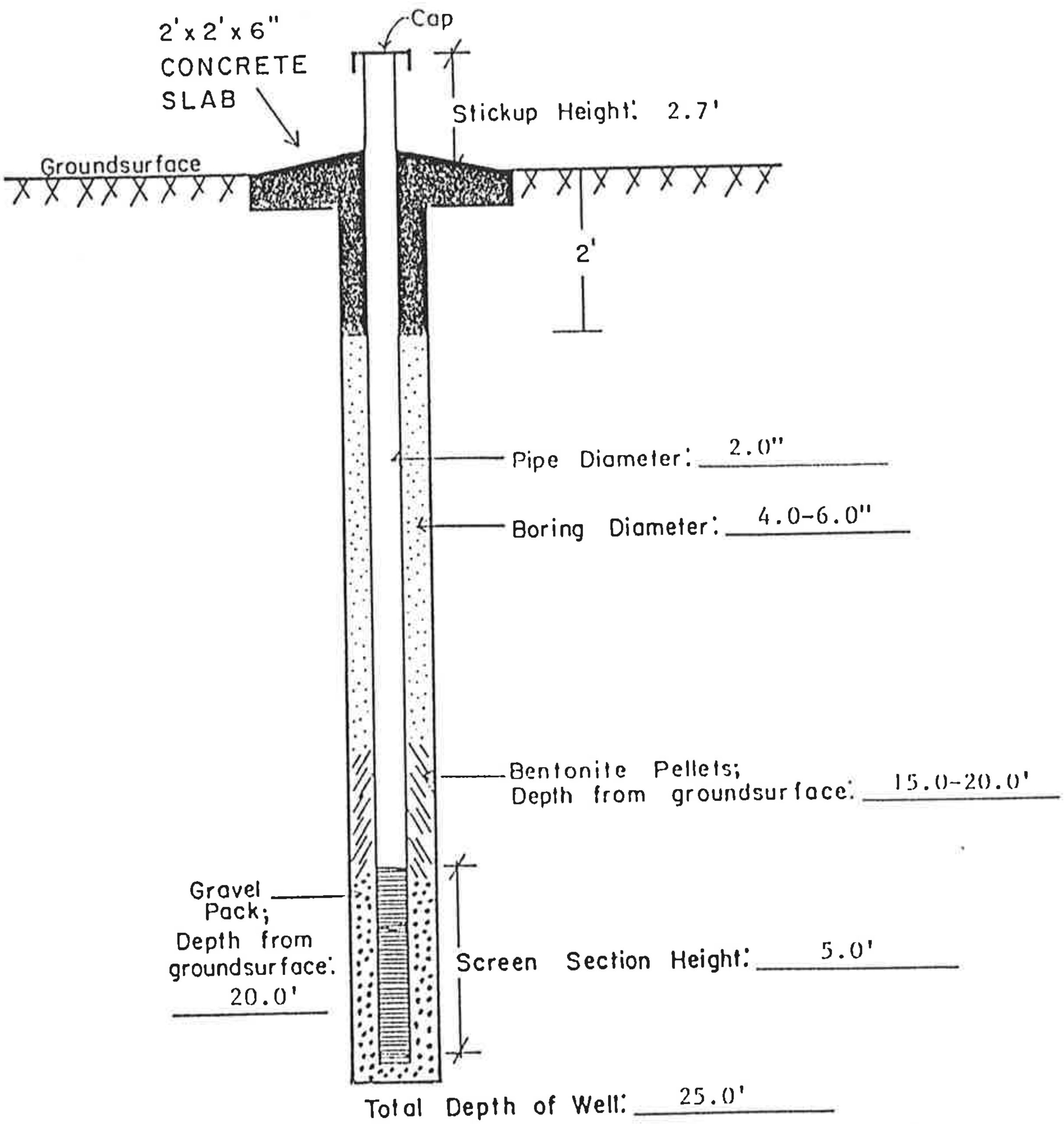
Water Level (groundsurface to water level): 15.2-19.0'



Trinity Engineering Testing Corporation

PIEZOMETER WELL DATA SHEET

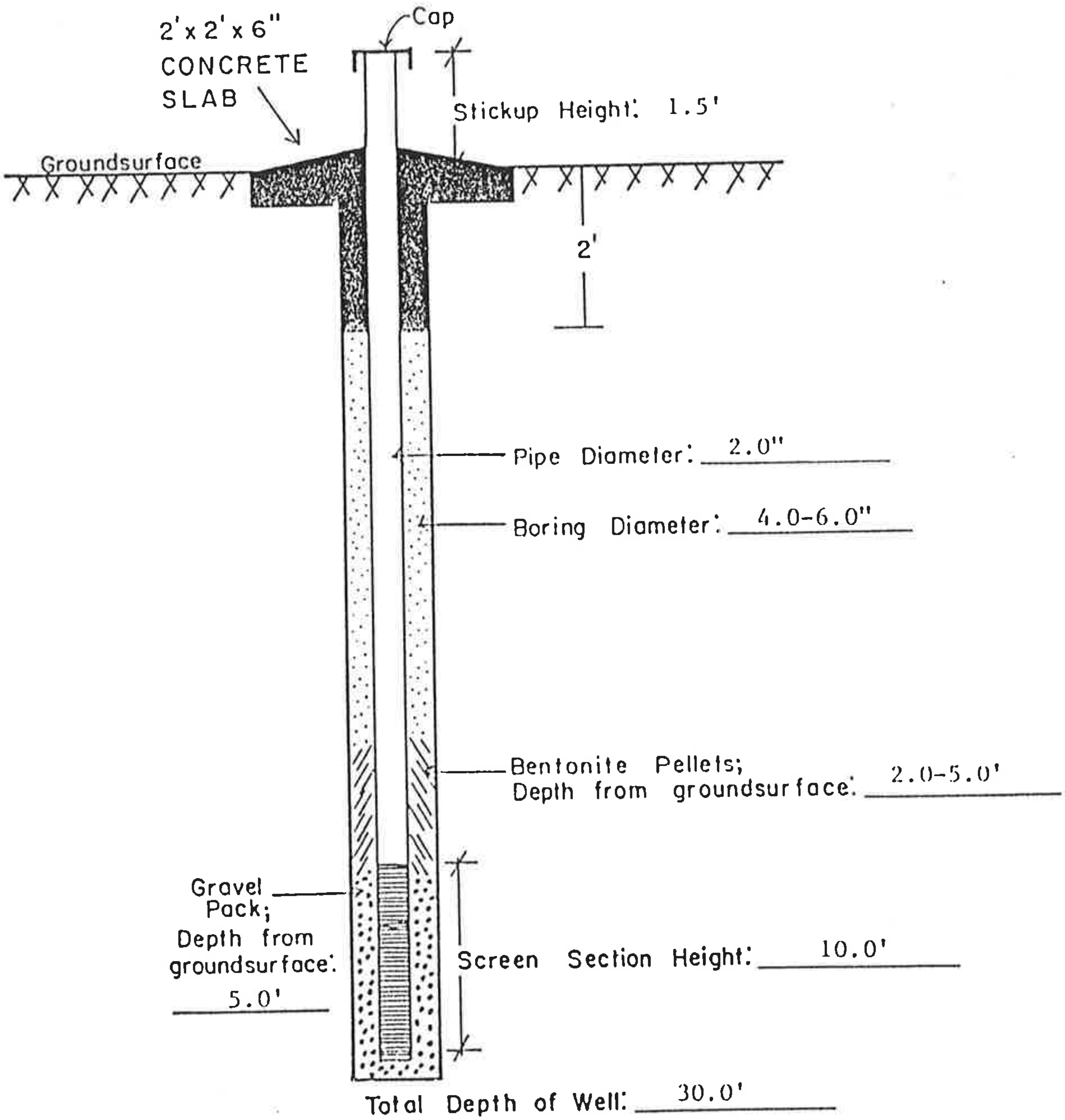
Piezometer No: B-16
Well Boring Depth: 34.0'
Date Installed: 9/4/90
Water Level (groundsurface to water level): 8.9-10.1'



Trinity Engineering Testing Corporation

PIEZOMETER WELL DATA SHEET

Piezometer No: B-17
Well Boring Depth: 100.0'
Date Installed: 9/24/90
Water Level (groundsurface to water level): 10.0-14.2'



Trinity Engineering Testing Corporation

Slug Test Calculation - Horslev Method

$$K = \frac{r^2 \ln (L/R)}{2LT_o}$$

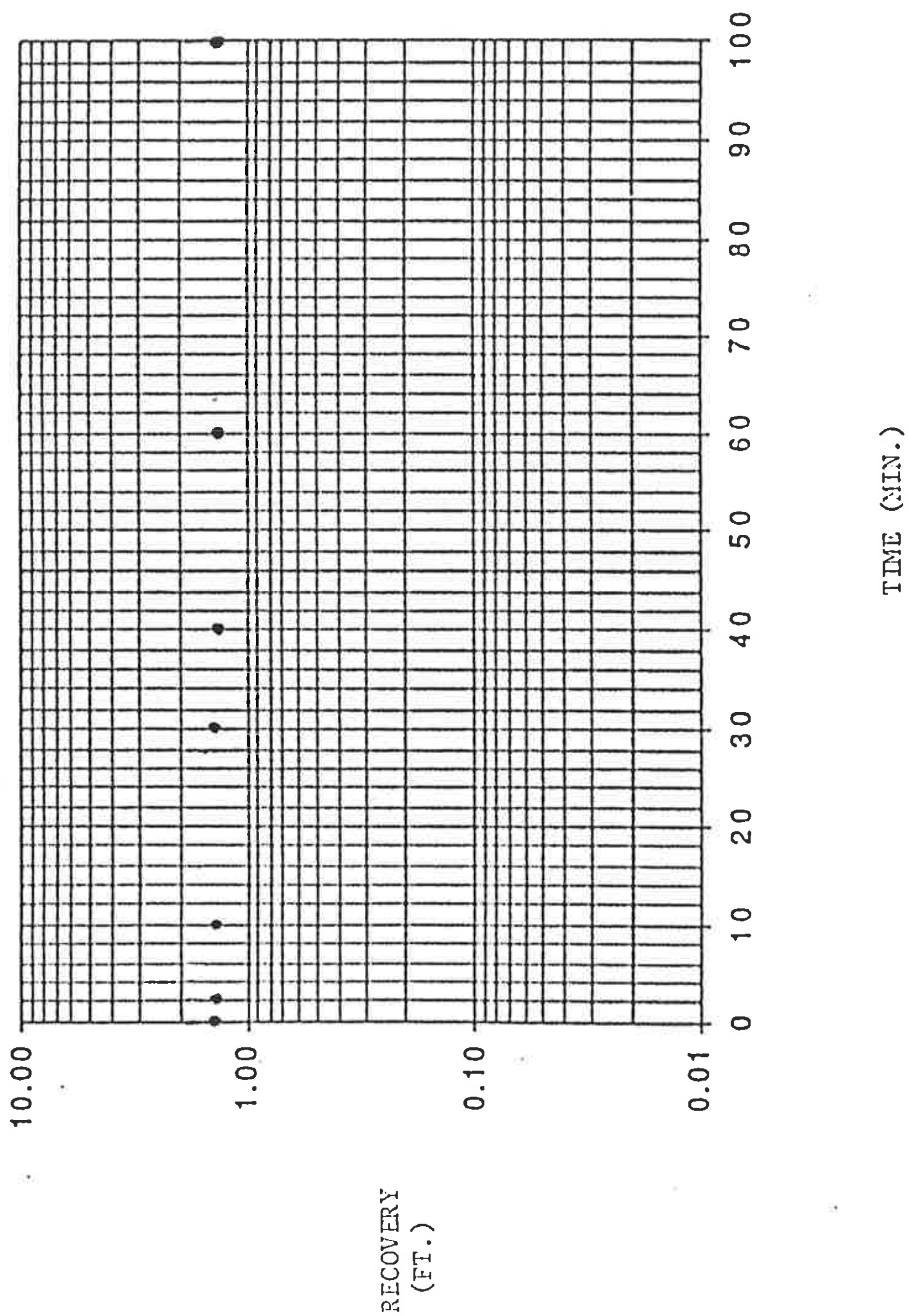
r = well radius, feet
L = length of screen, feet
R = bore hole radium, feet
T_o= time at which the well has recovered to within 37% of static, minutes.

Example: Piezometer #16
r = 0.08'
L = 10.0'
R = 0.17'
T_o= 14 minutes

$K = 9.3 \times 10^{-5}$ ft/min.
$K = 4.7 \times 10^{-5}$ cm/sec.

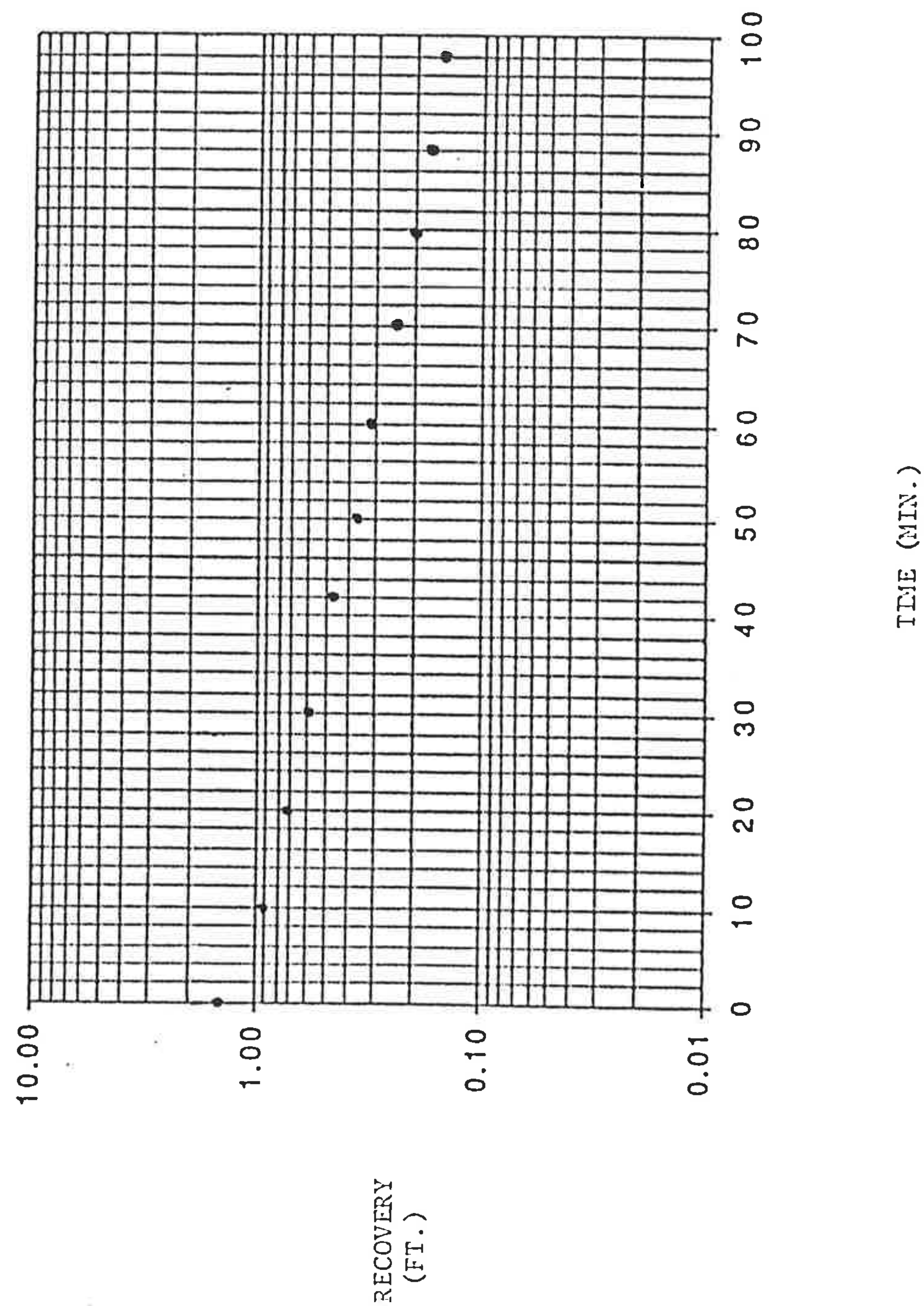
Trinity Engineering Testing Corporation

SLUG TEST - WELL NO. 5 (ADDITION)

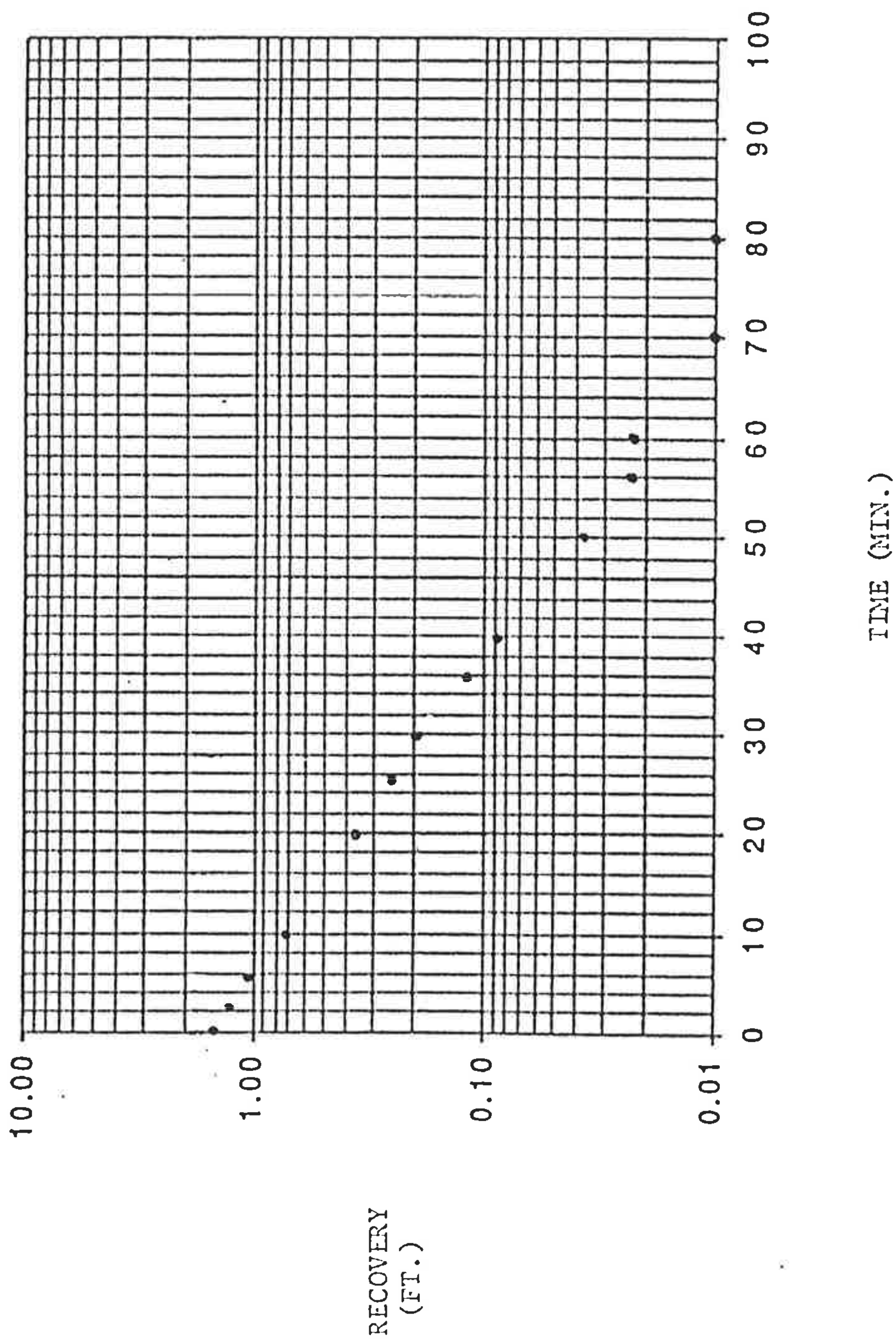


Trinity Engineering Testing Corporation

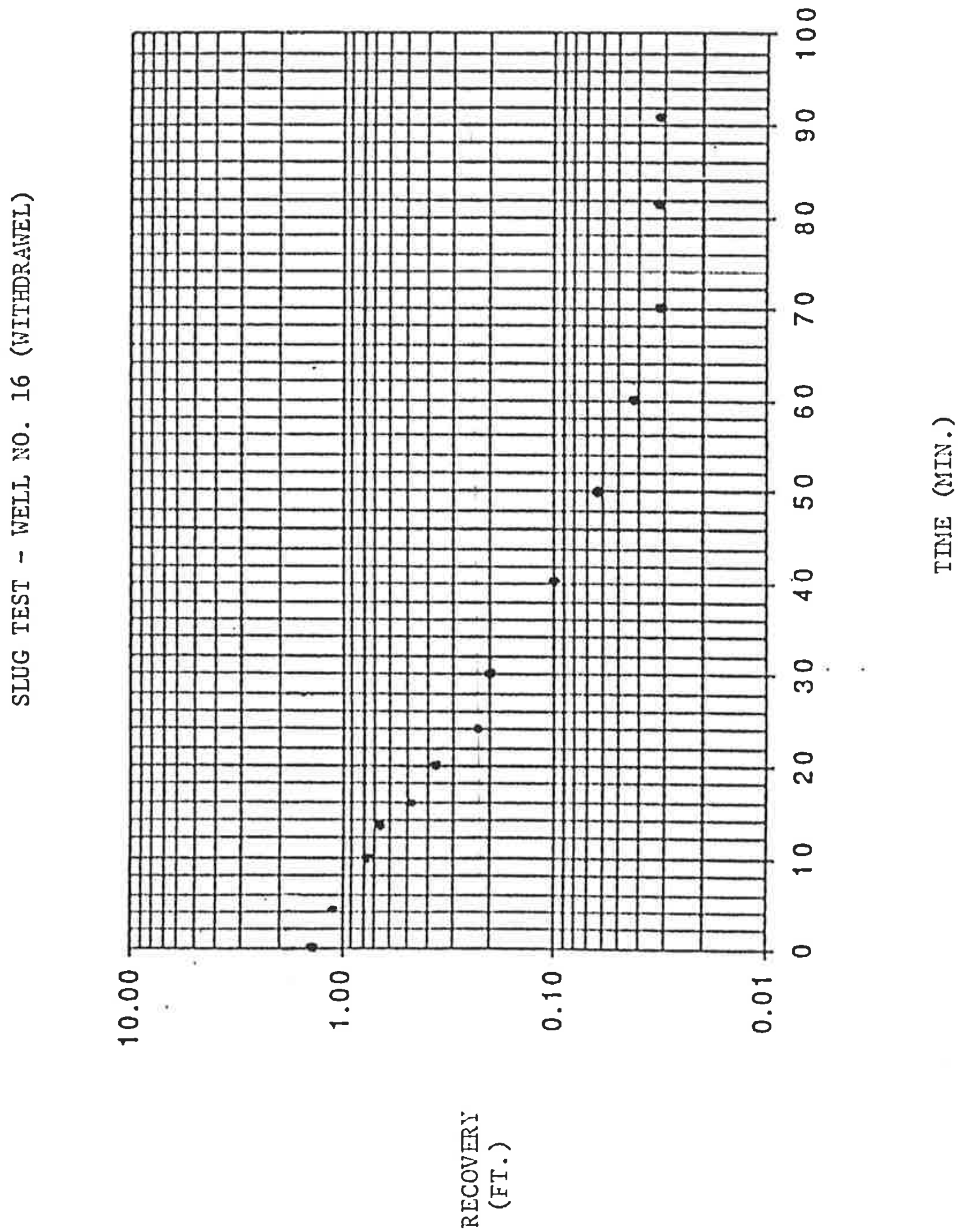
SLUG TEST - WELL NO. 12 (WITHDRAWEL)



SLUG TEST - WELL NO. 16 (ADDITION)



Trinity Engineering Testing Corporation



CITY OF ABILENE
QUALITY CONTROL DIVISION
LABORATORY REPORT

(915) 673-8531

SAMPLE ANALYSIS REQUESTED BY: MARC BURSON

REPORT CHECKED/APPROVED BY: KF

ANALYSIS	RESULTS		RESULTS		RESULTS		RESULTS	
LAB ID NO.	1115		1116		1117		1118	
CUSTOMER ID	B-5		B-6		B-9		B-10	
SAMPLE TYPE	GRAB		GRAB		GRAB		GRAB	
SAMPLE SOURCE	WELL		WELL		WELL		WELL	
SAMPLE APPEARANCE	MUDDY		MUDDY		MUDDY		MUDDY	
SAMPLE LOCATION	HASKELL LANDFILL		SAME		SAME		SAME	
COLLECTION DATE/TIME	09-05-90		SAME		SAME		SAME	
RECEIVED DATE/TIME/BY	09-06-90/1130/LW		SAME		SAME		SAME	
'ALYSIS DATE/TIME/BY	09-06-90/1225/LW		SAME		SAME		SAME	
	8.4	S.U.	7.9	S.U.	8.0	S.U.	8.2	S.U.
CHLORINE RESIDUAL		mg/L		mg/L		mg/L		
ALKALINITY (CO3)P/T	22/532	mg/L	/310	mg/L	26/600	mg/L	/800	mg/L
HARDNESS (CaCO3)	32	mg/L	872	mg/L	136	mg/L	48	mg/L (EDTA)
CHLORIDES	155	mg/L	883	mg/L	1102	mg/L	50	mg/L
FLUORIDE	1.4	mg/L	0.4	mg/L	1.6	mg/L	1.3	mg/L
SULFATES	109	mg/L	590	mg/L	424	mg/L	63	mg/L
NITRITE-NITROGEN		mg/L		mg/L		mg/L		
NITRATE-NITROGEN		mg/L		mg/L		mg/L	10	mg/L
AMMONIA-NITROGEN		mg/L		mg/L		mg/L		
TOT. KJELDAHL NITROGEN		mg/L		mg/L		mg/L		
TOTAL DISSOLVED SOLIDS	1000	mg/L	2400	mg/L	3400	mg/L	1167	mg/L (CALC.)
TOTAL SOLIDS		mg/L		mg/L		mg/L		
TSS		mg/L		mg/L		mg/L		
CONDUCTIVITY	1500	umhos	3600	umhos	5100	umhos	1600	umhos
TOTAL ORGANIC CARBON		mg/L		mg/L		mg/L		
BOD(5)		mg/L		mg/L		mg/L		
OIL & GREASE		mg/L		mg/L		mg/L		
THMs		ug/L		ug/L		ug/L		
TOTAL COLIFORM BACT.		/100ml		/100ml		/100ml		
FECAL COLIFORM BACT.		/100ml		/100ml		/100ml		
LEAD		mg/L		mg/L		mg/L		
CARBONATE	44		0		52		0	mg/L
BICARBONATE	488		310		548		800	mg/L

REMARKS: P/T = PHENOLPHTHALEIN AND TOTAL ALKALINITIES.

NOTE: CONSULT PERSONAL PHYSICIAN BEFORE USING WATER FOR HUMAN CONSUMPTION IF SAMPLE RESULTS EXCEED THE TEXAS HEALTH DEPARTMENT LIMITS AND/OR TREAT SOURCE AND RETEST.

C I T Y   O F   A B I L E N E

Q U A L I T Y   C O N T R O L   D I V I S I O N

L A B O R A T O R Y   R E P O R T

(915) 673-8531

CITY OF HASKELL
P.O. BOX 1003
HASKELL, TX 79521
ATTN:

SAMPLE ANALYSIS REQUESTED BY: MARC BURSON   REPORT CHECKED/APPROVED BY: KF

LAB ID NO. / CUSTOMER ID	* 1115 / * B-5	* 1116 / * B-6	* 1117 / * B-9	* 1118 / * B-10
SAMPLE TYPE	*	*	*	*
SAMPLE SOURCE	*	*	*	*
SAMPLE APPEARANCE	*	*	*	*
SAMPLE LOCATION	*	*	*	*
COLLECTION DATE/TIME	*	*	*	*
RECEIVED DATE/TIME/BY	*	*	*	*
ANALYSIS DATE/TIME/BY	*	*	*	*

ANALYSIS	*DET.LIM.	* RESULTS		* RESULTS		* RESULTS		* RESULTS	
ALUMINUM	* 0.2	* 1.4	mg/L	* 0.4	mg/L	* 1.0	mg/L	* 1.0	mg/L
ARSENIC	* 3	* 58	ug/L	* 3	ug/L	* 37	ug/L	* 123	ug/L
BARIUM	* 0.006	* 0.071	mg/L	* 0.169	mg/L	* 0.202	mg/L	* 0.130	mg/L
BERYLLIUM	* 0.0002	* <		*		*		*	mg/L
BORON	* 0.005	* 4.04	mg/L	* 0.539	mg/L	* 5.11	mg/L	* 1.738	mg/L
CADMIUM	* 0.004	* <	mg/L	* <	mg/L	* <	mg/L	*	mg/L
CALCIUM	*	* 4.23	mg/L	* 46.29	mg/L	* 6.35	mg/L	* 4.16	mg/L
CHROMIUM	* 0.005	* <	mg/L	* <	mg/L	* <	mg/L	*	mg/L
COPPER	* 0.008	* <	mg/L	* <	mg/L	* 0.018	mg/L	* 0.032	mg/L
IRON	* 0.01	* 0.93	mg/L	* 0.19	mg/L	* 0.48	mg/L	* 0.44	mg/L
LEAD	* 0.03	* <	mg/L	* <	mg/L	*	mg/L	*	mg/L
MAGNESIUM	*	* 2.4	mg/L	* 31.6	mg/L	* 4.3	mg/L	* 2.0	mg/L
MANGANESE	* 0.002	* 0.008	mg/L	* 0.068	mg/L	* 0.011	mg/L	* 0.024	mg/L
MERCURY	*	*	ug/L	*	ug/L	*	ug/L	*	ug/L
NICKEL	* 0.02	* <	mg/L	*	mg/L	*	mg/L	*	mg/L
PHOSPHORUS	* 0.2	*	mg/L	*	mg/L	*	mg/L	*	mg/L
POTASSIUM	*	* 1.49	mg/L	* 1.80	mg/L	* 2.46	mg/L	* 1.07	mg/L
SELENIUM	* 1	* 275	ug/L	* 66	ug/L	* 283	ug/L	* 47	ug/L
SILICON	*	* 2.79	mg/L	* 3.11	mg/L	* 1.28	mg/L	* 1.17	mg/L
SILVER	* 0.01	*	mg/L	*	mg/L	*	mg/L	*	mg/L
SODIUM,	*	* 480.9	mg/L	* 386.1	mg/L	* 1880.6	mg/L	* 366.4	mg/L
TELLERIUM	*	*	ug/L	*	ug/L	*	ug/L	*	ug/L
ZINC	* 0.005	* 0.009	mg/L	* 0.018	mg/L	* 0.034	mg/L	* 0.030	mg/L

REMARKS: "<" MEANS LESS THAN THE DETECTION LIMIT

CENTRAL TEXAS QUALITY ASSURANCE LABORATORY
P.O. Box 23147
WACO, TEXAS 76702-3147

RARD N. SCHANK
OFFICE (817) 772-5549

Customer:	Trinity Engineering Testing Co.
Sampling Location:	Haskell Regional Landfill, Haskell, TX
Project No.:	Ab-1455
Sample Date:	9/5/90

SAMPLE ID	TOTAL ORGANIC CARBON
B-5 27.9'	28.0 mg/l
B-6 15.9'	44.0 mg/l
B-9 29.2'	125.0 mg/l
B-10 20.9'	33.0 mg/l

Gerard N Schank

CITY OF ABILENE
QUALITY CONTROL DIVISION
LABORATORY REPORT

(915) 673-8531

CITY OF HASKELL
P.O. BOX 1003
HASKELL, TX 79521

SAMPLE ANALYSIS REQUESTED BY: WIN McATEE

REPORT CHECKED/APPROVED BY: KF

ANALYSIS	RESULTS		RESULTS		RESULTS		TEXAS HEALTH DEPARTMENT LIMITS (POTABLE WATER)
LAB ID NO.	1562		1563		1564		
CUSTOMER ID	B-3		B-6		B-9		
SAMPLE TYPE	GRAB		GRAB		GRAB		
SAMPLE SOURCE	LANDFILL		LANDFILL		LANDFILL		
SAMPLE APPEARANCE							
SAMPLE LOCATION							
COLLECTION DATE/TIME							
RECEIVED DATE/TIME/BY	11-07-90/1630/KF		11-07-90/1630/KF		11-07-90/1630/KF		
ANALYSIS DATE/TIME/BY	11-08-90/1300/LN		11-08-90/1300/LN		11-08-90/1300/LN		
pH	8.0	S.U.	7.6	S.U.	8.1	S.U.	
CHLORINE RESIDUAL		mg/L		mg/L		mg/L	
ALKALINITY (CO3)	336	mg/L	314	mg/L	536	mg/L	CALC.( ) EDTA(X)
HARDNESS (CaCO3)	1110	mg/L	1010	mg/L	100	mg/L	300 mg/L
CHLORIDES	2904	mg/L	1162	mg/L	1270	mg/L	
FLUORIDE	0.24	mg/L	0.16	mg/L	0.31	mg/L	300 mg/L
SULFATES	2018	mg/L	612	mg/L	520	mg/L	
NITRITE-NITROGEN		mg/L		mg/L		mg/L	
NITRATE-NITROGEN	10.5	mg/L	17.5	mg/L	18.5	mg/L	10 mg/L
AMMONIA-NITROGEN		mg/L		mg/L		mg/L	
TOT. KJELDAHL NITROGEN		mg/L		mg/L		mg/L	
TOTAL DISSOLVED SOLIDS	7333	mg/L	4333	mg/L	4667	mg/L	1000mg/L CALC.( ) DRYED( ).
TOTAL SOLIDS		mg/L		mg/L		mg/L	
TSS		mg/L		mg/L		mg/L	
CONDUCTIVITY	11000	umhos	6500	umhos	7000	umhos	
TOTAL ORGANIC CARBON		mg/L		mg/L		mg/L	
BOD(5)		mg/L		mg/L		mg/L	
OIL & GREASE		mg/L		mg/L		mg/L	
TTHMs		mg/L		mg/L		mg/L	
TOTAL COLIFORM BACT.		/100ml		/100ml		/100ml	0/100ml
FECAL COLIFORM BACT.		/100ml		/100ml		/100ml	0/100ml
LEAD	0	mg/L	0	mg/L	0	mg/L	
CARBONATE		mg/L		mg/L		mg/L	

REMARKS: BICARBONATE IS EQUIVALENT TO ALKALINITY.

NOTE: CONSULT PERSONAL PHYSICIAN BEFORE USING WATER FOR HUMAN CONSUMPTION IF SAMPLE RESULTS EXCEED THE TEXAS HEALTH DEPARTMENT LIMITS AND/OR TREAT SOURCE AND RETEST.

CITY OF ABILENE
QUALITY CONTROL DIVISION
LABORATORY REPORT

(915) 673-8531

CITY OF HASKELL
P.O. BOX 1003
HASKELL, TX 79521

SAMPLE ANALYSIS REQUESTED BY: WIN McATEE

REPORT CHECKED/APPROVED BY: KF

LAB ID NO.	1562	1563	1564	
CUSTOMER ID	B-3	B-6	B-9	
SAMPLE TYPE	GRAB	GRAB	GRAB	
SAMPLE SOURCE	LANDFILL	LANDFILL	LANDFILL	
SAMPLE APPEARANCE				
SAMPLE LOCATION				
COLLECTION DATE/TIME				
RECEIVED DATE/TIME/BY	11-07-90/1630/KF	11-07-90/1630/KF	11-07-90/1630/KF	
ANALYSIS DATE/TIME/BY	11-08-90/ /LT	11-08-90/ /LT	11-08-90/ /LT	

ANALYSIS	DET. LIM.	RESULTS		RESULTS		RESULTS		RESULTS
ALUMINUM	0.1	0.1	mg/L	0.1	mg/L	0.1	mg/L	mg/L
ARSENIC	2	10.9	ug/L	7.0	ug/L	2	ug/L	ug/L
BARIUM	0.01	0.024	mg/L	0.088	mg/L	0.105	mg/L	mg/L
BERYLLIUM	0.0004	0.0004	mg/L	0.0004	mg/L	0.0004	mg/L	mg/L
BORON	0.01	4.4	mg/L	0.522	mg/L	4.3	mg/L	mg/L
CADMIUM	0.008	0.008	mg/L	0.008	mg/L	0.008	mg/L	mg/L
CALCIUM	0.04	104.31	mg/L	199.7	mg/L	13.93	mg/L	mg/L
CHROMIUM	0.02	0.02	mg/L	0.02	mg/L	0.02	mg/L	mg/L
COPPER	0.01	0.01	mg/L	0.01	mg/L	0.01	mg/L	mg/L
IRON	0.02	0.02	mg/L	0.02	mg/L	0.02	mg/L	mg/L
LEAD	0.1	0.1	mg/L	0.1	mg/L	0.1	mg/L	mg/L
MAGNESIUM	0.1	32.9	mg/L	88.1	mg/L	12.3	mg/L	mg/L
MANGANESE	0.003	0.0585	mg/L	0.003	mg/L	0.003	mg/L	mg/L
MERCURY			mg/L		mg/L		mg/L	mg/L
NICKEL	0.05	0.05	mg/L	0.05	mg/L	0.05	mg/L	mg/L
PHOSPHORUS	0.2	0.2	mg/L	0.2	mg/L	[illegible]	mg/L	mg/L
POTASSIUM	0.5	[illegible]	mg/L	1.95	mg/L	2.55	mg/L	mg/L
SELENIUM	1	[illegible]	mg/L	1	mg/L	[illegible]	mg/L	mg/L
SILICON	0.1	[illegible]	mg/L	[illegible]	mg/L	[illegible]	mg/L	mg/L
SILVER	0.01	0.01	mg/L	0.01	mg/L	0.01	mg/L	mg/L
SODIUM	0.13	1847.1	mg/L	776.1	mg/L	1138.4	mg/L	mg/L
TELLERIUM	4	[illegible]	mg/L	4	mg/L	4	mg/L	mg/L
THALLIUM	0.02		mg/L		mg/L		mg/L	mg/L
ZINC	0.01	0.01	mg/L	0.01	mg/L	0.01	mg/L	mg/L

REMARKS: SAMPLE B-17 WAS LOST.

CENTRAL TEXAS QUALITY ASSURANCE LABORATORY
P.O. Box 23147
WACO, TEXAS 76702-3147

OFFICE (817) 772-5549

GERARD N. SCHANK

Customer:	Trinity Engineering Testing Co.
Sampling Location:	Haskell Landfill, Haskell, Texas
Project No.:	Ab 1455
Sample ID:	B-9 16.83'
Sample Date:	11/6/90

POLLUTANT	CONCENTRATION
Benzene	6.80 µg/l
Benzene, chloro	<5.0 µg/l
Benzene, 1,2-dichloro	<5.0 µg/l
Benzene, 1,3-dichloro	<5.0 µg/l
Benzene, 1,4-dichloro	<5.0 µg/l
Benzene, ethyl	7.25 µg/l
Toluene	9.60 µg/l

CENTRAL TEXAS QUALITY ASSURANCE LABORATORY
P.O. Box 23147
WACO, TEXAS 76702-3147

GERARD N. SCHANK

OFFICE (817) 772-5549

Customer:	Trinity Engineering Testing Co.
Sampling Location:	Haskell Landfill, Haskell, Texas
Project No.:	Ab 1455
Sample ID:	B-6 13.12'
Sample Date:	11/6/90

POLLUTANT	CONCENTRATION
Benzene	5.35 µg/l
Benzene, chloro	<5.0 µg/l
Benzene, 1,2-dichloro	<5.0 µg/l
Benzene, 1,3-dichloro	<5.0 µg/l
Benzene, 1,4-dichloro	<5.0 µg/l
Benzene, ethyl	6.10 µg/l
Toluene	8.50 µg/l

Drinking Water Standards

Constituent	Recommended concentration limit* (mg/ℓ)
Inorganic	
Total dissolved solids	500
Chloride (Cl)	250
Sulfate (SO_4^{2-})	250
Nitrate (NO_3^-)	45†
Iron (Fe)	0.3
Manganese (Mn)	0.05
Copper (Cu)	1.0
Zinc (Zn)	5.0
Boron (B)	1.0
Hydrogen sulfide (H_2S)	0.05
	Maximum permissible concentration‡
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Cr^{VI})	0.05
Selenium	0.01
Antimony (Sb)	0.01
Lead (Pb)	0.05
Mercury (Hg)	0.002
Silver (Ag)	0.05
Fluoride (F)	1.4–2.4§
Organic	
Cyanide	0.05
Endrine	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP silvex	0.01
Phenols	0.001
Carbon chloroform extract	0.2
Synthetic detergents	0.5
Radionuclides and radioactivity	Maximum permissible activity (pCi/ℓ)
Radium 226	5
Strontium 90	10
Plutonium	50,000
Gross beta activity	30
Gross alpha activity	3
Bacteriological	
Total coliform bacteria	1 per 100 mℓ

SOURCES: U.S. Environmental Protection Agency, 1975 and World Health Organization, European Standards, 1970.

*Recommended concentration limits for these constituents are mainly to provide acceptable esthetic and taste characteristics.

†Limit for NO_3^- expressed as N is 10 mg/ℓ according to U.S. and Canadian standards; according to WHO European standards, it is 11.3 mg/ℓ as N and 50 mg/ℓ as NO_3^-.

Recommended Concentration Limits for Water Used for Livestock and Irrigation Crop Production

	Livestock: Recommended limits (mg/ℓ)	Irrigation crops: Recommended limits (mg/ℓ)
Total dissolved solids		
Small animals	3000	700
Poultry	5000	
Other animals	7000	
Nitrate	45	—
Arsenic	0.2	0.1
Boron	5	0.75
Cadmium	0.05	0.01
Chromium	1	0.1
Fluoride	2	1
Lead	0.1	5
Mercury	0.01	—
Selenium	0.05	0.02

Trinity Engineering Testing Corporation

APPENDIX IV

STANDARD PROCTOR DATA SHEET
LABORATORY PERMEABILITY DATA SHEETS

TRINITY ENGINEERING TESTING CORPORATION
Box 1994, Waco, TEXAS 76703-1994

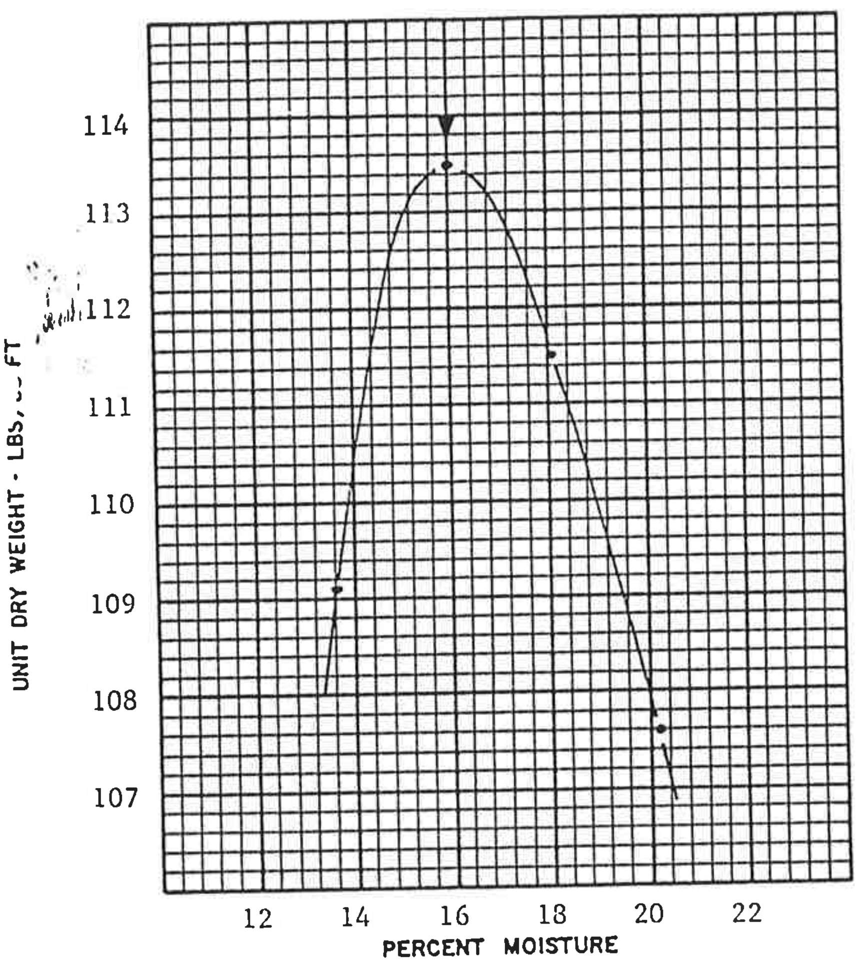
TETCO

MOISTURE-DENSITY CURVE

TO: City of Haskell

PROJECT: Haskell Landfill

DATE: July 23, 1990
REPORT NO: AB-1455



MATERIAL DESCRIPTION:
Reddish Brown
Weathered Silty Shale

SAMPLED BY:

TEST PERFORMED BY: R. Poston

TEST METHOD: ASTM D 698
Method "A"

TRIAL NO.	PERCENT MOISTURE	UNIT DRY WEIGHT LBS/CU FT
1	13.6	109.1
2	16.0	113.5
3	18.1	111.5
4	20.2	107.6

OPTIMUM MOISTURE, PERCENT: 16.0

MAXIMUM DENSITY, LBS/CU FT: 113.5

ATTERBERG LIMIT:

Liquid Limit: 42
Plasticity Index: 24

COPIES TO:

TRINITY ENGINEERING TESTING CORPORATION

Wm McAtee

TRINITY ENGINEERING TESTING CORPORATION

Box 1994 Waco, TEXAS 76703-1994

TETCO

TO: City of Haskell

DATE: 7/31/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale, Excavated from active area trench

DRY DENSITY 108.3 p.c.f. L.L. 42 P.L. 18 P.I. 24

PASSING 200-MESH SIEVE 93.9%

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5.0 p.s.i. HYDRAULIC GRADIENT 30.8

EFFECTIVE CONFINING STRESS 7.5 p.s.i.

TOTAL TEST TIME 72 hrs. STEADY STATE CONDITION 18 hrs.

INFLOW / OUTFLOW 9 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☐ UNDISTURBED ☒ REMOLDED

DIAMETER 4.0 in. THICKNESS 4.5 in.

INITIAL MOISTURE 16.3% FINAL MOISTURE 17.3%

INITIAL SATURATION 82% FINAL SATURATION 87 %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 4.5×10^{-8} cm / sec

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TRINITY ENGINEERING TESTING CORPORATION

Box 1994 Waco, TEXAS 76703-1994

TETCO

TO: City of Haskell

DATE: 8/1/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale, Fractured
B-1 7.5-9.0'

DRY DENSITY 119.7 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 0.5 hrs. STEADY STATE CONDITION 0.5 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 1.50 in. THICKNESS 2.75 in.

INITIAL MOISTURE 13.6% FINAL MOISTURE 16.1%

INITIAL SATURATION 95 % FINAL SATURATION 100 %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 1.2×10^{-5} cm / sec

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TETCO

Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 9/11/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale
B-2/22.2-22.9'

DRY DENSITY 136.9 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 50.4

EFFECTIVE CONFINING STRESS 7.5 p.s.i.

TOTAL TEST TIME 144 hrs. STEADY STATE CONDITION 21 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.00 in. THICKNESS 2.75 in.

INITIAL MOISTURE 10.6% FINAL MOISTURE 11.0%

INITIAL SATURATION 100 % FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 5.2×10^{-9} cm / sec

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Wm McGhee

TRINITY ENGINEERING TESTING CORPORATION
TETCO
Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 9/15/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale
B-4/12.5-13.0'

DRY DENSITY 133.8 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 69.2

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 240 hrs. STEADY STATE CONDITION -- hrs.
Calculated on inflow

INFLOW/OUTFLOW -- % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 2.0 in.

INITIAL MOISTURE 10.3 % FINAL MOISTURE 11.3%

INITIAL SATURATION 100% FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 8.6×10^{-10} cm / sec

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TETCO

Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 9/18/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale (Vertical Fracture)
B-4/26.0-27.0'

DRY DENSITY 129.3 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 72.9

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 25 hrs. STEADY STATE CONDITION 17 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.9 in.

INITIAL MOISTURE 10.8% FINAL MOISTURE 11.6 %

INITIAL SATURATION 100% FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 4.2×10^{-8} cm / sec

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Box 1994 Waco, TEXAS 76703-1994

TETCO

TO: City of Haskell

DATE: 8/22/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale (Fractured)
B-7/26.0-27.6'

DRY DENSITY 134.2 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 7.5 p.s.i.

TOTAL TEST TIME 52 hrs. STEADY STATE CONDITION 12 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.5 in.

INITIAL MOISTURE 12.2% FINAL MOISTURE 12.9%

INITIAL SATURATION 100% FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 8.6×10^{-8} cm / sec

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TETCO
Box 1994 Waco TEXAS 76703-1994

TO: City of Haskell

DATE: 8/15/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Gray Siltstone
B-12/35.0-35.8'

DRY DENSITY 128.6 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 106.5

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 6 hrs. STEADY STATE CONDITION 3 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.3 in.

INITIAL MOISTURE 13.2% FINAL MOISTURE 13.5%

INITIAL SATURATION 100 % FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 1.9×10^{-7} cm / sec

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Wm McAfee

TRINITY ENGINEERING TESTING CORPORATION
Box 1994 Waco, TEXAS 76703-1994

TETCO

TO: City of Haskell

DATE: 9/10/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale (Fractured)
B-13/18.0-19.0'

DRY DENSITY 128.4 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 7.5 p.s.i.

TOTAL TEST TIME 28 hrs. STEADY STATE CONDITION 12 hrs.

INFLOW / OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.5 in.

INITIAL MOISTURE 13.4% FINAL MOISTURE 14.3%

INITIAL SATURATION 96 % FINAL SATURATION 100 %

ORIENTATION ☐ VERTICAL ☒ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 4.2×10^{-7} cm / sec

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Wm McAtee

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TETCO

Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 9/17/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Gray Siltstone

B-14/8.0-8.5'

DRY DENSITY 126.9 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 41 hrs. STEADY STATE CONDITION 16 hrs.

INFLOW/OUTFLOW 6 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.75 in. THICKNESS 1.50 in.

INITIAL MOISTURE 11.1% FINAL MOISTURE 15.4%

INITIAL SATURATION 98% FINAL SATURATION 100 %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 8.1×10^{-8} cm / sec

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TETCO

Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 9/25/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale (Blocky Fractures)
B-14/21.1-21.5'

DRY DENSITY 124.4 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 76.9

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 4 hrs. STEADY STATE CONDITION 3.5 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.8 in.

INITIAL MOISTURE 11.9% FINAL MOISTURE 13.4%

INITIAL SATURATION 96 % FINAL SATURATION 100 %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 8.7×10^{-7} cm / sec

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TETCO

Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 8/6/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale (Blocky Fractures)
B-16/6.0-7.5'

DRY DENSITY 121.2 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 1.0 hrs. STEADY STATE CONDITION 0.2 hrs.

INFLOW/OUTFLOW 0% difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.75 in. THICKNESS 1.50 in.

INITIAL MOISTURE 11.5% FINAL MOISTURE 15.8%

INITIAL SATURATION 85% FINAL SATURATION 100 %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 1.7×10^{-6} cm / sec

COPIES:

TRINITY ENGINEERING TESTING CORPORATION

Wm McAtee

TRINITY ENGINEERING TESTING CORPORATION
Box 1994 Waco, TEXAS 76703-1994

TETCO

TO: City of Haskell

DATE: 9/19/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Sandy Clay (Fractured)
B-17/7.5-9.0'

DRY DENSITY 113.1 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 34 hrs. STEADY STATE CONDITION 33 hrs.

INFLOW / OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.75 in. THICKNESS 1.50 in.

INITIAL MOISTURE 17.7% FINAL MOISTURE 19.4%

INITIAL SATURATION 100% FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 1.0×10^{-6} cm / sec

COPIES:

TRINITY ENGINEERING TESTING CORPORATION

Wm McGhee

TRINITY ENGINEERING TESTING CORPORATION
Box 1994 Waco, TEXAS 76703-1994

TETCO

TO: City of Haskell

DATE: 9/5/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale
B-17/56.5-58.0'

DRY DENSITY 134.3 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 92.3

EFFECTIVE CONFINING STRESS 7.5 p.s.i.

TOTAL TEST TIME 154 hrs. STEADY STATE CONDITION -- hrs.
Calculated on inflow.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.5 in.

INITIAL MOISTURE 11.2% FINAL MOISTURE 11.4%

INITIAL SATURATION 100 % FINAL SATURATION -- %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 4.6×10^{-9} cm / sec

COPIES:

TRINITY ENGINEERING TESTING CORPORATION

Wm McElhattan

TRINITY ENGINEERING TESTING CORPORATION

TETCO

Box 1994 Waco, TEXAS 76703-1994

TO: City of Haskell

DATE: 9/19/90

REPORT NO.: AB-1455

PROJECT: Haskell Regional Landfill

LABORATORY PERMEABILITY TEST RESULTS

MATERIAL DESCRIPTION: Reddish Brown Shale (Fractured)

B-18/16.6-17.7'

DRY DENSITY 124.1 p.c.f. L.L. P.L. P.I.

PASSING 200-MESH SIEVE %

SAMPLING INFORMATION: ☐ DELIVERED BY CLIENT ☒ OBTAINED BY TETCO

TYPE OF PERMEAMETER: ☐ RIGID WALL ☒ FLEXIBLE WALL

TESTING PARAMETERS: ☐ FALLING ☐ CONSTANT ☒ BACK-PRESSURE HEAD

HYDRAULIC HEAD 5 p.s.i. HYDRAULIC GRADIENT 72.9

EFFECTIVE CONFINING STRESS 5.0 p.s.i.

TOTAL TEST TIME 1.7 hrs. STEADY STATE CONDITION 1.7 hrs.

INFLOW/OUTFLOW 0 % difference

PERMEANT FLUID: ☒ TAP WATER ☐ 0.005 N $CaSO_4$ ☐

SAMPLE CONDITIONS: ☒ UNDISTURBED ☐ REMOLDED

DIAMETER 2.0 in. THICKNESS 1.9 in.

INITIAL MOISTURE 12.1% FINAL MOISTURE 13.1%

INITIAL SATURATION 97 % FINAL SATURATION 100 %

ORIENTATION ☒ VERTICAL ☐ HORIZONTAL

TEST RESULT HYDRAULIC CONDUCTIVITY: 2.0×10^{-5} cm / sec

COPIES:

TRINITY ENGINEERING TESTING CORPORATION

[signature]

Trinity Engineering Testing Corporation

APPENDIX V

MISCELLANEOUS WELL DATA

WILDCAT WELL DATA
WELL DATA

MISCELLANEOUS WELL DATA

Abandoned livestock well near southeast corner of tract:

Depth: 27.0'
Diameter: 6.0"
Water Depth: 10.0' (8/22/90)
Old Windmill

Abandoned livestock well approximately 450' north of property line:

Depth: 25.0'
Diameter: 6.0"
Water Depth: 10.2' (9/24/90)
Old Windmill

9-185—July
Revised

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

WELL SCHEDULE

Date October 30, 1956 Field No. E-1
Record by E.L. Osborne Office No. E6
Source of data Earland Foote [redacted]

1. *Location:* State Texas County Haskell
Map
¼ ¼ sec. T N/S R E/W
2. *Owner:* Earland Foote Address Haskell
Tenant Clyde Hendricks Address R.R., Haskell
Driller Address
3. *Topography* Rolling
4. *Elevation* ft. above/below
5. *Type:* Dug, (drilled), driven, bored, jetted 1947
6. *Depth:* Rept. ft. Meas. 427 ft.
7. *Casing:* Diam. 6 in., to in., Type galv
Depth ft., Finish
8. *Chief Aquifer* Pcf From ft. to ft.
Others
9. *Water level* 300 ft. ~~rept.~~ meas. 10/30 1956 ~~above~~ below top of casing which is 2.62 ft. above ~~below~~ surface
10. *Pump:* Type Capacity G. M.
Power: Kind Windmill Horsepower
11. *Yield:* Flow G. M., Pump G. M., Meas., Rept. Est.
Drawdown ft. after hours pumping G. M.
12. *Use:* (Dom.), (Stock), PS., RR., Ind., Irr., Obs.
Adequacy, permanence strong
13. *Quality* Temp °F.
Taste, odor, color gypsy Sample Yes ~~No~~ 10/30/56
Unfit for
14. *Remarks:* (Log, Analyses, etc.)

21-51-601

F-6

Well-F-1

9-260
(January 1960)

UNITED STATES DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

ANALYTICAL STATEMENT HASKELL COUNTY
[Parts per million]

Location 4.4 mi E of Haskell

Source

Owner: Garland Foot
Depth: 43
Formation: Pcf

Date of collection Oct. 30, 1956
Use dom, stock
Temperature (°F)
Color pH 8.8
Suspended matter
Hardness as $CaCO_3$
N. C. Total 58
Ignition loss
Dissolved solids
Specific conductance at 25°C (micromhos) 3510

KEY PUNCHED

SiO_2	
Fe	
Ca	
Mg	
Na	
K	
CO_3	83
HCO_3	863 / 1040
SO_4	
Cl	422
F	
NO_3	
Sum	

Chemist J. F. Blakey
Lab. No. 57557
Collector E. L. Osborne

16—55248-4

DRILLERS LOG

FROM	TO	FORMATION
0	260	Red Bed, Sand
260	1060	Limestone, Sand, Clay
1060	2004	Shale, Limestone, Sand
2004	2770	Shale
2770	3390	Limestone, Shale
3390	3996	Limestone, Shale
3996	4315	Shale, Limestone
4315	4764	Shale, Limestone
4764	5125	Shale
5125	5398	Shale, Limestone
5398	5575	Dolomite

EP Operating Company

B. G. Vick

B. G. Vick

5-30-85

Date

Plugging Record

RAILROAD COMMISSION OF TEXAS
OIL AND GAS DIVISION

FORM W-3
Rev. 10/78

API NO. (if available) 4220731689

FILE IN DUPLICATE WITH DISTRICT OFFICE OF DISTRICT IN WHICH WELL IS LOCATED WITHIN THIRTY DAYS AFTER PLUGGING

1. RRC District: 7B
4. RRC Lease or Id. Number:
2. FIELD NAME (as per RRC Records): Wildcat
3. Lease Name: Nash
5. Well Number: 1
6. OPERATOR: EP Operating Company (Enserch Exploration, Inc.)
6a. Original Form W-1 Filed in Name of: Enserch Exploration, Inc.
10. County: Haskell
7. ADDRESS: 1230 River Bend Dr. #136 Dallas, TX 75247
6b. Any Subsequent W-1's Filed in Name of: EP Operating Company
11. Date Drilling Permit Issued: 5-6-85 4-10-85
8. Location of Well, Relative to Nearest Lease Boundaries of Lease on which this Well is Located: 1328 1762 Feet From East West Line and 1245 Feet From North Line of the Nash Lease
12. Permit Number: 271874
9a. SECTION, BLOCK, AND SURVEY: Section 55 - L. Willoughby Survey A-408
9b. Distance and Direction From Nearest Town in this County: Two miles east of Haskell
13. Date Drilling Commenced: 5-10-85
16. Type Well (Oil, Gas, Dry): Dry
Total Depth: 5575
17. If Multiple Completion List All Field Names and Oil Lease or Gas ID No.'s — GAS ID or OIL LEASE # | Oil-O Gas-G | WELL #
14. Date Drilling Completed: 5-21-85
18. If Gas, Amt. of Cond. on Hand at time of Plugging
15. Date Well Plugged: 5-22-85

CEMENTING TO PLUG AND ABANDON DATA:	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7	PLUG #8
*19. Cementing Date	5-22	5-22	5-22	5-22				
20. Size of Hole or Pipe in which Plug Placed (inches)	7-7/8	7-7/8	(7-7/8-8-5/8)	8-5/8				
21. Depth to Bottom of Tubing or Drill Pipe (ft.)	5523	700	310	19				
*22. Sacks of Cement Used (each plug)	45	45	45	5				
*23. Slurry Volume Pumped (cu. ft.)	54	54	54	6				
Calculated Top of Plug (ft.)	5363	540	155	3				
Measured Top of Plug (if tagged) (ft.)								
Slurry Wt. #/Gal.	15.6	15.6	15.6	15.6				
*27. Type Cement	H	H	H	H				

RECORD MODIFICATION ... 1985
ADC 6-25-85

28. CASING AND TUBING RECORD AFTER PLUGGING

SIZE	WT.#/FT.	PUT IN WELL (ft.)	LEFT IN WELL (ft.)	HOLE SIZE (in.)
8-5/8	24	260	260	12-1/4"

29. Was any Non-Drillable Material (Other than Casing) Left in This Well? Yes ☐ No ☒
29a. If answer to above is "Yes" state depth to top of "junk" left in hole and briefly describe non-drillable material. (Use Reverse Side of Form if more space is needed.)

WATER BOARD LETTER DATED 4-12-85
Depth 100 ft.
~~13(A) Exception Dated~~
Surface Casing 260 ft.

30. LIST ALL OPEN HOLE AND/OR PERFORATED INTERVALS

FROM	TO	FROM	TO
260	5575		

Return to Central Records

I have knowledge that the cementing operations, as reflected by the information found on this form were performed as indicated by such information. DSVmR
* Designates items to be completed by Cementing Company. Items not so designated shall be completed by Operator.

Signature of Cementer or Authorized Representative

Halliburton, Abilene (915)692-3555
Name of Cementing Company

CERTIFICATE:
I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this report, that this report was prepared by me or under my supervision and direction, and that data and facts stated therein are true, correct, and complete, to the best of my knowledge.

B. G. Vick
B. G. Vick — REPRESENTATIVE OF COMPANY
Drilling Superintendent — TITLE
5/30/85 — DATE
Phone 214 (A/C) 630-8711 (NUMBER)

RECEIVED R.R.C. OF TEXAS
JUN 7 1985
O.G. ABILENE, TEXAS

SIGNATURE: REPRESENTATIVE OF RAILROAD COMMISSION

Was Well filled with Mud-Laden Fluid, according to the regulations of the Railroad Commission [X] Yes [ ] No	32. How was Mud Applied? Rig Pump	33. Mud Weight 9.5 LBS/GAL

34. Total Depth 5575	Other Fresh Water Zones by T.D.W.R. TOP / BOTTOM	35. Have all Abandoned Wells on this Lease been Plugged according to RRC Rules? [ ] Yes [ ] No
Depth of Deepest Fresh Water 100		36. If NO, Explain

37. Name and Address of Cementing or Service company who mixed and pumped cement plugs in this well: Halliburton, Abilene (915) 692-3555

Date RRC District Office notified of plugging: 5-22-85

38. Names and Addresses of Surface Owner of Well Site and Operators of Offset Producing Leases

39. Was Notice Given Before Plugging to Each of the Above?

FILL IN BELOW FOR DRY HOLES ONLY

40. For Dry Holes, this Form must be accompanied by either a Driller's, Electric, Radioactivity or Acoustical/Sonic Log or such Log must be released to a Commercial Log Service.

[X] Log Attached [ ] Log released to ______ Date ______

Type Logs: [X] Driller's [ ] Electric [ ] Radioactivity [ ] Acoustical/Sonic

41. Date FORM P-8 (Special Clearance) Filed?

42. Amount of Oil produced prior to Plugging 0 bbls*

* File FORM P-1 (Oil Production Report) for month this oil was produced

RRC USE ONLY

Nearest Field ______

WATER BOARD LETTER DATED ______

Depth ______ ft.

REMARKS

13(A) Exception Dated ______

Surface Casing ______ ft.

D.V. @ ______ ft.

Cement Records

JUN 7 1985

Cementer: Fill in shaded areas.
Operator: Fill in other items.

FILE

Form W-15
Cementing Report
Rev. 4/1/83
483-045

RAILROAD COMMISSION OF TEXAS
Oil and Gas Division

1. Operator's Name (As shown on Form P-5, Organization Report) TP Operating Company	2. RRC Operator No. 253275	3. RRC District No. 7B	4. County of Well Site Haskell
5. Field Name (Wildcat or exactly as shown on RRC records) Wildcat		6. API No. 42- 207 31689	7. Drilling Permit No. 271874
8. Lease Name Nash	9. Rule 37 Case No.	10. Oil Lease/Gas ID No.	11. Well No. 1

CASING CEMENTING DATA:		SURFACE CASING	INTER-MEDIATE CASING	PRODUCTION CASING Single String	PRODUCTION CASING Multiple Parallel Strings	MULTI-STAGE CEMENTING PROCESS Tool	MULTI-STAGE CEMENTING PROCESS Shoe
12. Cementing Date		5-10-85					
13. •Drilled hole size		12 1/4					
•Est. % wash or hole enlargement		100					
14. Size of casing (in. O.D.)		8 5/8					
15. Top of liner (ft.)							
16. Setting depth (ft.)		260					
17. Number of centralizers used		3					
18. Hrs. waiting on cement before drill-out		29					
1st Slurry — 19. API cement used:	No. of sacks ▶	170					
	Class ▶	C					
	Additives ▶	2% CC					
2nd Slurry	No. of sacks ▶						
	Class ▶						
	Additives ▶						
3rd Slurry	No. of sacks ▶						
	Class ▶						
	Additives ▶						
1st — 20. Slurry pumped:	Volume (cu. ft.) ▶	244					
	Height (ft.) ▶	Top					
2nd	Volume (cu. ft.) ▶						
	Height (ft.) ▶						
3rd	Volume (cu. ft.) ▶						
	Height (ft.) ▶						
Total	Volume (cu. ft.) ▶	244					
	Height (ft.) ▶	Top					
21. Was cement circulated to ground surface (or bottom of cellar) outside casing?		Yes					

RECEIVED
R.R.C. OF TEXAS
JUN 21 1985
O.G.
ABILENE, TEXAS

ks

OVER

CEMENTING TO PLUG AND ABANDON	PLUG # 1	PLUG # 2	PLUG # 3	PLUG # 4	PLUG # 5	PLUG # 6	PLUG # 7	PLUG # 8
23. Cementing date	5-22	5-22	5-22	5-22-85				
... e of hole or pipe plugged (in.)	8-7/8	7 7/8	7 8	8 5/8				
Depth to bottom of tubing or drill pipe (ft.)	5523	700	310	19				
..6. Sacks of cement used (each plug)	45	45	45	5				
27. Slurry volume pumped (cu. ft.)	54	54	54	6				
28. Calculated top of plug (ft.)	5363	540	155	3				
29. Measured top of plug, if tagged (ft.)								
30. Slurry wt. (lbs/gal)	15.6	15.6	15.6	15.6				
31. Type cement	H	H	H	H				

CEMENTER'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that the cementing of casing and/or the placing of cement plugs in this well as shown in the report was performed by me or under my supervision, and that the cementing data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers cementing data only.

Bart Baker — Name and title of cementer's representative
HALLIBURTON SERVICES — Cementing Company
Signature: [signature]

2701 Industrial Blvd. — Address; Abilene — City; Texas — State; 79605 — Zip Code; 915 692-3555 — Tel.: Area Code Number; 5-23-85 — Date: mo. day yr.

OPERATOR'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that I have knowledge of the well data and information presented in this report, and that data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers all well data.

B. G. Vick — Typed or printed name of operator's representative
Drilling Superintendent — Title
Signature: [signature]

30 River Bend Dr. #136 — ...ss; Dallas — City; TX — State; 75247 — Zip Code; 214 600-8711 — Tel.: Area Code Number; Date: 5 mo. 30 day 85 yr.

Instructions to Form W-15, Cementing Report

IMPORTANT: Operators and cementing companies must comply with the requirements of the Commission's Statewide Rules 8 (Water Protection), 13 (Casing, Cementing, Drilling, and Completion), and 14 (Well Plugging). For offshore operations, see the requirements of Rule 13 (c).

A. What to file. An operator should file an original and one copy of the completed Form W-15 for each cementing company used on a well. The cementing of different casing strings on a well by one cementing company may be reported on one form. Form W-15 should be filed with the following:

- An initial oil or gas completion report, Form W-2 or G-1, as required by Statewide or special field rules;
- Form W-4, Application for Multiple Completion, if the well is a multiple parallel casing completion; and
- Form W-3, Plugging Record, unless the W-3 is signed by the cementing company representative. When reporting dry holes, operators must complete Form W-15, in addition to Form W-3, to show any casing cemented in the hole.

B. Where to file. The appropriate Commission District Office for the county in which the well is located.

C. Surface casing. An operator must set and cement sufficient surface casing to protect all usable-quality water strata, as defined by the Texas Department of Water Resources, Austin. Before drilling a well in any field or area in which no field rules are in effect or in which surface casing requirements are not specified in the applicable rules, an operator must obtain a letter from the Department of Water Resources stating the protection depth. Surface casing should not be set deeper than 200 feet below the specified depth without prior approval from the Commission.

D. Centralizers. Surface casing must be centralized at the shoe, above and below a stage collar or diverting tool, if run, and through usable-quality water zones. In nondeviated holes, a centralizer must be placed every fourth joint from the cement shoe to the ground surface or to the bottom of the cellar. All centralizers must meet API specifications.

E. Exceptions and alternative casing programs. The District Director may grant an exception to the requirements of Statewide Rule 13. In a written application, an operator must state the reason for the requested exception and outline an alternate program for casing and cementing through the protection depth for strata containing usable-quality water. The District Director may approve, modify, or reject a proposed program. An operator must obtain approval of any exception before beginning casing and cementing operations.

...mediate and production casing. For specific technical requirements, operators should consult Statewide Rule 13 (b) (3) and (4).

...ging and abandoning. Cement plugs must be placed in the wellbore as required by Statewide Rule 14. The District Director may require additional cement ...For onshore or inland wells, a 10-foot cement plug must be placed in the top of the well, and the casing must be cut off three feet below the ground surface. All cement plugs, except the top plug, must have sufficient slurry volume to fill 100 feet of hole, plus ten percent for each 1,000 feet of depth from the ground surface to the bottom of the plug.

To plug and abandon a well, operators must use only cementers approved by the Director of Field Operations. Cementing companies, service companies, or operators can qualify as approved cementers by demonstrating that they are able to mix and pump cement in compliance with Commission rules and regulations.

▶ ... W-1 with plat and $100.00 fee. ...k or money order payable to the ...urer of Texas. Address to: ...oad Commission of Texas, Oil and Gas Division, Drilling Permits, P. O. Drawer 12967, Capitol Station, Austin, Texas 78711

▶ File a copy of W-1 and plat in RRC District Office.

RAILROAD COMMISSION OF TEXAS

Oil and Gas Division

Application for Permit to Drill, Deepen, Plug Back, or Re-Enter

▶ Read Instructions on Back

Form W-1 Rev. 9/1/83 483-060

Purpose of filing (mark appropriate boxes): ☐ Drill ☐ Deepen (below casing) ☐ Deepen (within casing) ☐ Plug Back ☐ Re-Enter ☐ Directional Well ☐ Sidetrack [X] Amended Permit (enter permit no. at right & explain fully in Remarks)

Enter here, if assigned: API No. 42- 207-31689; Permit No. 271874; Rule 37 Case No.

1. Operator's Name (exactly as shown on Form P-5, Organization Report)	3. RRC Operator No.	4. RRC District No.	5. County of Well Site
EP Operating Company	253275	7B	Haskell

2. Address (including city and zip code): 1230 River Bend Drive, Suite 136, Dallas, Texas 75247-4995

6. Lease Name (32 spaces maximum): Nash — 7. RRC Lease/ID No.: — 8. Well No.: 1 — 9. Total Depth: 5700'

10. Location
- Section 55 Block ____ Survey L. Willoughby Abstract No. A-408
- This well is to be located 2 miles in a Easterly direction from Haskell, Texas which is the nearest town in the county of the well site.

11. Distance from proposed location to nearest lease or unit line 1245 ft.

12. Number of contiguous acres in lease, pooled unit, or unitized tract 160 (OUTLINE ON PLAT.)

13. FIELD NAME (Exactly as shown on RRC proration schedule). List all established and wildcat zones of anticipated completion. Attach additional Form W-1s as needed to list these zones. One zone per line.	14. Completion depth	15. Spacing pattern (ft.)	16. Density pattern (acres)	17. Number of acres in drilling unit for this well. OUTLINE ON PLAT.	18. Is this acreage assigned to another well on this lease & in this reservoir? If so, explain in Remarks.	19. Distance from proposed location to nearest applied for, permitted, or completed well, this lease & reservoir. (ft.)	20. Oil, gas, or other type well (Specify)	21. No. of applied for, permitted, or completed locations (including this one) on lease in this reservoir. OIL	GAS
~~Wildcat (Canyon Sand)~~	~~2500~~	330 ~~933~~	~~20~~	~~20~~	~~No~~	~~NA~~	~~Oil~~	1	-
~~Wildcat (Canyon Reef)~~	~~2700~~	330 ~~933~~	~~20~~	~~20~~	No	NA	Oil	1	-
Wildcat above 5700	5700	467 1200	40	40	No	NA	Oil	1	-

22. Perpendicular surface location from two nearest designated lines:
- Lease/Unit 1327.5' FEL & 1245' FNL
- Survey/Section 1245' FNL & 1438.5' FEL

If a directional well, show also projected bottom-hole location:
- Lease/Unit
- Survey/Section

23. Is this a pooled unit? Yes ☐ ▶ (Attach Form P-12 and certified plat.) No [X]

24. Is Item 17 less than Item 16 (substandard acreage for any field applied for)? Yes ☐ ▶ (Attach Form W-1A) No [X]

25. Is this wellbore subject to Statewide Rule 36 (hydrogen sulfide area)? Yes ☐ No [X]

If subject to Rule 36, is Form H-9 filed? Yes ☐ No ☐ ▶ If not filed, explain in Remarks.

26. Do you have the right to develop the minerals under any right-of-way that crosses, or is contiguous to, this tract? Yes [X] No ☐ If not, and if the well requires a Rule 37 or 38 exception, see Instructions for Rule 37.

I certify that information stated in this application is true and complete, to the best of my knowledge.

Signature B. G. Vick — Drilling Superintendent (Name and title of operator's representative)

Date: 5 (mo.) 3 (day) 85 (yr.) — Tel.: 214 (Area Code) 630-8711 (Number)

Remarks

Amended to indicate operator name correction from ENSERCH EXPLORATION, INC. (Operator #253210), to EP OPERATING COMPANY and to demonstrate a new surface location.

• RRC Use Only •

222248 MAY 6 85

283429

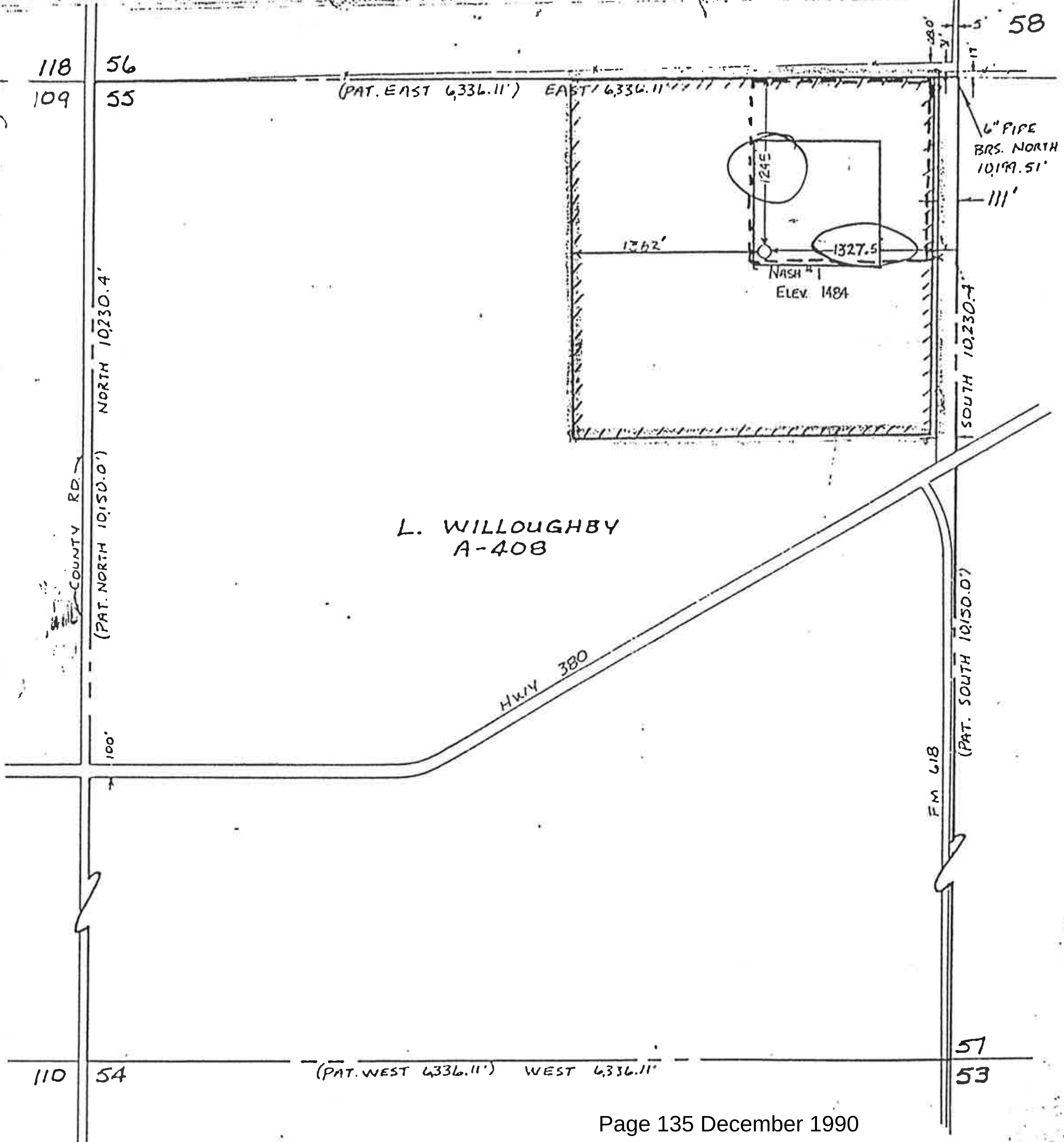
RECEIVED RRC OF TEXAS MAY 06 1985 O.G. AUSTIN, TEXAS

Permit mailed 5-6-85 Becky Meier

Code 5700

Delete per Jenny Wat...

EP OPERATING COMPANY,
1230 RIVER BEND DR. SUITE 136
DALLAS, TEXAS 75247



Page 135 December 1990

RECEIVED
RRC OF TEXAS
MAY 06 1985
O. G.
AUSTIN TEXAS

A. PLAT SHOWING
THE LOCATION OF THE NASH #1,
OUT OF SEC. 55, L. WILLOUGHBY
ABST-408, HASKELL COUNTY, TEXAS.

(———) 160 Acre Drilling Lease
(- - - -) 40 Acre Drilling Unit
(——) 20 Acre Drilling Unit

STATE OF TEXAS

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #4

Attachment 4-i
August 2, 2021

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8/9/21

TABLE OF CONTENTS

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

Texas Commission on Environmental Quality

Transportation Data and Coordination Report Form for Municipal Solid Waste Type I Landfills

This form is for use by applicants or site operators of Municipal Solid Waste (MSW) Type I landfills to provide data and information to address the availability and adequacy of access roads to a landfill site, the volume of vehicular traffic on and generated by the facility on area roadways, and to provide coordination information as required under 30 TAC §330.61(i). Roadways that provide primary access to a landfill facility must be adequate and possess appropriate design capacity to safely accommodate the additional volumes and weights of traffic generated or expected to be generated by this landfill facility during its active life. Data provided in this form should correspond with data contained in the coordination documents submitted to the Texas Department of Transportation or other agency that has jurisdiction over affected area roads.

If you need assistance in completing this form, please contact the Municipal Solid Waste Permits Section of the Waste Permits Division at (512) 239-2335.

I. General Information

Facility Name: City of Haskell MSW Transfer Station located at Haskell MSW Landfill

MSW Permit No.: 1604B

Site Operator/Permittee Name and Mailing Address: City of Haskell 301 S. 1st Haskell, TX 79521

II. Documentation of Coordination with the Texas Department of Transportation (TXDOT) for Traffic and Location Restrictions

1. A traffic study document and cover letter was submitted to TXDOT as Coordination for traffic and location restrictions for the subject facility and a copy of the documents submitted to TXDOT is attached herein: ☐ Yes ☒ No

   If you checked "No" , provide explanation: Based on the existing data of road usage and population estimates & projections, there is little to no change expected on wear and tear of the roadways. Usage of the roads will continue at or near to current numbers allowing existing maintenance and repairs to proceed without change.

2. Date of submission of the coordination documents to TXDOT: 1/04/2021; 6/24/21

3. TXDOT's response received? ☐ Yes ☒ No

4. If "No" is checked in response to Item I.3 above, complete Items I.4 and I.5 below only after TxDOT's response is received.

5. Did TxDOT's response include recommendation of improvements to any of the roadways or intersections that lead to the site? ☐ Yes ☐ No

6. If you checked "Yes" in Item I.5 above, proceed to Section III., TxDOT's Recommended Roadway or Intersection Improvements (as applicable).

7. If you checked "No" in Item I.5 above, provide TxDOT's response to the traffic and location restrictions compliance coordination for the subject site: *(Enter TxDOT's response to coordination correspondence)* No objections to the project

III. TxDOT Recommended Roadway or Intersection Improvements (as applicable)

Enter TxDOT's recommendations for improvement of roadways or intersections that lead to the site:

1. None as of 8/2/21

2.

3.

IV. Documentation of Coordination of Improvement Designs of Public Roadways *(e.g., Turning Lanes, Storage Lanes, Acceleration/Deceleration Lanes, etc.)* at and Near the Site Entrances with Agencies that Exercise Maintenance Responsibility

1. Complete Table 1 with information regarding documentation of coordination of improvement designs for existing and proposed roads.

Table 1: Public Roadway Improvements Coordination

Existing and Proposed Roads Associated with the Site Entrance(s)	Agency Exercising Maintenance Responsibility	Date of Coordination Correspondence from the Applicant or Site Operator to the Agency Responsible	Date of the Coordination Response Letter from the Agency Responsible	Did the Agency Responsible Require Improvements to the Roadway(s) Associated with the Site Entrance(s) (check Yes or No as applicable)
US 380	TXDOT	6/24/2021	None as of 8/2/21	☐Yes ☐No
FM618	TXDOT	6/24/2021	None as of 8/2/21	☐Yes ☐No

2. If you checked "Yes" in the last column of Table 1, indicating that improvements are required, address the following:

   (a) Briefly describe the improvements proposed for the public roadway(s) associated with the site entrance(s):

   (b) A copy of the proposed improvement design submitted to the agency exercising maintenance responsibility over the roadway is attached herein: ☐Yes ☐No. If you checked "No" please explain:

   (c) A copy of the response letter from the agency exercising maintenance responsibility over the roadway(s) associated with the site entrance(s) approving the improvement design is attached herein: ☐Yes ☐No. If you checked "No" please explain:

V. Facility Location and Operation Information Used in Estimating Transportation Data

1. Facility Location Information

City of Haskell Transfer Station, Haskell County, TX approximately 4 miles East of Haskell on US 380.

2. Waste Acceptance Rates

   (a) Initial Waste Acceptance Rate: 40 tons per day

   (b) Estimated Maximum Waste Acceptance Rate at any Time During Facility Life: 125 tons per day

3. Hours of Operation and Site Life

   (a) a. Operating Hours: 6-6:00 M-F 8-2:30 Sat

   (b) b. Waste Acceptance Hours: 8-6:00 M-F 8-2:00 Sat

   (c) c. Estimated Site Life: 50

4. Other Information Used or Assumed in Estimating Transportation Data:

VI. Facility Daily Traffic Volume Data

1. Complete Table 2 with estimated existing daily volume of traffic generated by the facility.

Table 2: Estimated Existing Daily Volume of Traffic Generated

Vehicle Type	Traffic Volume to Facility (vehicles per day, vpd)	Traffic Volume from Facility (vpd)
Trucks	14	14
Employee Vehicles	2	2
Visitors Vehicles	10	10
Other Vehicles	0	0
Summation of Daily Volume of Traffic to and from the Facility		
Total Daily Volume of Traffic	26	26

(a) Describe the source(s) of or method(s) used to obtain the existing daily volume of traffic generated by the facility: average count

(b) Location(s) of traffic counts (if applicable):

2. Complete Table 3 with estimated future daily volume of traffic generated by the facility.

Table 3: Estimated Future Daily Volume of Traffic Generated

Vehicle Type	Traffic Volume to Facility (vpd)	Traffic Volume from Facility (vpd)
Trucks	15	15
Employee Vehicles	2	2
Visitors Vehicles	11	11
Other Vehicles	0	0
Summation of Daily Volume of Traffic to and from the Facility		
Total Daily Volume of Traffic	28	28

3. Describe the method(s) used to obtain the estimated future daily volume of traffic generated by the facility, including dates, traffic growth rates, and sources of the growth rates: Population projections from the Texas Water Development Board

4. Maps showing the facility boundary and roads within 1 mile of the facility that provide access to the site are attached herein. Yes ☒ No☐. If you checked "No" please explain:

VII. Availability and Adequacy of Roads

1. Complete Table 4 with information regarding the primary access roadways.

Table 4: Roadway Characteristics of the Primary Access Roadways

List the roads that the owner or operator will use as primary access to the site	Existing Annual Average Daily Traffic on Roadway (vpd)	Expected Annual Average Daily Traffic on Roadway (vpd) *2038	Existing Roadway Capacity	Expected Roadway Capacity	Max Gross Weight Allowed (lbs)	Max/Min Posted Speed Limit (mph)	Min Vertical Clearance (ft)	Surface Type and No. of Lanes	Level of Service	Existing Traffic Generated by the Facility on Each Roadway	Expected Traffic Generated by the Facility on Each Roadway
US 380	913	1096	4400	4400	80000	75	18	Paved 2 lane	A	26	29

2. Complete Table 5 with information regarding other access roadways within one mile.

Table 5: Roadway Characteristics of Other Access Roadways within One Mile of the Facility Boundary

List other access roadways within 1 mile of the facility	Existing Annual Average Daily Traffic on Roadway	Expected Annual Average Daily Traffic on Roadway *2038	Existing Roadway Capacity	Expected Roadway Capacity	Max Gross Weight Allowed (lbs)	Max/Min Posted Speed Limit (mph)	Min Vertical Clearance (ft)	Surface Type and No. of Lanes	Level of Service	Existing Traffic Generated by the Facility on Each Roadway	Expected Traffic Generated by the Facility on Each Roadway
FM 618	158	203	2800	2800	80000	70	18	Paved 2 lane	5		

3. Complete Table 6 with information regarding access roadway intersections within one mile.

Table 6: Roadway Intersection Characteristics

Please list major (signalized) roadway intersections for access roads within 1 mile of facility	Existing Capacity	Existing Level of Service
None		

4. (For applicants that conducted traffic counts) Peak period traffic counts were conducted at critical intersections and roadways in the area: ☐ Yes ☒ No

If "No" is checked, please explain: No increase in traffic is expected

VIII. Conclusions on the availability and adequacy of roads to be used for accessing the facility

Enter conclusions regarding the availability and adequacy of roads to be used for accessing the facility using information obtained from access roadway data; data on the volume of existing and expected vehicular traffic on the access roads within one mile of the facility; and the projection of the volume of traffic expected to be generated by the facility on the access roads**:**

No changes are expected to the availability and adequacy of the roads to be used for accessing the facility.

IX. Highway Beautification

Enter facility distance from interstate or primary highways and screening information as required by 30 TAC 330.23(a).

1. Distance of Facility from Interstate or Primary Highway: US 380 1/4 mile

2. Type of Facility Screening Provided, if applicable: Fence and berms

X. Analysis of the Impact of the Facility upon Airports

Enter the Part, Appendix, Attachment, Section, and Page Number of the application where analysis of the impact of the facility upon airports is provided: Part II page 16 Section 8.3

XI. Documentation of Coordination with the Federal Aviation Administration for Compliance with Airport Location Restrictions

1. Applicant has submitted written information to FAA describing the facility location, maximum height of waste units, type of waste accepted at the facility, and other facility-relevant data and information as required: ☒ Yes ☐ No

   (a) Enter Date of Coordination Letter to FAA: 03/26/20,6/17/21

   (b) Enter Date of FAA Response: 07/12/2021;

2. Indicate FAA Response and Final Action:

   ☒ FAA Acknowledged No Adverse Impact.

☐ FAA Recommended Safety Improvements. (Complete Section XII if you check this item.)

3. A copy of the Documentation of Coordination with FAA for compliance with airport location restrictions is attached herein. ☒Yes ☐No. If you checked "No" please explain:

XII. FAA Recommended Changes or Improvements for Airport Safety, (as applicable)

Enter FAA's recommended changes or improvements to the facility for airport safety or for compliance with airport location restrictions.

NA

XIII. Attachments

- Maps showing the facility boundary and roads within 1 mile of the facility.
- Documentation of coordination of all designs of proposed public roadway improvements associated with site entrances with the agency exercising maintenance responsibility of the public roadway involved; and the response letter received from the agency, as applicable.
- Documentation of coordination with the Texas Department of Transportation (TxDOT) for traffic and location restrictions, including any traffic study report; and the response letter received from TxDOT.
- Documentation of coordination with the Federal Aviation Administration for compliance with airport location restrictions; and the response letter received from FAA.
- Other documents attached:

June 24, 2021

Glenn Allbritton, P.E.
Abilene District
Texas Department of Transportation
4250 N. Clack
Abilene, TX 79601

RE: City of Haskell, TX – TCEQ Municipal Solid Waste Transfer Station

Dear Sir:

The City of Haskell is working to obtain a registration for a transfer station at the current landfill with the Texas Commission on Environmental Quality (TCEQ). The proposed project would replace the existing landfill as it nears closure.

Acting on behalf of the City of Haskell, JACOB | MARTIN is in the process of preparing an application pursuant to the rules in 30 TAC § 330.

A project description is hereby submitted to your office along with project maps. Further information is available upon request.

We are requesting that your office review the proposed project and issue comments regarding potential impacts to the environment and other interests that pertain to or are potential conflicts with projects being implemented by your agency.

While we understand the volume of request that the agency receives, we are requesting a response within 30 days. Thank you for your assistance on this project. Should you need additional information or have any questions, please contact me at (325)-695-1070 or through email at dhudson@jacobmartin.com. Please address all correspondence to our Abilene office location.

Sincerely,

JACOB | MARTIN

David Hudson

Part I/II
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Page 9

PROJECT DESCRIPTION – CITY OF HASKELL, TEXAS

The Haskell Transfer Station is proposing a Type V Registration Facility to be located in Haskell County, Texas. It will be located at the landfill, which is owned and operated by the City of Haskell, which lies approximately 3.8 miles west of the city. This will provide transfer operations for the City of Haskell, Haskell County, and infrequently, the surrounding counties.

The proposed transfer station will be inside the currently permitted property boundary and may utilize the undeveloped southern portion of the property. A gatehouse, scales, and earthmoving equipment are already staged on the permitted area. No change in traffic patterns is expected as the landfill will be closing and replaced with the transfer station.

The overall property consists of gently undulating grasslands with no canopy cover or woody vegetation. The property generally slopes to the north towards Red Creek located in the northernmost portion of the property. The permit boundary has been formed to avoid the creek and FEMA designated floodplain.

The City of Haskell has owned the property for over 30 years; therefore, no transactions will need to take place to expand the landfill permit boundary.

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #5

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER
8-9-21

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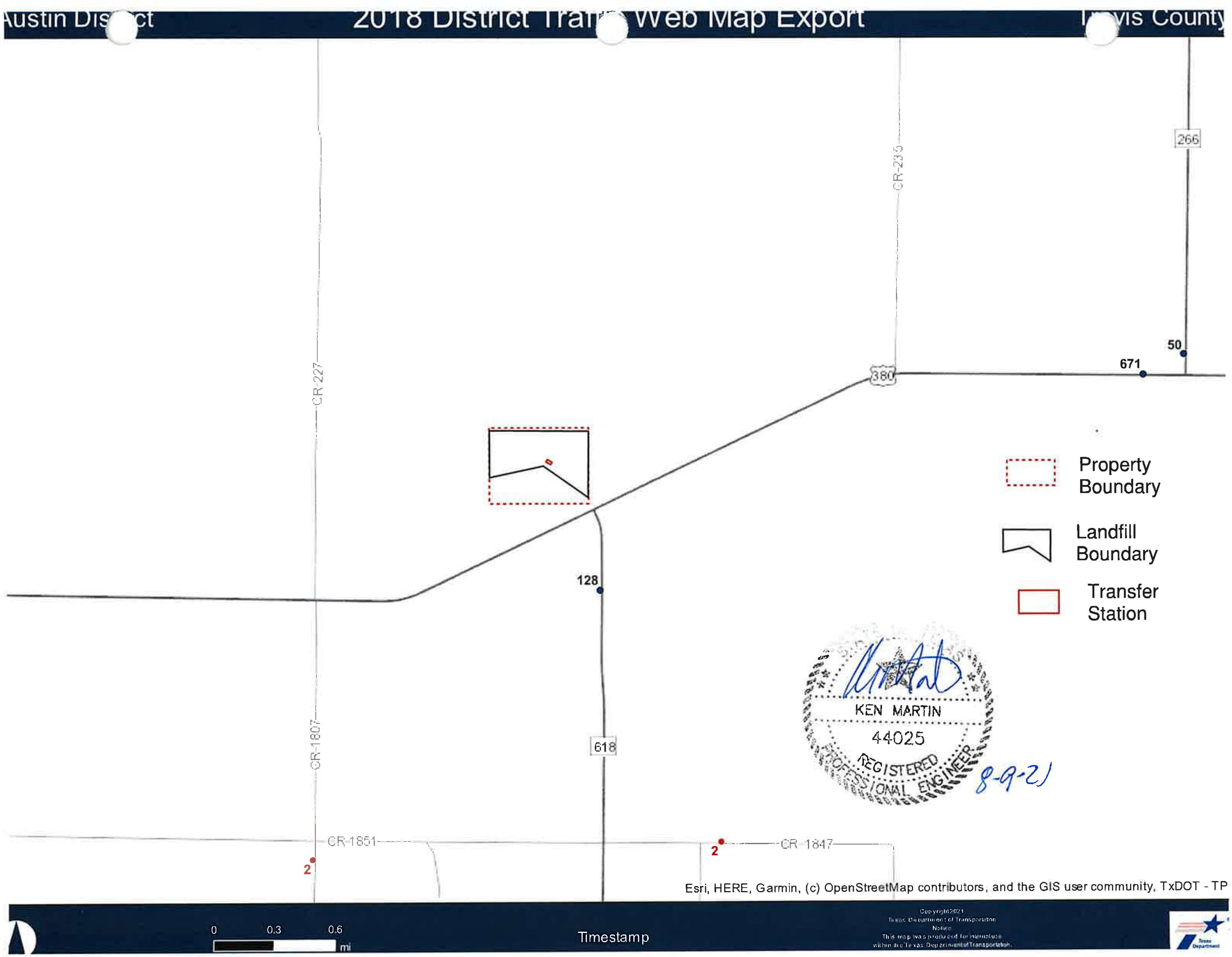
STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21


Austin District
2018 District Traffic Web Map Export
Travis County
266
CR-235
50
671
380
CR-227
Property Boundary
Landfill Boundary
Transfer Station
128
618
KEN MARTIN
44025
REGISTERED
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8-9-21
CR-1807
CR-1851
CR-1847
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Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community, TxDOT - TP
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HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #6

KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

Attachment 6-1
August 2, 2021

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STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER

8-9-21

Mail Processing Center
Federal Aviation Administration
Southwest Regional Office
Obstruction Evaluation Group
10101 Hillwood Parkway
Fort Worth, TX 76177

Aeronautical Study No.
2021-ASW-8696-OE

Issued Date: 07/12/2021

Winston Stephens
City of Haskell
301 S 1st Street
PO Box 103
Haskell, TX 79521

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Building Haskell Transfer Station
Location:	Haskell, TX
Latitude:	33-10-24.43N NAD 83
Longitude:	99-38-42.88W
Heights:	1486 feet site elevation (SE)
	24 feet above ground level (AGL)
	1510 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

Based on this evaluation, marking and lighting are not necessary for aviation safety. However, if marking/ lighting are accomplished on a voluntary basis, we recommend it be installed in accordance with FAA Advisory circular 70/7460-1 M.

This determination expires on 01/12/2023 unless:

(a) the construction is started (not necessarily completed) and FAA Form 7460-2, Notice of Actual Construction or Alteration, is received by this office.
(b) extended, revised, or terminated by the issuing office.
(c) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE E-FILED AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE. AFTER RE-EVALUATION OF CURRENT OPERATIONS IN THE AREA OF THE STRUCTURE TO DETERMINE THAT NO

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SIGNIFICANT AERONAUTICAL CHANGES HAVE OCCURRED, YOUR DETERMINATION MAY BE ELIGIBLE FOR ONE EXTENSION OF THE EFFECTIVE PERIOD.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power, except those frequencies specified in the Colo Void Clause Coalition; Antenna System Co-Location; Voluntary Best Practices, effective 21 Nov 2007, will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.This determination includes all previously filed frequencies and power for this structure.

If construction or alteration is dismantled or destroyed, you must submit notice to the FAA within 5 days after the construction or alteration is dismantled or destroyed.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

If we can be of further assistance, please contact our office at (817) 222-5933, or andrew.hollie@faa.gov. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2021-ASW-8696-OE.

Signature Control No: 485042390-487708837 (DNE)
Andrew Hollie
Specialist

Attachment(s)
Case Description
Map(s)

Case Description for ASN 2021-ASW-8696-OE

Construction of a 60 by 70 by 24 foot building at the existing landfill location

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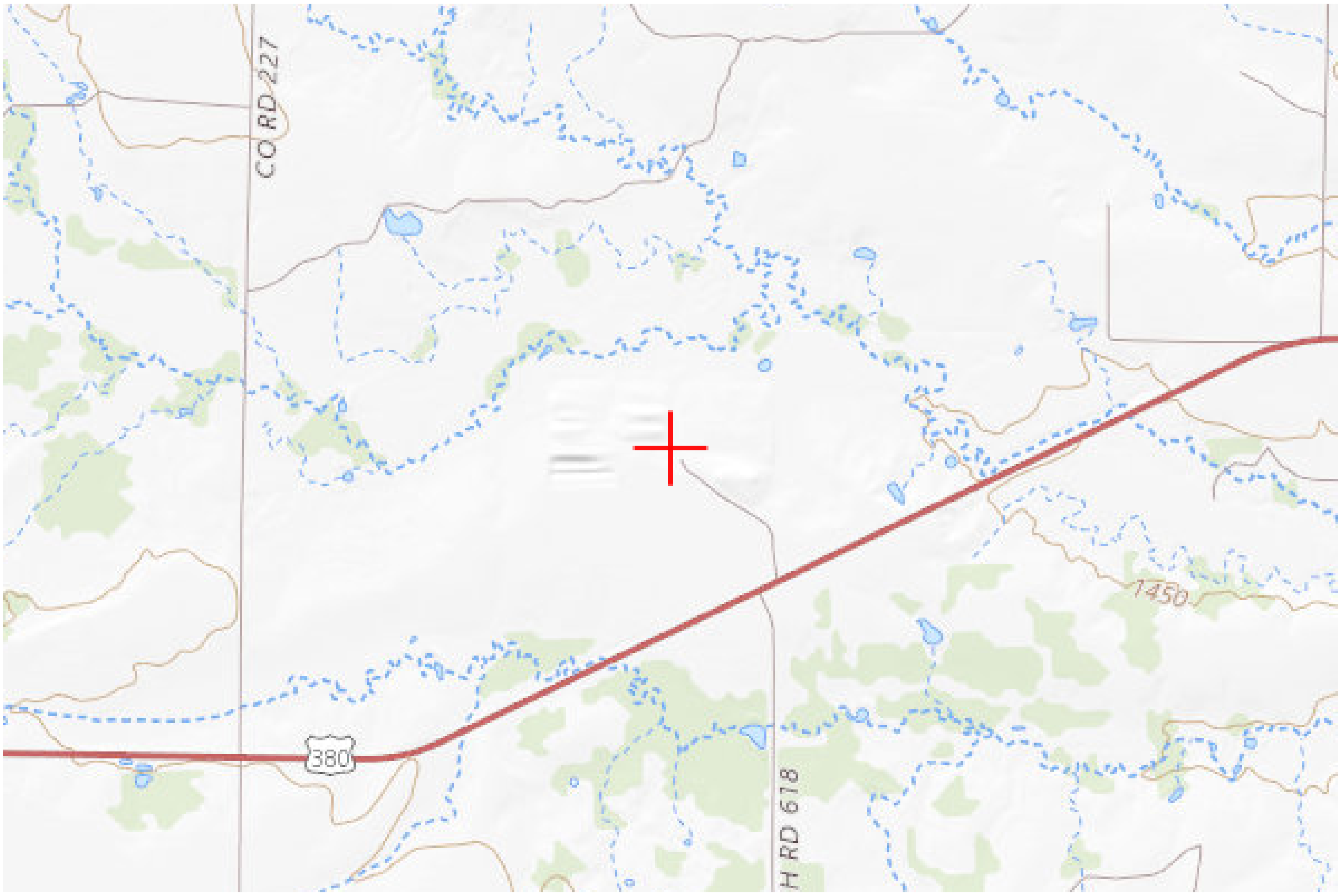
TOPO Map for ASN 2021-ASW-8696-OE



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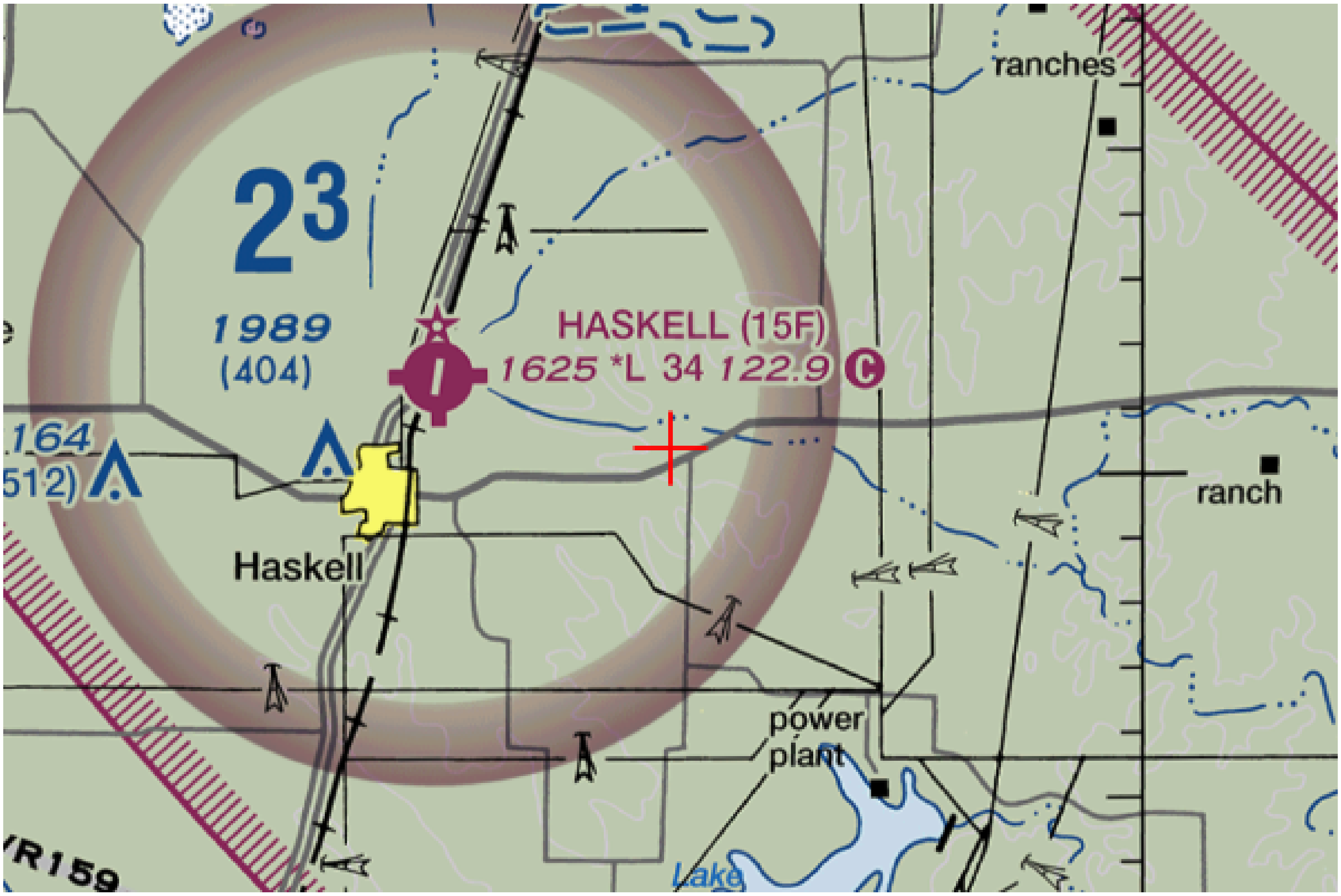
Sectional Map for ASN 2021-ASW-8696-OE



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HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #7

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER

8-9-21

Attachment 7-1
August 2, 2021

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STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER
8-9-21

TEXAS DEPARTMENT OF WATER RESOURCES

REPORT 226

THE SEYMOUR AQUIFER

Ground-Water Quality and Availability in Haskell and Knox Counties, Texas

Volume I

By
R.W. Harden and Associates
Consulting Ground-Water Hydrologists and Geologists

Prepared under contract for the
Texas Department of Water Resources

December 1978

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page 7-3

Published and distributed
by the
Texas Department of Water Resources
Post Office Box 13087
Austin, Texas 78711

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THE SEYMOUR AQUIFER

GROUND-WATER QUALITY AND AVAILABILITY IN HASKELL AND KNOX COUNTIES, TEXAS

VOLUME I

CONCLUSIONS

The Seymour Formation contains an important water-bearing unit in an irregularly shaped area in northwestern Haskell and southern Knox Counties, Texas. The Seymour aquifer is the only source of moderate to large supplies of fresh ground water within the area. No alternative fresh supplies exist from deeper formations. The aquifer underlies 274,500 acres and furnishes water to over 2,000 irrigation wells. Municipal, domestic, and stock supplies are also dependent on the Seymour.

The geologic and hydrologic character of the Seymour is quite variable. Typically, wells are 40 to 60 feet deep and are completed in the lower part of the formation which normally consists of sand and gravel. Well yields average 270 gallons per minute and are as high as 1,300 gallons per minute. Specific capacities of wells average over 50 gallons per minute per foot of drawdown. Saturated thicknesses are typically between 20 and 40 feet. Transmissivities range from 20,000 to over 300,000 gallons per day per foot and average 100,000 gallons per day per foot. Ground-water movement rates, unaffected by pumping, average between 800 and 1,200 feet per year.

Nearly all recharge to the Seymour is by direct infiltration of precipitation on the land surface. Analysis of pumpage, water levels, and precipitation over the past 20 years indicates that nearly 50,000 acre-feet per year is available for pumping by wells. Annual pumpage in recent years has ranged from about 25,000 acre-feet to about 65,000 acre-feet, averaging 40,600 acre-feet.

Water quality in the Seymour is variable. The dissolved solids content of natural water from individual wells ranges from about 300 milligrams per liter to 3,000 milligrams per liter. Most values are between 400 and 1,000 milligrams per liter. The best quality water is found in and adjacent to the more important recharge areas. Generally, water quality is satisfactory for irrigation purposes. Most water quality meets state standards for public supplies, except for nitrate content which commonly exceeds the limit of 45 milligrams per liter. Nitrate contents of Seymour water are typically from 30 to 90 milligrams per liter. Available chemical analyses and nitrogen isotope analyses indicate most of the nitrate in the Seymour results from leaching of natural soil nitrate due to cultivation.

The Seymour aquifer is susceptible to pollution from both surface and near surface sources. Over 3,200 past and present, actual and potential pollution sources exist on the Seymour. Most are only potential sources; actual sources are believed to number a few hundred. Existing pollution is due mainly to past pollution sources and activities, and not to current practices. Most existing pollution has been due to oil field brines and septic tank discharge.

It is estimated that about 2 percent of the water in the Seymour aquifer is affected by pollution. About 75 percent of the existing pollution is estimated to be due to the former disposal of oil field brine into unlined surface pits. An estimated 20 percent has been caused by leaky injection wells and unplugged, abandoned holes. About 4 percent of the existing pollution results from septic tanks, while miscellaneous sources are responsible for 1 percent. Little effect on water quality results from return flow of irrigation water, evapotranspiration, or agricultural application of fertilizers and pesticides.

The portions of the aquifer affected currently by pollution are relatively localized. The portions of the aquifer affected by pollution will increase in the future due to the natural movement of ground water and to the spreading effects caused by pumping wells. However, portions of the aquifer affected by significant pollution will not become extremely large in the future. Significant future pollution problems will be confined mostly to individual properties as opposed to large areas of the aquifer.

Correcting existing pollution can take years, or even decades, and can be very costly. Thus, prevention rather than correction is most important in dealing with ground-water pollution. For past pollution sources, it is possible only to control the resulting pollution plumes either by removal or avoidance measures. Pollution removal measures involve pumping by wells to remove the pollutants from the aquifer. Typically, this is impractical because of the large volumes of water that must be pumped, the relatively long periods of time required, and problems regarding disposal of the pumped water. Avoidance methods include relocating wells affected by pollution or selective pumping and blending to obtain a quality of water that can be used. These can be effective methods if the pollution is not severe or if the property involved is large, and sufficient quantities of unpolluted water can be obtained.

INTRODUCTION

Purpose

This report describes the ground-water resources of the Seymour aquifer in Haskell and Knox Counties, Texas. Emphasis is on water quality, but important availability information is included. The investigation began in 1975 at the request of the Texas Department of Water Resources and citizens of Haskell and Knox Counties. The primary objective of the investigation was to gain a comprehensive understanding of:

1) the water quality in the Seymour aquifer;

2) the past, present, and potential sources of pollution to the aquifer due primarily to mineralized water; and,

3) the future quality and availability of water from the aquifer.

Volume I contains text and related illustrations and tables describing the quality and quantity of the ground-water resources of the Seymour aquifer. It includes an explanation of the geology as related to the occurrence of ground water, the ground-water conditions in the Seymour, ground water in other formations, and pollution in the Seymour. Provided in Volume I is information intended to aid in obtaining maximum benefits from the Seymour aquifer and to assist regulatory agencies in protecting the aquifer from pollution.

Volume II contains supporting basic data consisting of maps and tables including: 15 well location maps; records of 2,058 water wells; records of water levels in 93 wells; results of chemical analyses of 2,197 water samples plus 11 tables containing results of over 200 additional chemical analyses on various specialized samples; 240 drillers' logs; descriptions of geologic samples from 16 surface localities and 4 wells; results of sieve analyses of formation samples; a cross-index of previously published well numbers; a list of available aerial photographs; and information on production and disposal of oil field brines.

Scope

Compilation of Previous Data

The first phase of the investigation consisted of compiling previous geologic and hydrologic reports for the area. These were obtained from many sources, but primarily from the U.S. Geological Survey, Texas Department of Water Resources, Bureau of Economic Geology, and Texas Railroad Commission. The work included compilation of unpublished data on water wells, oil tests, and fluid injection wells, primarily from the files of the Texas Department of Water Resources, U.S. Geological Survey, Texas Department of Health, and Texas Railroad Commission. Climatic data including temperature, precipitation, and evaporation records were obtained from the National Weather Service.

Literature Survey on Effects of Nitrate

A survey of the more readily available literature on the effects on humans and livestock of consuming water with high nitrate levels was conducted. Over 150 published reports and articles were reviewed for this phase of the investigation. The results of the survey are included as an appendix to Volume I.

Water Well Inventory

A field inventory was made to obtain information on water wells and to update existing information where necessary. Approximately 1,200 previous well schedules were updated, and approximately 800 wells were scheduled which had not been inventoried previously. Special efforts were made to locate all wells for which important previous data were available. Many of the earlier records were found to be particularly significant because they include historical water quality data and water-level information. Only a small percentage of those wells previously scheduled could not be located during the field work.

Wells inventoried include all public supply and industrial wells. In addition, selected wells used for irrigation, stock, and domestic supply were scheduled to provide representative coverage. All wells scheduled were located and assigned elevations based on 7½-minute topographic quadrangles with 5-foot or 10-foot contour intervals. In addition, all irrigation wells were located on 7½-minute topographic maps, and the type of power used for each irrigation well was noted. This step provided information on the number and distribution of irrigation wells powered by electricity, butane, or natural gas.

Geology

The surface geology of the Seymour and Permian rocks adjacent to the Seymour was inspected in the field, and descriptions were prepared for the outcrops studied. Also, drillers were interviewed regarding the subsurface conditions encountered in the Seymour and in underlying zones. The drilling of four Seymour wells was observed, and geologic descriptions of the sediments encountered were prepared. Formation samples from the 4 drilling sites and from 12 outcrop localities were collected, and sieve analyses were made on 27 samples. Drillers' logs for 240 wells were reviewed. To study the geology of the Permian rocks underlying the Seymour aquifer, 23 electric logs and 6 sample logs were obtained for selected oil tests.

Hydrology

In order to determine 1-hour specific capacity, transmissivity, and permeability, 11 pumping tests were conducted, and 13 prior test results were analyzed. Records of pumpage were obtained, and estimates were made of the ground-water withdrawals from the Seymour. Records of municipal and industrial pumpage were obtained from the Texas Department of Water Resources or from well owners. Irrigation pumpage was estimated by field counts of electrically-powered and gas-powered wells, by obtaining power figures from three electric utility companies which serve the area, and by tests on 45 wells to determine the amount of water pumped per unit of power consumed. Estimates were made of pumpage for rural, domestic, and livestock use.

Records of past water levels in wells were obtained from the Texas Department of Water Resources, the U.S. Geological Survey, well owners, and drillers. Water-level measurements were made on approximately 450 wells during January 1977 to define conditions. Seasonal water-level fluctuations were investigated through the use of two continuous water-level recorders operated during the period 1975–1977. One of the recorders was in the vicinity of Munday; the other in the vicinity of Rochester. Records for 93 water-level observation wells were obtained and evaluated.

The direction and rate of ground-water movement in the Seymour aquifer were estimated. Also, maps of the water table, the base of the aquifer, and the saturated thickness were prepared. The amount of water in storage in 1977 was estimated and compared to the amount in storage 20 years ago. Also, estimates of the annual availability of water were made.

Water Quality

Extensive sampling of water wells was done to obtain representative water quality for both Seymour and Permian wells. Over 1,100 water samples from wells and springs were collected and analyzed. In addition, the results of approximately 1,100 previous chemical analyses were obtained, primarily from records of the Texas Railroad Commission, the Texas Department of Health, the Texas Department of Water Resources, and the U.S. Geological Survey. Also, approximately 200 samples were obtained for analysis of special constituents such as pesticides, nitrogen cycle, and nitrogen isotope, or for analysis of water from special sources such as springs, creeks, bailed samples from wells, consecutive samples from wells, sewage effluent samples, oil field brine samples, and formation sample extracts.

The water quality section of this report presents the current water quality in the Seymour, includes comparisons useful in identifying water pollution, and provides a basis for detecting future changes in water quality.

Man's Effects on Water Quality

An important part of this investigation was an appraisal of the effects of man's activities on the water quality in the Seymour aquifer. An extensive pollution source inventory was made. Past pollution sources were located with the aid of aerial photographs of varying dates from 1939 to 1970, pollution complaint files of state agencies, and Texas Railroad Commission files on saltwater disposal and fluid injection operations. Existing pollution sources were located from these same sources, as well as from topographic maps, ownership maps, and visual field inspections. Over 3,200 past and present, actual and potential pollution sources on the Seymour were inventoried and located on 7½-minute topographic maps.

From the information obtained, the more significant past and present sources of mineralized water pollution to the Seymour were evaluated. The indicated areal extent, severity, and probable sources of the present pollution were studied. Future movement and effects of past pollution sources were evaluated. Also, methods to control and deal with pollution of the aquifer are presented.

Planning Sessions

Periodic planning sessions were held during this investigation with personnel from state agencies and a seven-member citizens' advisory committee. The state agencies involved included the Texas Department of Water Resources (and its predecessor agencies, the Texas Water Quality Board and Texas Water Development Board), the Texas Railroad Commission, and the Texas Department of Health. The progress of the investigation was reviewed during the meetings, and ideas for data collection and analysis were discussed. The meetings helped tailor the investigation to correspond to the needs of the citizens of Haskell and Knox Counties and to the planning and regulatory functions of the state agencies involved.

Area of Investigation

The investigation focused on that part of the Seymour Formation located principally in southern Knox and northwestern Haskell Counties as shown on Figure 1. Very small portions of southwestern Baylor County and eastern Stonewall County were covered, also. The area represents a single hydrologic unit of the Seymour aquifer covering approximately 274,500 acres.

The area is approximately 60 miles north of Abilene and 75 miles southwest of Wichita Falls. It is located in the Brazos River Basin; the Brazos River is located immediately to the north and west of the area studied.

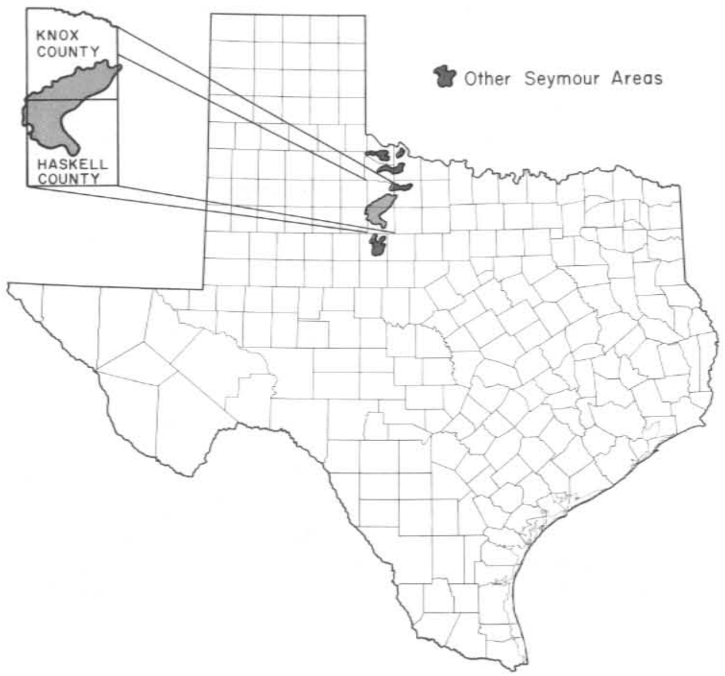


Figure 1. Location of Area

The area immediately surrounding the Seymour aquifer in Haskell and Knox Counties was studied also during the investigation. The surrounding area was investigated principally from geologic and water quality standpoints to better understand the water quality in the Seymour aquifer, to help determine the extent to which fresh water is present in the Permian formations, and to determine the relationship of the Permian formations to the Seymour aquifer.

Population

The Seymour aquifer is of major importance to the population and economy of the area. It is the only available source of large quantities of fresh water. Throughout the 1900's, people have depended on the Seymour for fresh water for domestic and stock use and, more recently, as a supplemental irrigation supply.

The estimated population living on the Seymour Formation from 1890 to 1973 is shown in Figure 2, together with a comparison of rural and urban population. The population figures are estimates, based on city and county population data obtained from the U.S. Bureau of Census and adjusted to the area of the Seymour aquifer.

Small groups of pioneers began settling the area in the mid-1800's, but the area remained sparsely populated until the very early 1900's. Between 1900 and 1910, the population rose rapidly. Approximately 10,000 people moved into the area during this period. The population peaked at about 14,000 in the 1950's, and is currently slightly less than 11,000.

The communities and towns on the Seymour include:

	1973 Population
Goree	538
Haskell	3,650
Knox City	1,750
Munday	1,925
O'Brien	250
Rhineland	196
Rochester	529
Rule	1,024

Except for Rhineland, which does not have a public water supply, all the towns listed obtain their municipal supplies from the Seymour aquifer, currently. Three other towns, Aspermont, Benjamin, and Weinert, receive their municipal water supplies from the area, also.

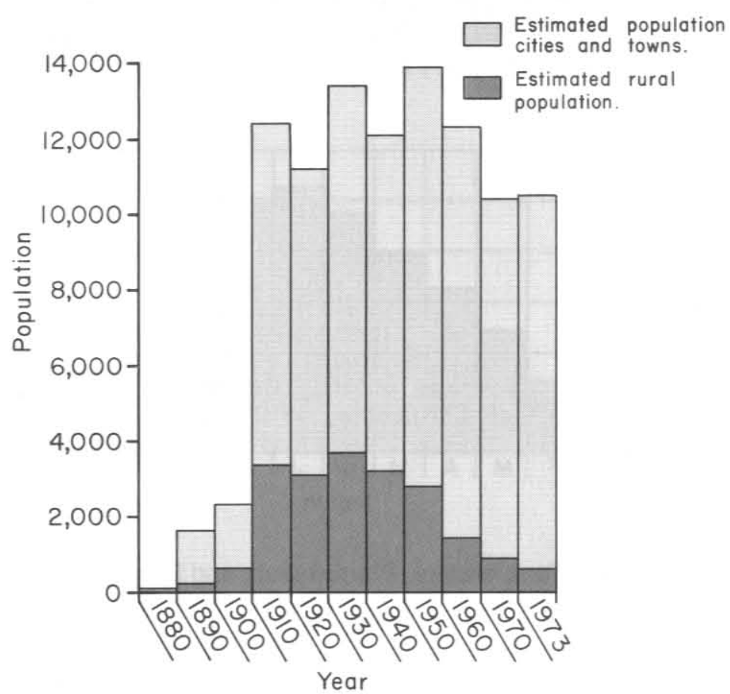


Figure 2. Estimated Population on Seymour Formation

Recently, the North Texas Water Authority constructed Millers Creek Reservoir. The reservoir will yield approximately 5,000 acre-feet per year and will be the source of water for Munday, Goree, Haskell, and Knox City.

Economy

The primary income in Haskell and Knox Counties comes from farming and ranching (See Figure 3). In 1976, $48,000,000 or 69 percent of the total annual income was attributed to farming and ranching (*Dallas Morning News*, 1975). Mineral production, primarily oil and gas, accounted for 20 percent or $14,000,000 of the total income in 1976. Small businesses, mostly associated with agriculture such as grain, fertilizer, and farm equipment, and other businesses associated with urban activities such as food, clothing, real estate, and insurance, comprised the remaining 11 percent of the total income of Haskell and Knox Counties in 1976.

Climate

The Seymour area is in the eastern half of the Low Rolling Plains. The area is characterized by precipitation maximums

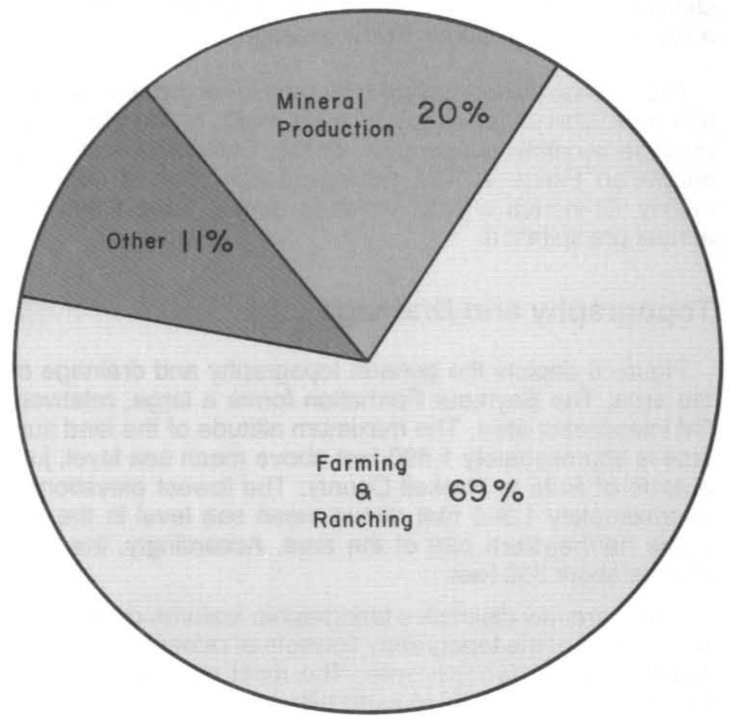


Figure 3. Income Sources in Haskell and Knox Counties

in late spring and early fall, mild winters, and very warm summers. Figure 4 shows the average monthly temperature at Munday, the average monthly precipitation at Haskell and Munday, and the monthly evaporation at Chillicothe. The average monthly temperature reaches a maximum in July of 85 degrees Fahrenheit (°F). The growing season in Knox County lasts approximately 217 days from approximately April 3 to November 6. Haskell County has one of the longest growing seasons in the northwestern half of Texas of approximately 232 days. The average date of the first freeze in the fall is November 15.

Figure 5 shows the annual precipitation at Munday and Haskell since the early 1900's. The average annual precipitation is 24.7 inches at Munday and 24.3 inches at Haskell. The annual precipitation is quite variable, ranging from a maximum in 1942 of almost 50 inches to a minimum in 1956 of approximately 10 inches.

More than 75 percent of the precipitation occurs typically during the period of April through October, coinciding with the growing season in the area. The heaviest rainfall occurs typically in May when between 3 and 4 inches fall. During winter months, the precipitation averages between 1 and 2 inches per month.

Figure 5 illustrates past precipitation trends for the area. Some of the wetter and drier periods are indicated on the graph. The 1944–1955 period was very dry, especially after 1950. The precipitation was above average in only three years of the 11-year period. The period 1957–1976 was characterized by average or above average rainfall with only a few years being slightly below average.

The closest station having a long-term record of evaporation is at Chillicothe about 55 miles north of Munday. The average monthly evaporation at the Chillicothe station is shown on Figure 4. The average evaporation is approximately 72 inches a year, which is almost three times the annual precipitation.

Topography and Drainage

Figure 6 depicts the general topography and drainage of the area. The Seymour Formation forms a large, relatively flat interstream area. The maximum altitude of the land surface is approximately 1,690 feet above mean sea level, just outside of Rule in Haskell County. The lowest elevation is approximately 1,340 feet above mean sea level in the extreme northeastern part of the area. Accordingly, the total relief is about 350 feet.

There are few distinctive topographic features on the Seymour. Most of the topography consists of rather flat surfaces sloping 8 to 10 feet per mile. The most prominent feature in the area is a group of sand hills located in the western part of the area in 1-degree quadrangle 21–41 and adjoining parts of adjacent quadrangles. Also, there is normally a significant topographic drop along the border of the Seymour.

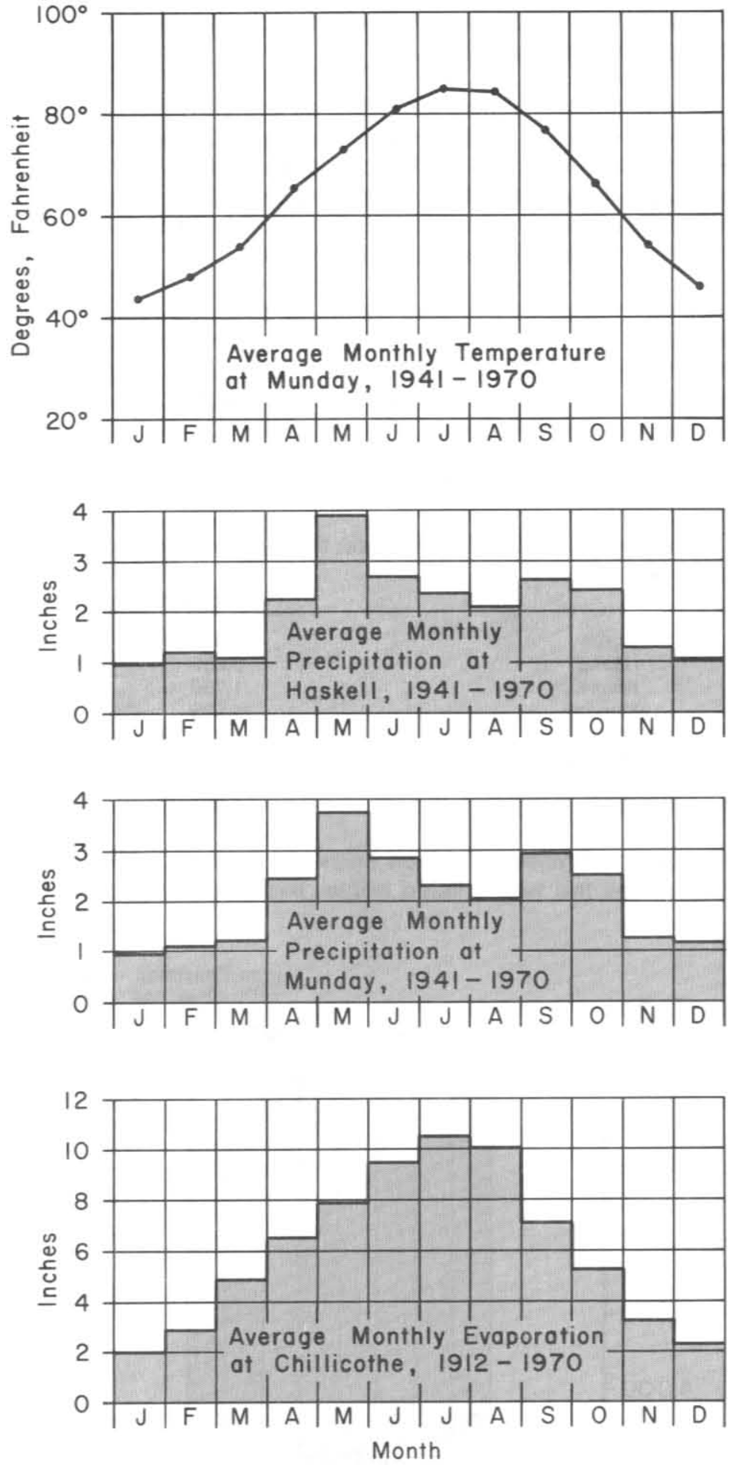


Figure 4. Temperature, Precipitation, and Evaporation

Another significant, but more subtle feature is a small topographic break which separates the Seymour into two sections as shown on Figure 7. The topographic break separates older Seymour deposits to the south and east from younger Seymour deposits to the north and west. The break represents an episode of valley deepening which was followed subsequently by alluviation. The younger deposits occur beneath a terrace extending along the northern and northwestern edge of the area in a belt approximately 4 miles wide.

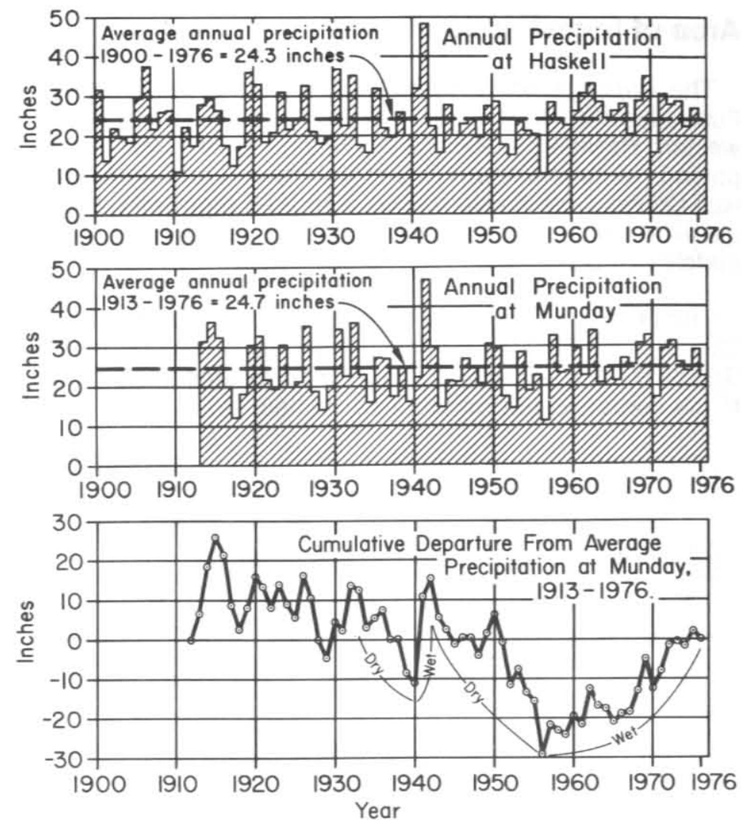


Figure 5. Precipitation at Munday and Haskell

The outcrop of the Seymour is characterized by a general lack of surface drainage. A few drainages are located near the edge of the formation. These are mapped on Figure 6. Most of the creeks in the area are intermittent with the exception of a few such as Wild Horse Creek. Wild Horse Creek, which is spring-fed, flowed several hundred gallons per minute during the summer of 1976. Other spring-fed creeks include Union Creek and China Branch in the northwestern part of the area and Rice Springs Branch at Haskell. Each flowed only a few gallons per minute in the summer of 1976. Results of chemical analyses of water from creeks are given in Table 21.

Land Use

Figure 8 illustrates the land use on the Seymour Formation. Of approximately 274,500 acres comprising the Seymour Formation, an estimated 265,000 acres (97 percent)

Figure 6. General Topography and Drainage

are used for farming. Approximately 105,000 acres (39 percent) are used for irrigation farming. In many instances, only supplemental irrigation is practiced. About 160,000 acres are used for dryland farming. Approximately 2,800 acres are used for ranching. The remaining 6,700 acres include homesteads, roads and other transportation facilities, and areas associated with oil production.

Until the late 1800's, the land use on the Seymour Formation was limited to ranching. Local residents report that originally the area was a treeless grassland with thick native, "stirrup high" grasses. Brush and trees occurred only along the principal creeks and along those edges of the Seymour bordering the Brazos River and Lake Creek.

Beginning in approximately 1890 and continuing until 1910, farming became a major activity in the area. Most all of the land was cultivated initially during this period and essentially has been cultivated continuously to the present. The major crops harvested in Haskell and Knox Counties in 1976, according to the Texas Department of Agriculture (1975 and 1976), included:

Crop	Yield
Wheat	4,013,000 bushels
Oats	221,100 bushels
Sorghum	2,305,000 bushels
Guar	2,866,000 pounds
Cotton	66,200 bales

Melons, potatoes, and other vegetables are grown in the area, also.

Two types of irrigation are used in the area. Row irrigation is prevalent on the flatter, gently sloping land. Sprinkler irrigation systems are used on sandier land and on the rolling topography.

Previous Investigations

The earliest report containing information on ground-water conditions for the Seymour is by Gordon (1913). Well records and chemical analyses of water are included in the Gordon report for a few wells. Later, Huggins and Turner (1937) conducted an extensive well inventory of Knox County. Their report includes records of 550 wells and test holes, approximately 185 chemical analyses of water, and logs of 22 test holes.

A preliminary report on ground-water resources by Broadhurst and Follett (1944) contains records of wells, chemical analyses, and water-level data for an area between Rochester, Rule, and Haskell. Public water supplies at Haskell, Rochester, Rule, Goree, Knox City, and Munday were investigated a few years later by Sundstrom, Broadhurst, and Dwyer (1947).

Ogilbee and Osborne reported on the ground-water resources of Haskell and Knox Counties in 1962. Their report contains records for over 1,100 wells, describes conditions as of 1957, and contains chemical quality data on 163 wells in Haskell and Knox Counties.

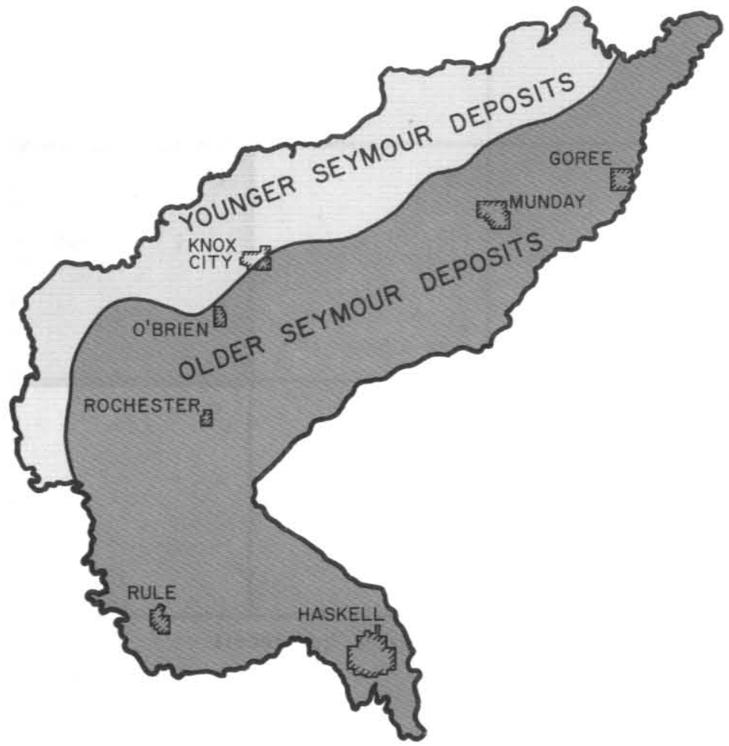


Figure 7. Seymour Units

Several other brief or specialized reports have been made on parts of the area. These include reports on water-level measurements and reports dealing with poor quality or contaminated water in the Seymour. All of these are listed in the bibliography of this report.

Basic data on wells from all past reports were incorporated into this report if it was possible to locate the wells in the field during this investigation. Table 31 is an index of identifying numbers for such wells.

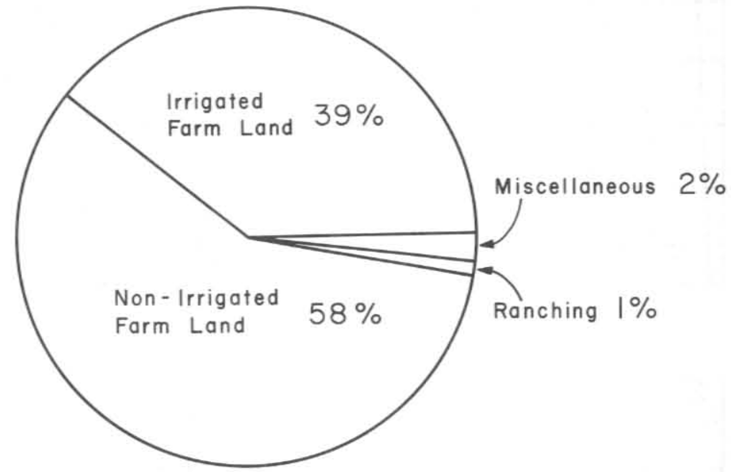


Figure 8. Land Use for Seymour Formation

Well-Numbering System

The well-numbering system used in this report is one adopted by the Texas Department of Water Resources. The system, as shown in Figure 9, is based on longitude and latitude. It facilitates the location of wells and prevents duplication of well numbers. Each well is assigned a seven-digit number which is derived as follows.

The State is divided into 1-degree quadrangles of latitude and longitude. There are 89 such quadrangles numbered 01 through 89. Each 1-degree quadrangle is subdivided into 7½-minute quadrangles numbered 01 through 64. Finally, each 7½-minute quadrangle is subdivided into 2½-minute quadrangles numbered 1 through 9. Within these 2½-minute quadrangles, each well is assigned a two-digit number beginning with 01.

The first two digits of each well number identify the 1-degree quadrangle. The third and fourth digits indicate the 7½-minute quadrangle. The fifth digit identifies the 2½-minute quadrangle. Together, the sixth and seventh digits identify the well within the 2½-minute quadrangle.

In addition to the seven-digit well number, a two-letter prefix is used to identify the county in which the well is located. The county prefixes used in this report are:

Prefix	County
AU	Baylor
LP	Haskell
RS	Knox
XR	Stonewall

For example, well RS 21-35-609 is in Knox County (RS); 1-degree quadrangle 21; 7½-minute quadrangle 35; 2½-minute quadrangle 6; and was the ninth well (09) inventoried in that 2½-minute quadrangle.

The area studied in this report is in that part of Texas covered by 1-degree quadrangles 21 and 22. Figure 10 shows the 1-degree and 7½-minute quadrangles within the primary study area. Well locations within each 7½-minute quadrangle are shown on Figures 58 through 72. On the location maps, the 2½-minute quadrangles are not shown, but their notation occurs as the first digit of the three-digit number adjacent to each numbered well location.

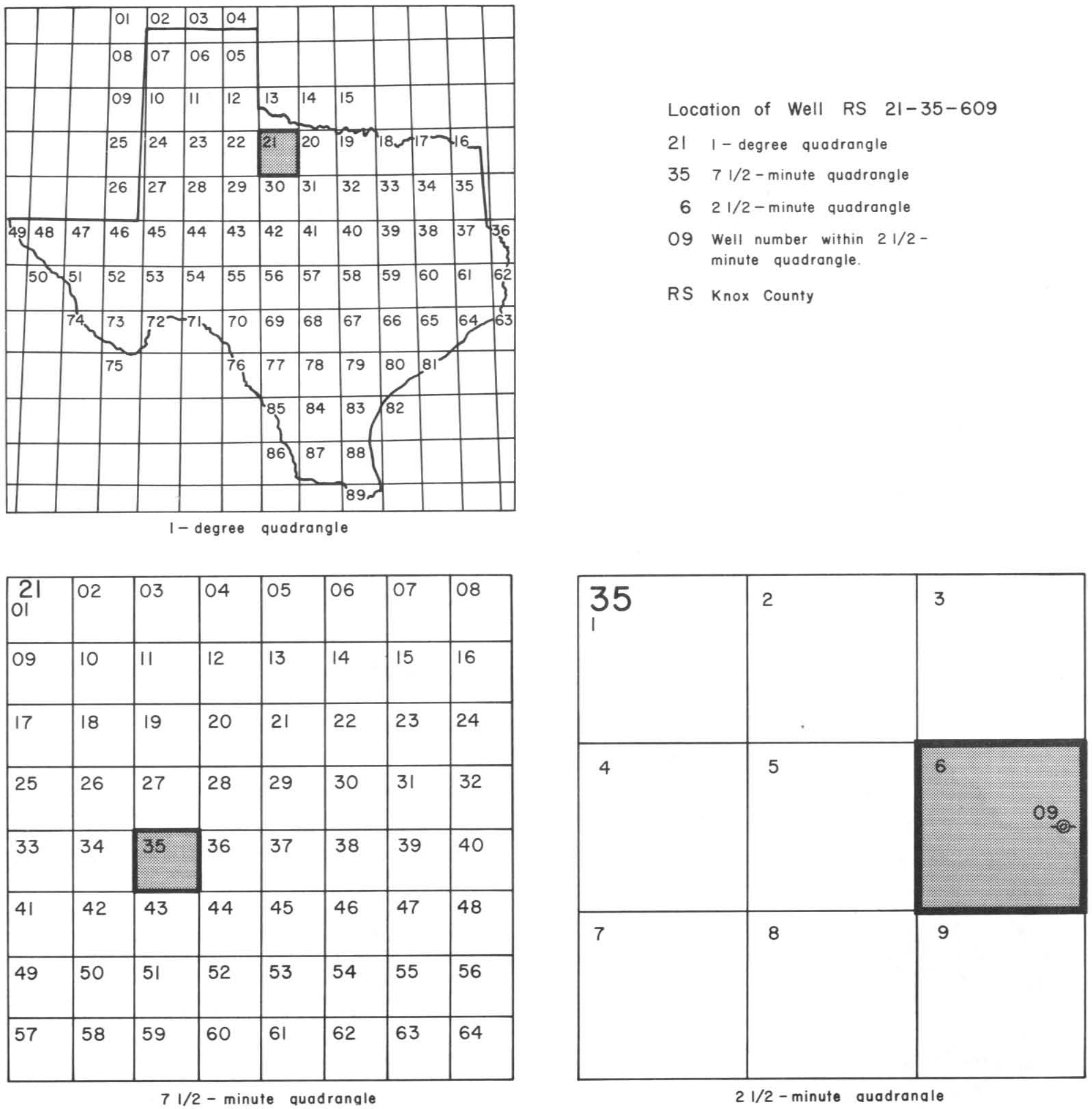


Figure 9. Well-Numbering System

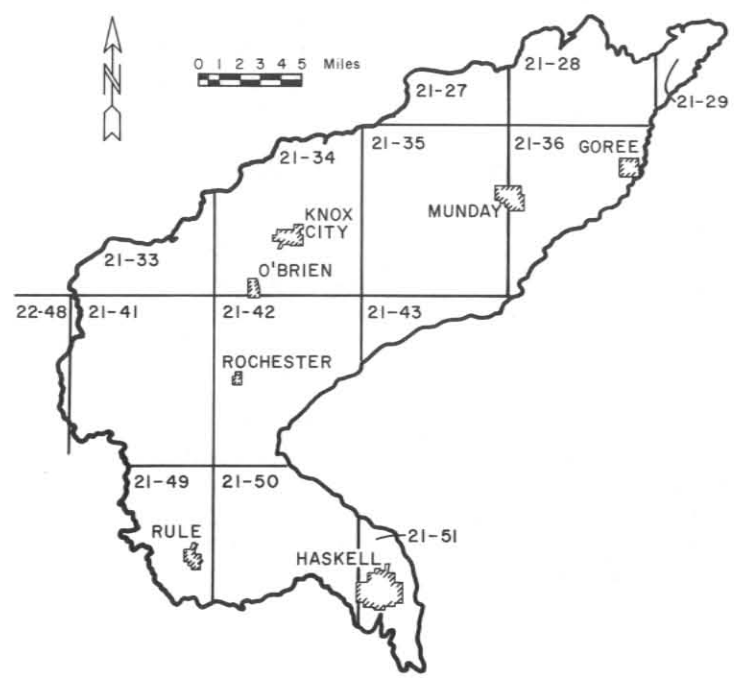


Figure 10. 7½-Minute Quadrangle Numbers

Acknowledgements

Sincere thanks are extended to the landowners, farmers, and municipal officials of Haskell and Knox Counties for their assistance and cooperation in providing information concerning the ground-water conditions and for allowing access to property in order that sampling and testing could be performed.

Particular recognition is due the Citizens' Advisory Committee for their continuing interest and helpful advice throughout this project. The committee included M. L. Wiggins, Callie Ann Combs, Clint Norman, Calvin Christian, Ted Alexander, A. A. Cox, and Joe Cloud.

Special thanks are given to Helen McClure, Clarence Brown, Wayne Speck, and Earl Avis for permitting the construction and maintenance of water-level recorder stations on their property.

Finally, appreciation is expressed to those individuals in the following organizations who provided assistance, data, and expertise in their respective fields: Texas Department of Water Resources, Austin; Texas Highway Department, Austin; U. S. Geological Survey, Austin; Texas A&M University, College Station; Texas Department of Health, Austin; Bureau of Economic Geology, University of Texas, Austin; Texas Railroad Commission, Austin, Wichita Falls, and Abilene; Environmental Protection Agency, Dallas; University of Texas Southwestern Medical School, Dallas; West Texas Utilities, Stamford; B-K Electric Cooperative, Seymour; Stamford Electric Cooperative, Stamford; Federal Land Bank Association, Haskell; Soil Conservation Service, Haskell and Knox Counties; Agricultural Stabilization and Conservation Service, Haskell and Knox Counties; Texas A&M Vegetable Research Center, Munday; and Hise Welding and Drilling Company, Haskell.

GENERAL GEOLOGY AS RELATED TO THE OCCURRENCE OF GROUND WATER

Those geologic units important to the occurrence of fresh ground water include rocks of Permian age and sediments of Pleistocene and Recent age. Figure 13 shows the general surface extent of the units. A summary of the important units and their water-bearing properties is included in Table 1. The relationship of the Clear Fork Group, the Seymour Formation, and the younger terrace and alluvial deposits is shown on Figures 11 and 12.

Rocks belonging to the Clear Fork Group of Permian age underlie the entire area. The Clear Fork consists predominately of red shales and silty shales with a very few, thin beds of dolomite, sandstone, siltstone, and gypsum. Typically, shales of the Clear Fork are referred to as "red beds" by drillers, but sometimes they are described as "birds-eye clay" due to the presence of green spots, caused by iron reduction, in the otherwise red shales.

Table 1. Geologic Units and Their Water-Bearing Properties

Unit	Area of Occurrence	Maximum Thickness	Principal Composition	Number of Wells in Unit According to Table 11	General Water-Bearing Properties
Younger terrace deposits and river alluvium	Along and in the present valley of the Brazos River at altitudes lower than the Seymour Formation	40 feet	Gravel, sand, silt, and clay	4	Yields small to moderate quantities of fresh to mineralized water.
Younger Seymour deposits	See Figure 7	65 feet	Gravel, sand, silt, and clay	1,913 (Younger and Older Seymour deposits combined)	Important aquifer with well yields ranging up to 500 gpm. Water is of satisfactory chemical quality for most purposes.
Older Seymour deposits	See Figure 7	94 feet	Gravel, sand, silt, and clay		Principal aquifer in Haskell and Knox Counties. Well yields range up to 1,300 gpm. Water is of satisfactory chemical quality for most purposes.
Clear Fork Group	Adjacent to and beneath Seymour and younger deposits	300 feet in extreme eastern part of area, but over 1,100 feet in northwestern part of area	Called "red beds" by drillers. Consists mostly of red shales and silty shales. Contains a few beds of siltstone, sandstone, dolomite, and gypsum.	75	Yields small quantities of water which is locally potable, but is typically of poor chemical quality.

The Clear Fork beds dip to the west-northwest at 40 to 50 feet per mile. Progressing westward across the area, successively younger Permian beds occur at the surface and beneath the Seymour and younger deposits. No large amounts of water are available from the Clear Fork. Only meager supplies of mostly mineralized water are available. Studies of electric logs of oil tests indicate no fresh water occurs in the Clear Fork or in deeper zones beneath the Clear Fork.

Prior to deposition of the Seymour sediments, the rocks of the Clear Fork were subjected to a long period of erosion resulting in a well-developed drainage pattern. Generally, this erosional surface slopes to the northeast, east, and southeast at an average rate of about 8 feet per mile. Locally, valleys exist which slope toward the southeast or northeast. The Clear Fork surface was covered later by Seymour and younger sediments deposited by eastward flowing streams.

The Seymour and the younger terrace and alluvial sediments occur in patterns controlled by successive cycles of terrestrial erosion and alluviation due to climatic cycles caused by successive advances and retreats of glaciers. The Seymour deposits in the area of this investigation represent at least two of these successive cycles; the deposits younger in age than the Seymour represent other such cycles. The areas of occurrence of the two Seymour units are shown in Figure 7, and they are termed in this report the "older Seymour deposits" and the "younger Seymour deposits."

Terrace deposits and river alluvium of more recent origin than the Seymour deposits occur principally between the

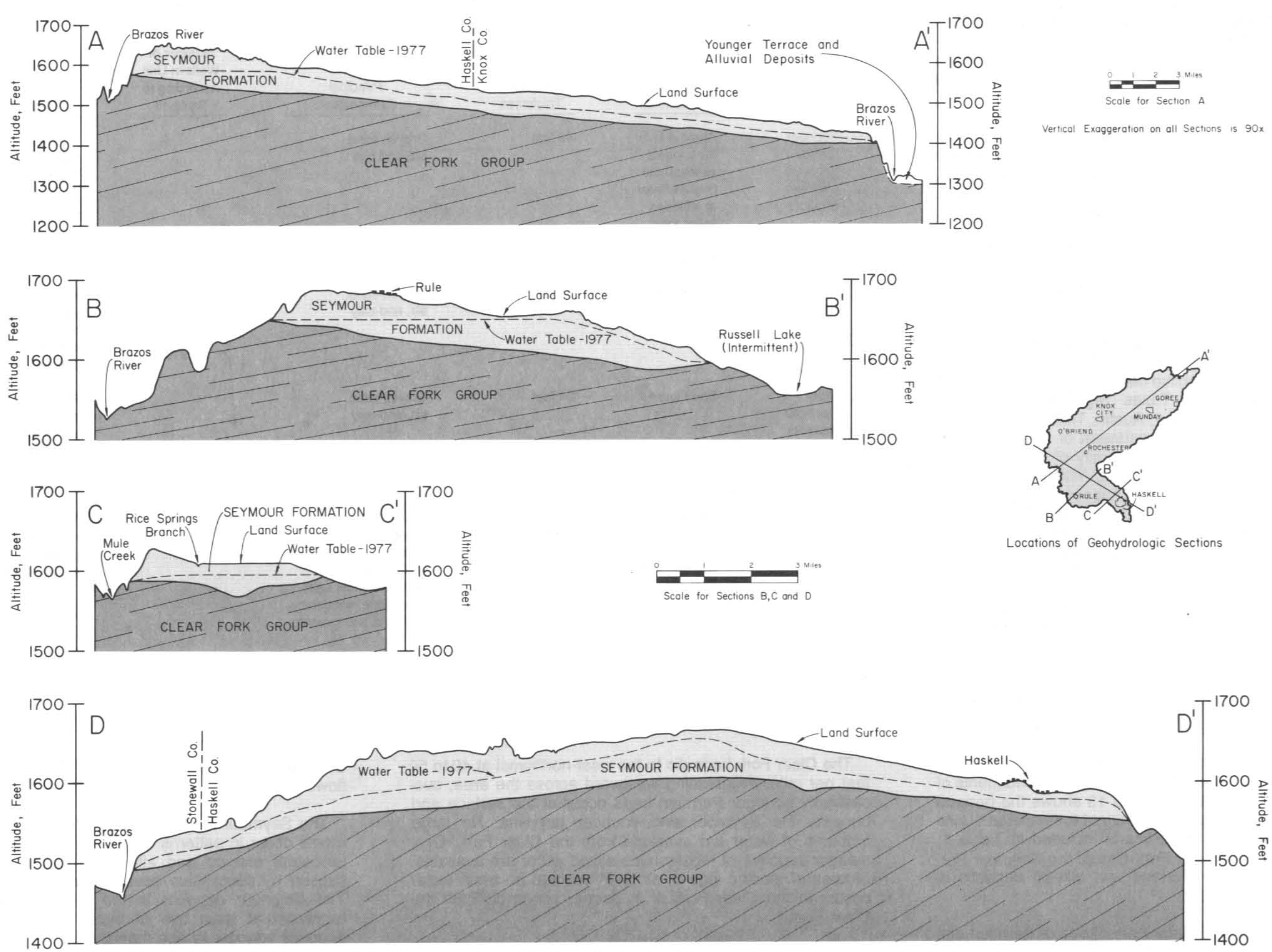


Figure 11. Geohydrologic Sections A-A′, B-B′, C-C′, and D-D′

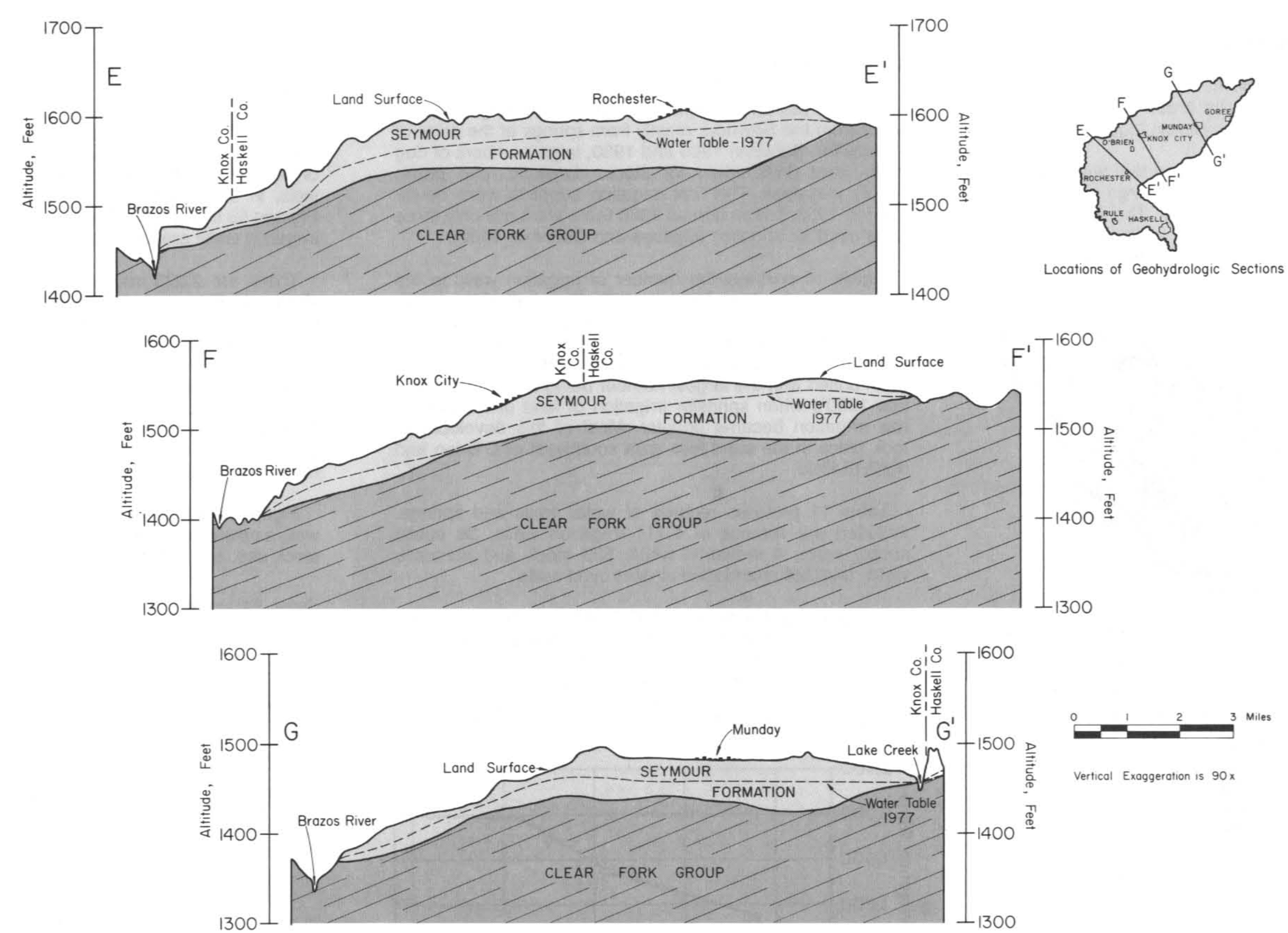


Figure 12. Geohydrologic Sections E-E′, F-F′, and G-G′

Seymour deposits and the Brazos River near the northern and western boundaries of the Seymour. One of the terrace deposits was termed the Lewis Creek Formation by Stricklin (1961). These younger deposits are at lower elevations than the Seymour at all localities where they were observed.

Both the Seymour and the younger terrace and alluvial deposits consist typically of a graded sequence having coarse materials at the base and increasingly finer materials toward the top. Recent windblown sand covers a large part of the Seymour in the sand hills area. These sands are mapped and shown with the Seymour on Figure 13.

The Seymour is by far the most important water-bearing unit in the area. It is the only source of large supplies and almost the only source of fresh water. The Seymour furnishes water to over 2,000 irrigation wells with yields as great as 1,300 gpm. The Seymour is responsible for the general availability of water over a large area.

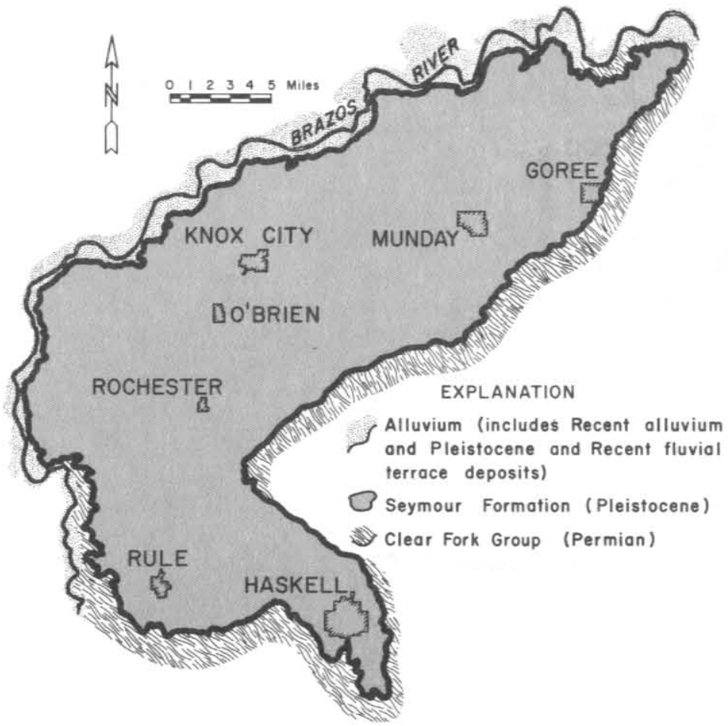


Figure 13. General Geologic Map

GROUND WATER IN THE SEYMOUR FORMATION

Extent of Aquifer

The lower water-saturated part of the Seymour Formation forms an important ground-water reservoir over an irregularly shaped area mostly in northwest Haskell and southern Knox Counties. It is the only available source of moderate to large irrigation supplies and a widely used source for domestic and stock supplies. The extent of the aquifer is shown on Figure 7. It comprises an area of about 430 square miles or 274,500 acres. Throughout this area, the Seymour is essentially a separate hydrologic unit.

Well Construction, Distribution, and Use

In early years, pioneers engaged in ranching obtained water from the Seymour mainly from springs at the edge of the aquifer. Between 1900 and 1930, large numbers of dug wells were constructed for stock, domestic, and public supply purposes. The first irrigation supplies were developed in 1938, but as late as 1950 there were still only three wells used for irrigation (Ogilbee and Osborne, 1962).

Figure 14 portrays the number of irrigation wells in the Seymour aquifer from 1952 to 1976. Over half of the irrigation wells were drilled during the drought of the 1950's. The number of irrigation wells increased from approximately 115 in 1952 to 1,100 in 1956. Since 1956, additional wells have been drilled with the largest number being drilled during the late 1960's when sprinkler irrigation of land unsuitable for row irrigation became popular. Most of this development took place in the sand hills area southwest of O'Brien and north of Rule.

Table 11 provides records of water wells and springs. Included are records of 1,111 irrigation wells, 38 public supply wells, 4 industrial wells, 533 stock and domestic wells, and 324 abandoned or destroyed wells.

There are approximately 3,000 Seymour water wells in the area. Table 11 lists records of over 1,900 wells tapping the Seymour aquifer. It also includes records of 4 alluvium wells, 75 Permian wells, and 20 wells believed to draw water from both the Seymour and the Permian. In conducting the field inventory to prepare Table 11, it was not practicable in all

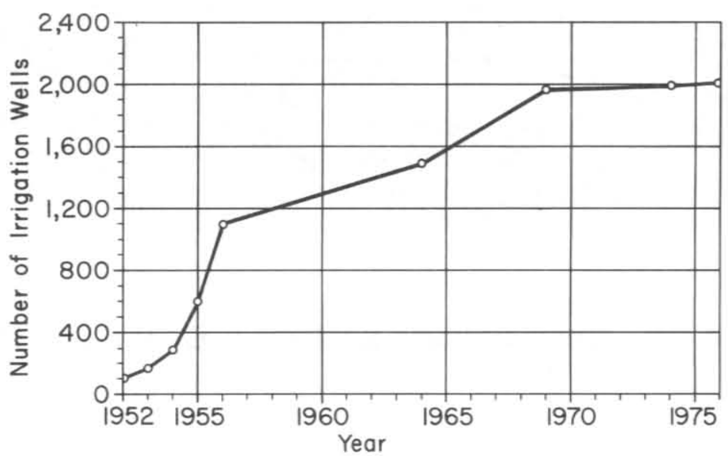


Figure 14. Number of Irrigation Wells

cases to update owners' names. Consequently, some names shown in Table 11 represent previous rather than current owners.

The stock and domestic wells are widely scattered over the Seymour aquifer. Irrigation wells tend to be located in those areas where ground-water conditions are more favorable for relatively high-yielding wells, namely those areas having larger saturated thicknesses and thicker, well-sorted sands and gravels.

Figure 16 shows the distribution of irrigation and municipal wells for the Seymour aquifer. The map also shows the type of power used for the irrigation wells. All of the irrigation wells in the Seymour are located on Figure 16 and on Figures 58 through 72. Records for approximately half of the irrigation wells are included in Table 11.

There are 2,023 irrigation wells and 38 municipal wells shown on Figure 16. Of the total irrigation wells, 1,665 are powered by electricity and 358 by butane or natural gas. The greatest density of irrigation wells tends to occur in a northeast-southwest belt approximately 6 miles wide, extending from southwest of Rochester to near the vicinity of Goree. The density of irrigation wells is not as great between Rule and Haskell and in the area shown on Figure 7 for the younger Seymour deposits. Generally, this is due to less favorable conditions for high-yielding wells in these areas.

Figure 15 shows the typical construction of an older dug well, a newer small-diameter drilled well for domestic or livestock use, and a larger-diameter drilled well for irrigation or

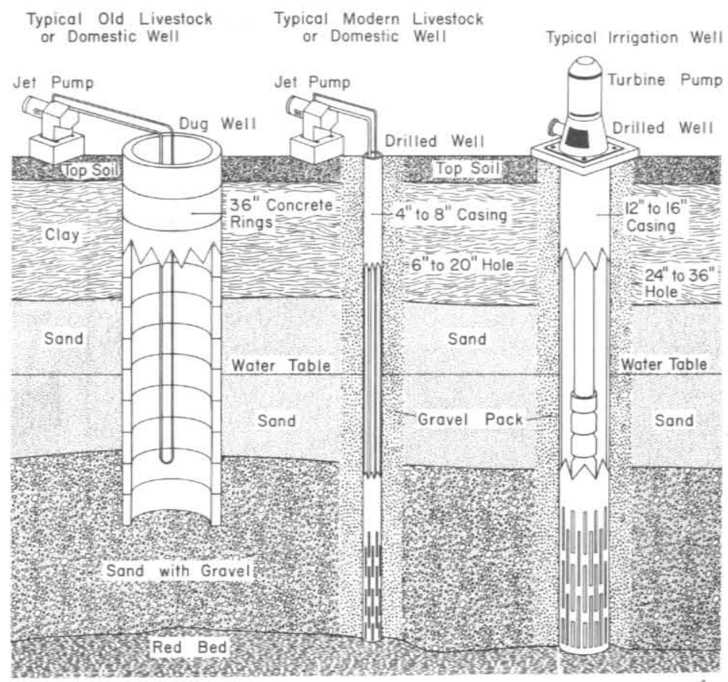


Figure 15. Construction of Wells

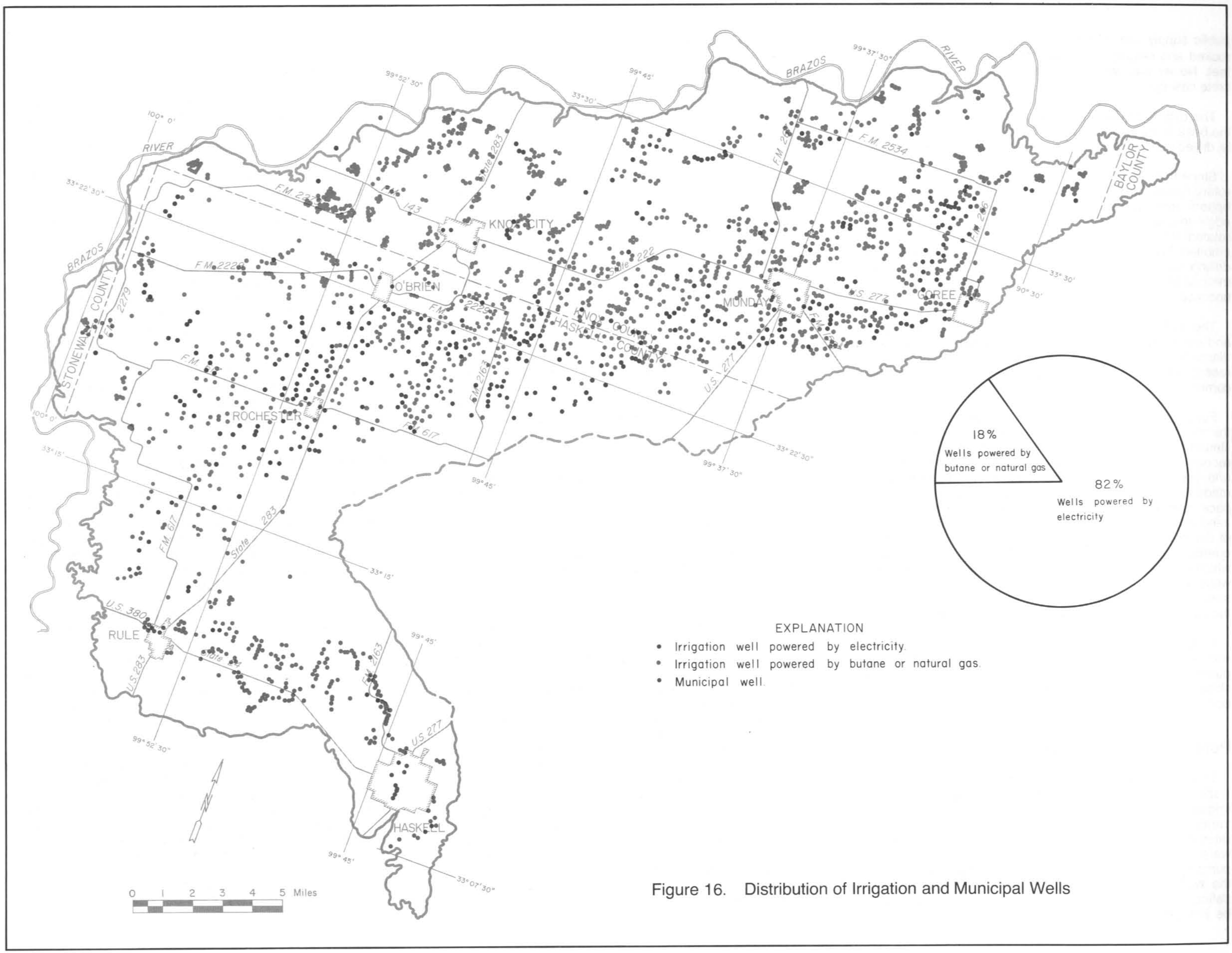


Figure 16. Distribution of Irrigation and Municipal Wells

public supply use. The earliest dug wells were bricked or rocked and ranged in diameter from 30 inches to over 20 feet. Newer dug wells are constructed using 36-inch concrete casings.

The depths of many of the dug wells are shallower than the base of the Seymour or the top of the red beds. Normally, drilled wells penetrate the entire thickness of the Seymour.

Since the 1950's, most of the wells have been drilled by rotary rigs equipped with 8 to 36-inch auger buckets. In the bottom of the bucket there is an entry slot above a cutting edge through which material enters the bucket as it is rotated. When the bucket is full, it is lifted to the surface and emptied. Typically, water and drilling mud are not used in the drilling operations unless the hole will not stand open. This method of shallow drilling has proven very successful in the unconsolidated materials.

The wells are cased to bottom with slotted steel casing and are gravel packed. Typically, casings are 4 to 8 inches in diameter for wells used for stock and domestic purposes. In recent years, plastic screen and casing have become more common.

For irrigation wells, steel casing 16 inches in diameter is the most common. In older irrigation wells, the casings were slotted from the water table to the bottom of the wells, but recently, only the bottom sections opposite the basal sand and gravel deposits have been slotted. No effort has been made to relate the width of the slots to the size of the gravel pack used, or the size of the gravel pack to the size of the sand in the Seymour. Most slots are 1/16-inch wide and most of the gravel ranges in diameter from ½ to 1 inch. Consequently, many of the wells pump large quantities of sand which results in worn, inefficient pumps. In some instances, wells are lost due to cave-ins. Also, it is common to see surface slumping in the vicinity of wells, allowing water from the surface to drain back underground outside the casing.

Most of the pumps for irrigation wells are turbine pumps with electric motors of 5 to 25 horsepower. Centrifugal pumps are common in areas where the water levels are shallowest. Jet pumps are the most common for stock and domestic wells.

Pumping Rates of Wells

There is a wide variation in pumping rates of Seymour wells and in well yields obtainable. Pumping rates for irrigation wells range from less than 50 gpm to a maximum measured rate of 1,300 gpm. Figure 17 shows the pumping rates measured for wells in the Seymour. The rates shown were measured in 1956 or 1975–1977 in connection with pumping tests or power tests. They are considered typical of the well yields available from Seymour wells, but do not define yields available in all areas. The largest yields tend to be in those areas having the larger saturated thicknesses and coarser, well-sorted sands and gravels. A large number of pumping rates are between 50 and 450 gpm. The average measured pumping rate is 270 gpm.

Geologic Character

Ground water in the Seymour is in unconsolidated sediments consisting principally of interfingering zones of fine to coarse-grained gravel, fine to coarse-grained sand, silt, and clay. The sediments were deposited by streams flowing generally eastward and mostly represent material eroded from the High Plains. The lowermost sediments are coarser, typically, and fill the valleys in the pre-Seymour or red bed surface. The lower zones consist typically of unconsolidated sands and gravels, although some cemented sandstone and conglomerate beds occur locally. The gravels are composed of rounded pebbles of quartz, chert, igneous rock, and some limestone. They range in size from less than ½ inch to approximately 4 inches in diameter. Occasionally, 1-foot blocks of Permian limestone and sandstone occur at the base of the formation. The basal gravel is not present consistently, and in some areas very little coarse water-bearing material is present. Also, the gravels are poorly sorted at some locations and mixed with clays and silts. Tables 28 and 29 give descriptive and sieve analyses data on the character of the Seymour.

The upper part of the Seymour is finer grained and consists of medium to fine-grained sands, silts, and clays. Frequently, the clays and silts are mixed with white or buff caliche nodules. Minor amounts of volcanic ash are present at some locations.

The thickness of the Seymour ranges from 0 to 94 feet. Throughout most of the area, its average thickness is greater than 40 feet.

Drillers' logs for 240 Seymour wells (Table 30) were plotted and analyzed statistically during this investigation for relative water-bearing characteristics of the materials described by the driller. This was done by listing all the descriptions used and by assigning each description to one of three categories of water-bearing materials: good, fair, or poor. For example, typical descriptions assigned to the good water-bearing category included: gravel, course sand, sand and small gravel, and clean coarse sand. This category included all descriptions containing the word "gravel" but none containing the word "clay." Descriptions assigned to the category of fair water-bearing materials included: fine sand, sand, dirty sand, sand and clay, and sand and sandstone. Descriptions included in the poor category of water-bearing materials included: clay, sandy clay, shale, top soil, rock, and soil and clay. For each 10-foot interval of each log, the footage of each of the three categories of water-bearing materials was noted. The data for all of the logs within each 7½-minute quadrangle were totaled, and the results are shown on Figure 18.

For each 7½-minute quadrangle and each 10-foot interval below land surface, Figure 18 shows the percentage of materials considered to be of good, fair, or poor character from a water-bearing standpoint. For example, in 1-degree quadrangle 21–27, the nine drillers' logs analyzed indicate that 90 percent of the material between the depths of 0 and 10 feet is in the poor category and 10 percent in the fair category. Similarly, between the depths of 20 and 30 feet, the nine logs indicate that 16 percent of the material is in the poor category, 45 percent in the fair category, and 39 percent in the good category.

The diagrams on Figure 18 show the extent to which the better water-bearing materials (gravels) occur in the lower part of the Seymour, and the extent to which the poorer water-bearing materials (clays and silts) occur in the upper part. Comparing areas, 7½-minute quadrangles 21–33, 21–41, and 21–51 have the least amount of poor water-bearing materials in the upper 10 feet. These quadrangles coincide approximately with areas where sandy materials are present at the surface. Those quadrangles which have the most clay in the upper part of the formation tend to be quadrangles 21–34, 21–35, and 21–36. These quadrangles, along with quadrangle 21–50, have little fair water-bearing material, whereas most of the other quadrangles show larger amounts of material in the fair category.

Base of Seymour Formation

The base of the Seymour represents the buried erosional surface on top of the Permian red beds. The relative position of the base is an important factor in the availability of large-capacity wells. Buried channels, where the depth to the base is deeper than normal, provide the possibility of obtaining large well yields due to an increased thickness and coarser character of water-bearing materials.

Figure 19 summarizes the available information on the depth to the base of the Seymour. The map is based on drillers' logs and on reported depths of wells. The depth to the base of the Seymour averages more than 50 feet over large areas extending generally from Rule to Rochester to Goree. It reaches a maximum of 94 feet in the vicinity of Rochester. Depths shallower than 40 feet occur typically in the vicinity of Haskell and along the northwestern part of the area where the younger Seymour deposits occur.

The altitude of the base of the Seymour is shown on Figure 20. The control points shown are based on drillers' logs penetrating the Seymour. In addition, the map is based on the altitudes of the total depths of a large number of wells. These depth data are considered reasonably reliable because most of the drilled depths of the irrigation wells and a large number of the stock and domestic wells reach the red beds. However, this is not always the case; consequently, in contouring the map some judgement was used as to which wells were most indicative of the altitude of the base of the Seymour.

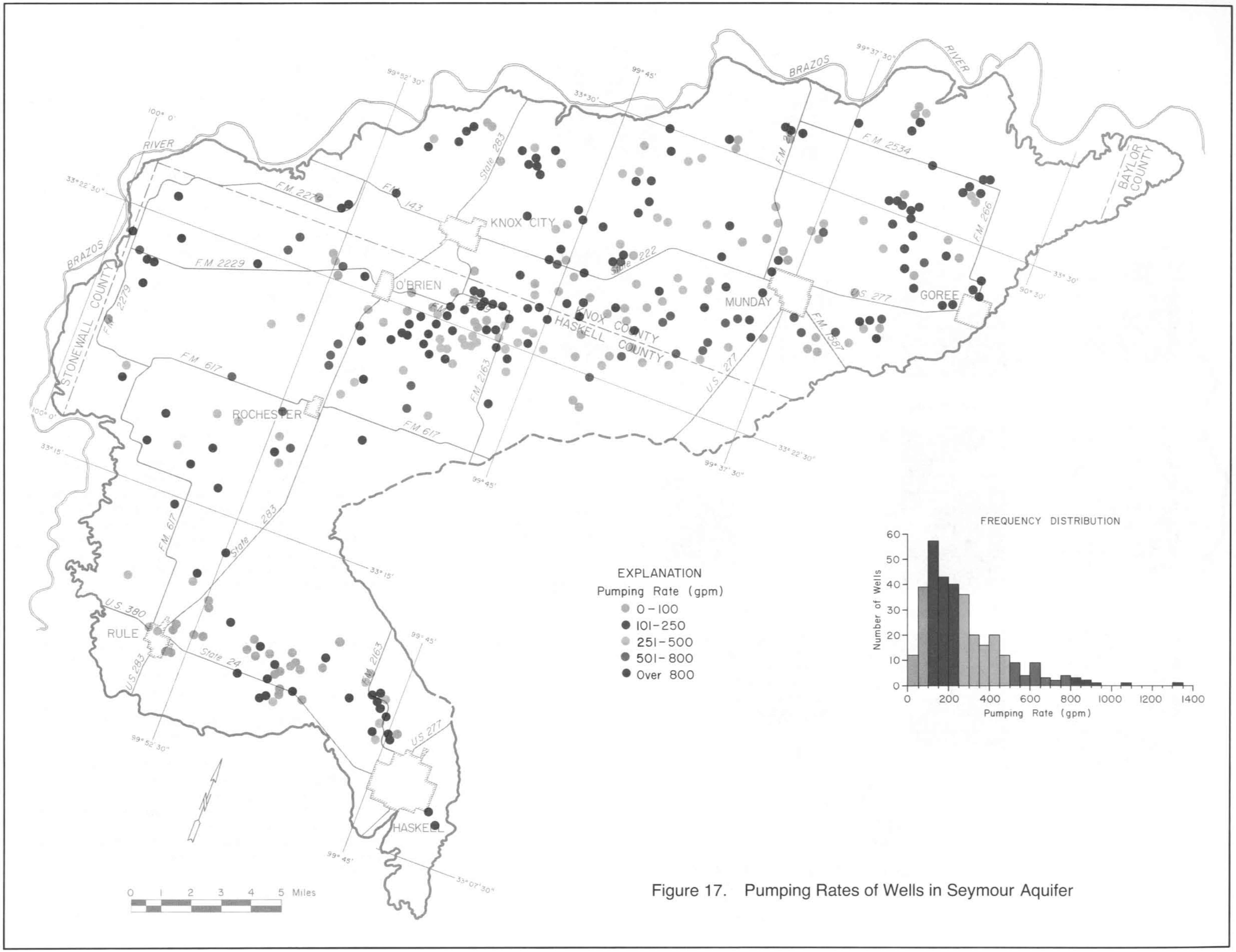


Figure 17. Pumping Rates of Wells in Seymour Aquifer

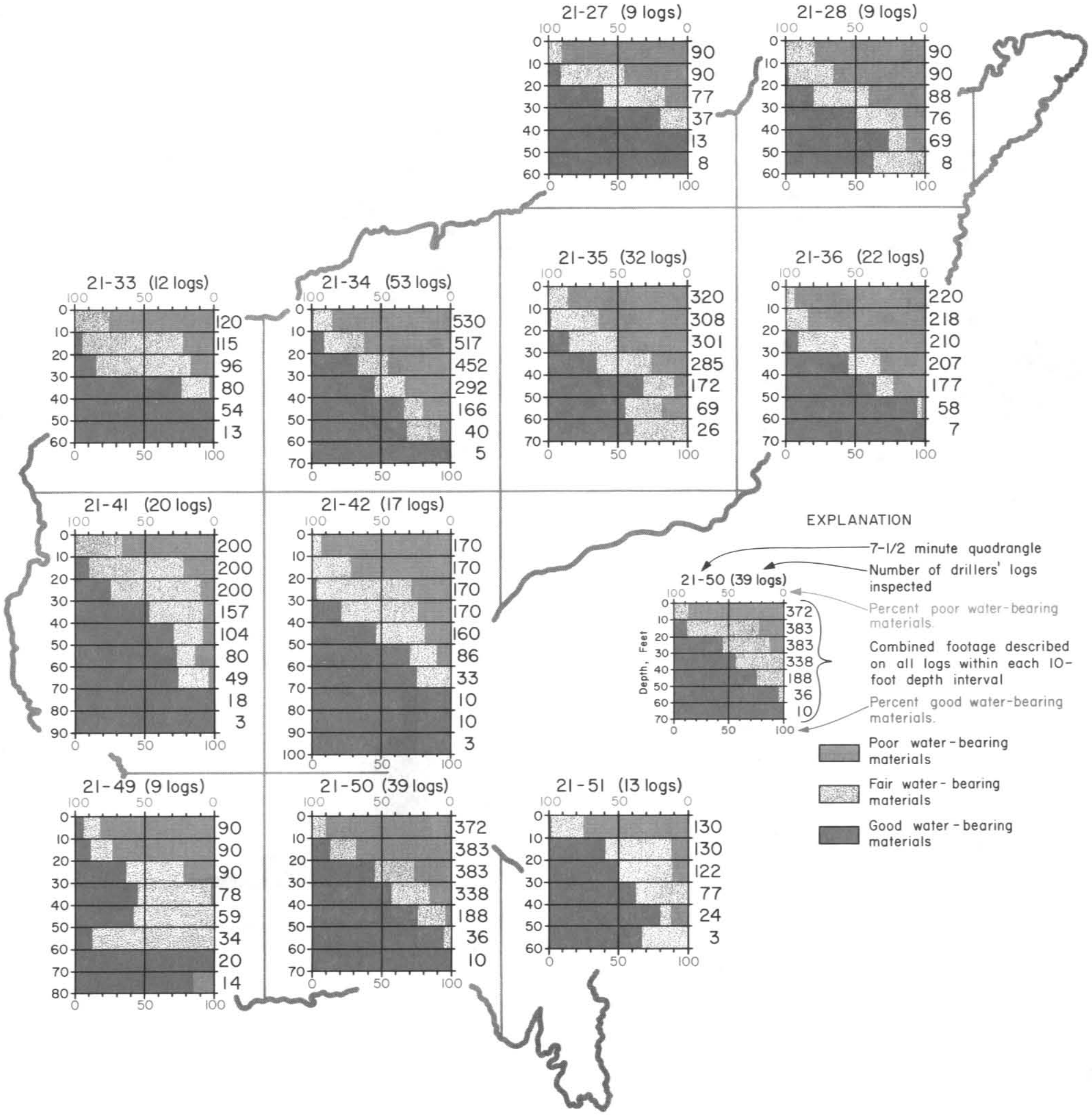


Figure 18. Characteristics of Seymour From Drillers' Logs

The base of the Seymour southwest of Rule is at an altitude of more than 1,640 feet above mean sea level. In general, the surface slopes to the east, northeast, and north away from this high point. The lowest elevation is found along the northernmost part of the area in quadrangle 21–28 where the altitude of the base of the Seymour is slightly below 1,360 feet above mean sea level.

The boundary between the older and the younger Seymour deposits is reflected on Figure 20 as a steepening of the base of the Seymour. The boundary is not well defined on Figure 20 due to the scarcity of wells along the boundary.

There are two major buried channels indicated by the map. The largest and most significant extends from near Rochester to approximately Goree. A smaller channel trends northwest-southeast through the Haskell area. It is likely that other, mostly smaller channels exist in the area, but the degree of accuracy and distribution of the well data makes mapping difficult.

Water Table

Figure 21 shows the depth to the water table for the Seymour aquifer based on measurements taken during January 1977. There is a wide variation in depth to water in most all of the individual 2½-minute quadrangles for which data are shown on Figure 21. The average depth to water is 23 feet. Measurements in individual wells range from about 4 feet to 55 feet. In general, the areas having the greater depths to water are west of Rochester, north of Rule, south of Knox City, and north of Goree. Those areas having the shallowest depths to water lie generally southeast and northeast of Rochester near the edges of the aquifer, at Haskell, and at numerous locations along the northern and western boundaries of the aquifer.

The altitude of the water table for the Seymour aquifer is shown on Figure 22. The map is based on approximately 450 water-level measurements made during January 1977. The highest water level was found just southeast of Rule at approximately 1,660 feet above mean sea level. The lowest level of approximately 1,370 feet above mean sea level was found along the northern border of the aquifer in quadrangle 21–28. The water table for January 1977 is shown also on the geohydrologic sections on Figures 11 and 12.

In general, the gradient of the water table is approximately equal to the gradient of the land surface and the top of the red beds. Water-level gradients range from approximately 5 feet per mile to 60 feet per mile and average about 7.6 feet per mile. The steepest gradients occur along the boundary between the older and younger Seymour deposits. These gradients indicate that the two parts of the Seymour are connected poorly.

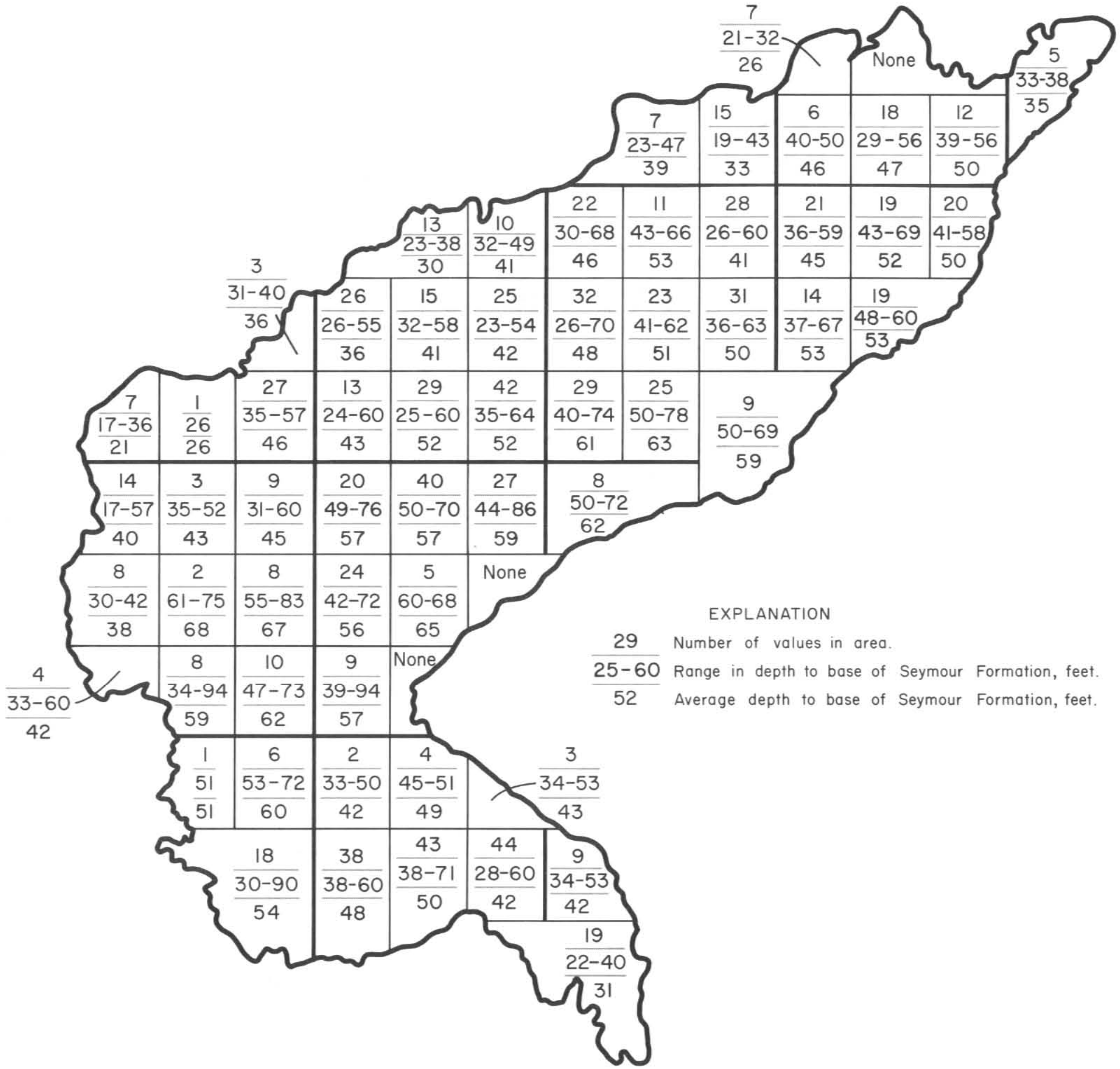


Figure 19. Depth to Base of Seymour Formation

Saturated Thickness

The saturated thickness of the Seymour is shown on Figure 23. The map is based on those wells having drillers' logs for which water-level measurements were made in January 1977 and a comparison of the altitude of the water table and the altitude of the base of the Seymour from Figures 20 and 22.

The saturated thickness ranges from less than 10 feet around the edge of the aquifer to more than 60 feet in a small area in northern Haskell County, northeast of Rochester. Large areas have saturated thicknesses between 20 and 40 feet.

For each 10-foot interval of saturated thickness, Table 2 shows the area and calculated volumes of water in storage in January 1977.

Hydraulic Properties

Results of pumping tests conducted to determine specific capacities of wells and the transmissivity of the Seymour are given in Table 3. Figure 24 shows the locations of the wells tested.

Specific Capacities of Wells

The specific capacity of a well indicates the amount of water which the well will produce with a given drawdown of water level within the well over a relatively short period of time. The units commonly used are gallons per minute per foot of drawdown (gpm/ft). The hydraulic characteristics of a formation and the construction efficiency of the well are the primary factors that determine the specific capacity of a well. A wide variance in specific capacities of Seymour wells indicates a wide variance in hydraulic character of the aquifer. Specific capacities range from less than 20 to 175 gpm/ft. The average for 24 tests is 57 gpm/ft.

Coefficients of Transmissivity, Permeability, and Storage

Table 3 lists the coefficients of transmissivity and permeability determined from pumping tests of Seymour wells. The coefficient of transmissivity is a measure of the amount of water that will move through an aquifer. It is expressed typically in gallons per day per foot (gpd/ft) of width of the aquifer. The coefficients of transmissivity for 24 wells tested range from 19,500 to over 300,000 gpd/ft. The average transmissivity is 100,000 gpd/ft. The wide range in values indicates a non-uniform aquifer which varies greatly in hydraulic character. This wide variance is typical of an aquifer with the geologic character of the Seymour.

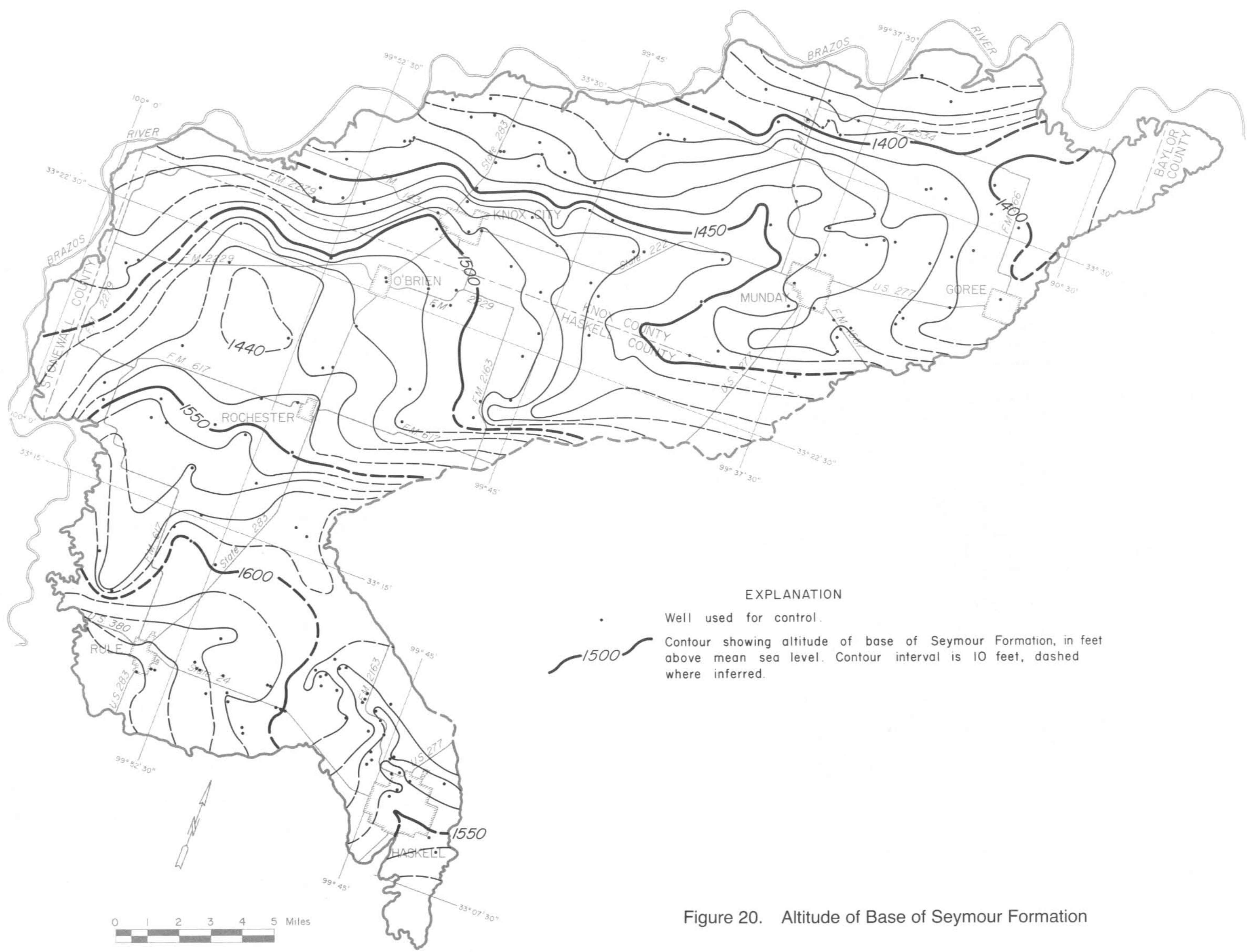


Figure 20. Altitude of Base of Seymour Formation

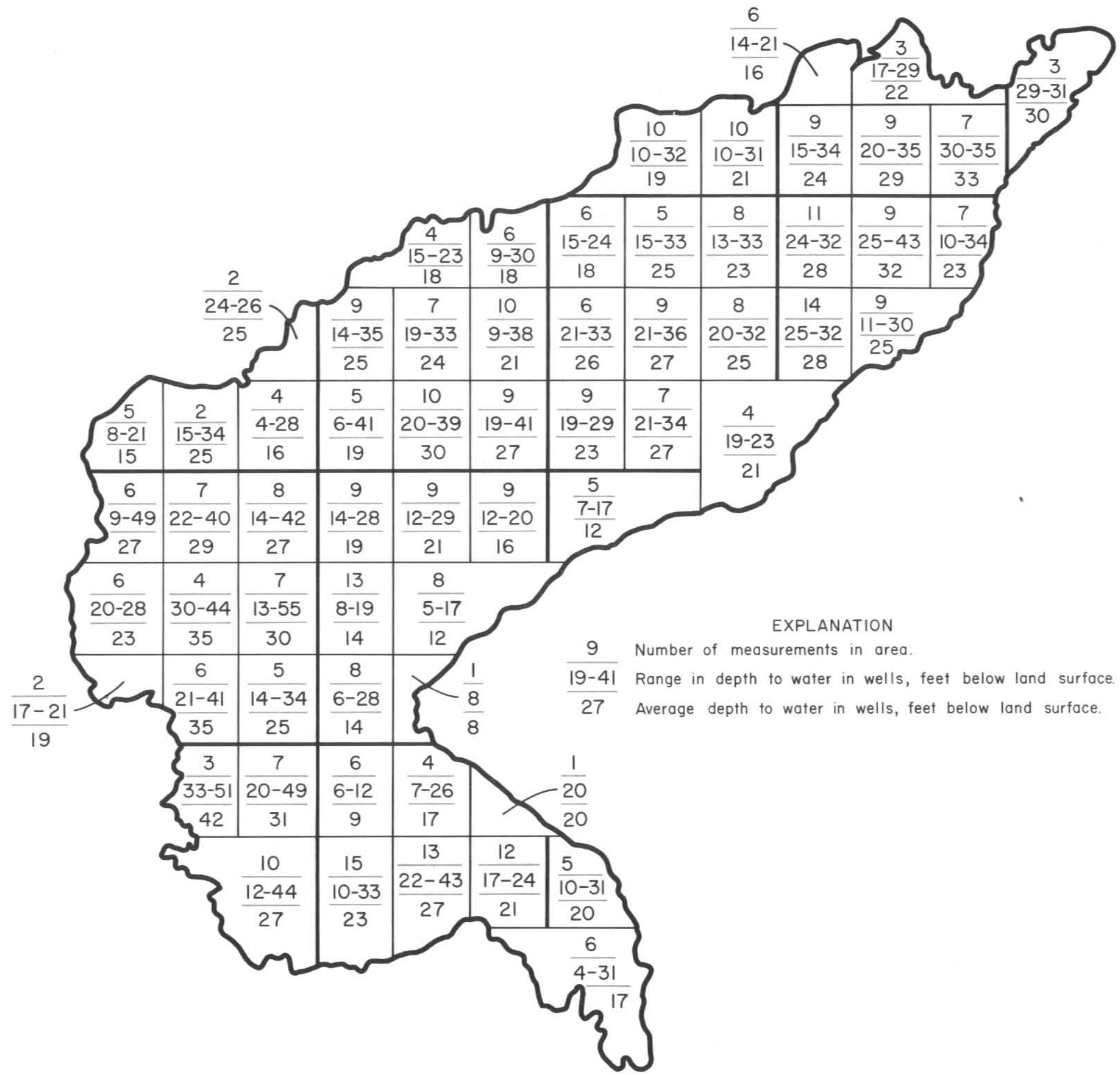


Figure 21. Depth to Water in Seymour Formation, January 1977

By using the coefficient of transmissivity and the thickness of the water-bearing materials at the pumped well, the field coefficient of permeability can be calculated. It is equal to the transmissivity divided by the thickness of the aquifer. It is expressed typically in gallons per day per square foot (gpd/ft²). The average permeability of the zones tested in 24 wells is 4,200 gpd/ft². The range in permeability for individual wells is from 900 to 17,800 gpd/ft².

The coefficient of storage is a measure of the amount of water which is given up from storage in an aquifer when the water level is lowered. It is dimensionless and is equivalent to the number of cubic feet of water released in each square-foot column of the aquifer when the later level is lowered one foot. In an unconfined aquifer under water-table conditions such as the Seymour, the coefficient of storage is equal to the specific yield. It is estimated that the coefficient of storage for the Seymour ranges from less than 10 percent to more than 20 percent and averages approximately 15 percent.

Interference Between Wells and Water-Level Drawdown

When a Seymour well is pumped, it creates drawdown effects in nearby wells. Figure 25 shows the typical drawdown due to pumping 300 gallons per minute from a well in an infinite aquifer having hydraulic characteristics similar to those of the Seymour. The maximum water-level drawdown occurs at the pumping well. The drawdown becomes progressively less at increasing distances from the well. The drawdowns shown on Figure 25 are proportional to the pumping rate shown; accordingly, the drawdown due to pumping at any rate can be estimated using the graph.

When wells are spaced close together, the interference between pumping wells can result in significant decreases in yields for the individual wells. These decreases are due to the interference effects diminishing the amount of available drawdown and causing larger pumping lifts. Figure 26 shows the interference between two pumping wells. The wells are spaced 200 feet apart, and the drawdown curves shown represent pumping for 90 days at 300 gpm. Normally, large-capacity irrigation wells in the Seymour should be spaced several hundred feet apart or more.

Recharge

Figure 27 schematically shows the hydrologic cycle as related to the Seymour, including general recharge and discharge relationships. Direct infiltration of precipitation at the land surface is the method by which nearly all recharge to the Seymour occurs. Surface streams adjoining the Seymour, including the Brazos River and Lake Creek, are at elevations lower than the water levels in the Seymour

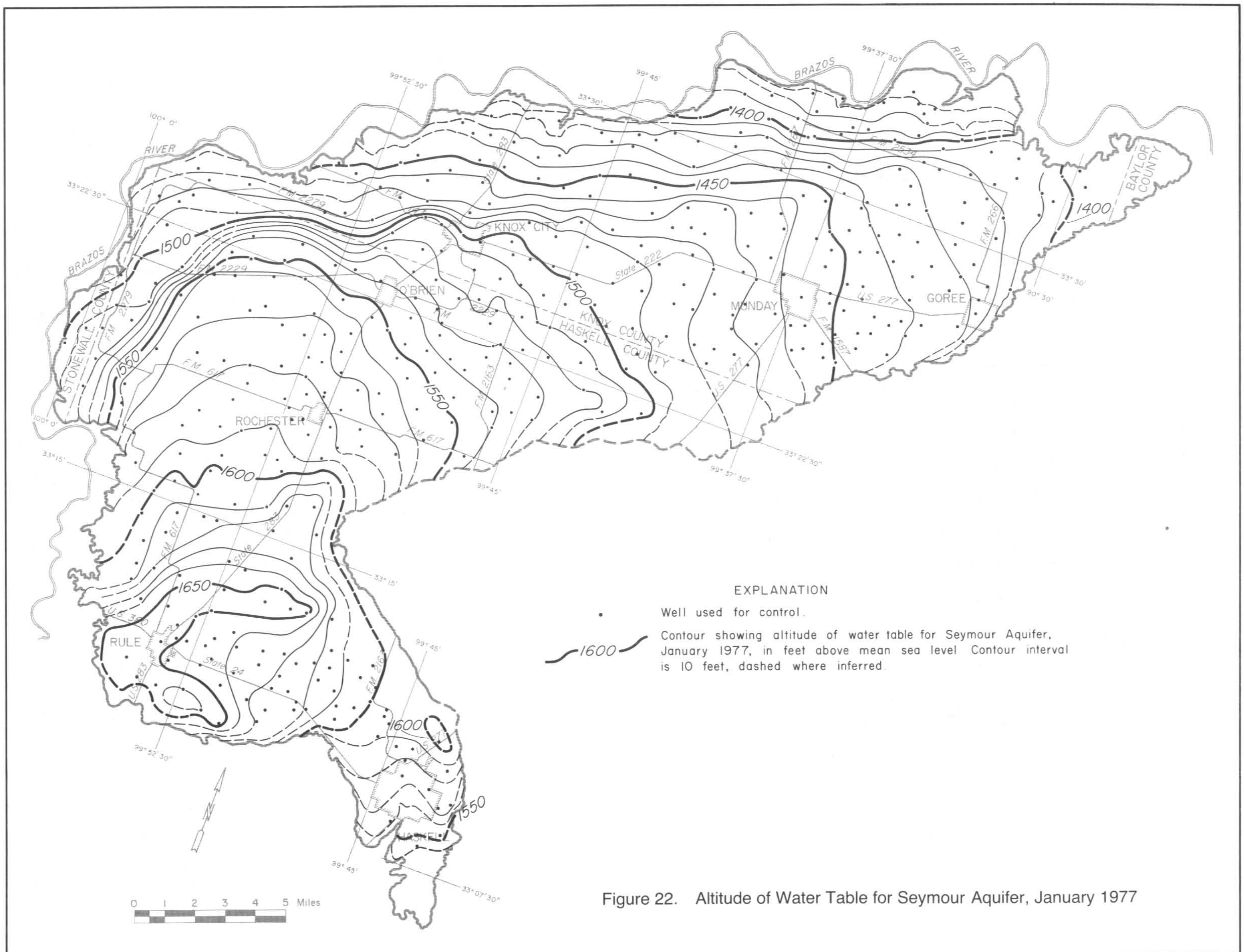
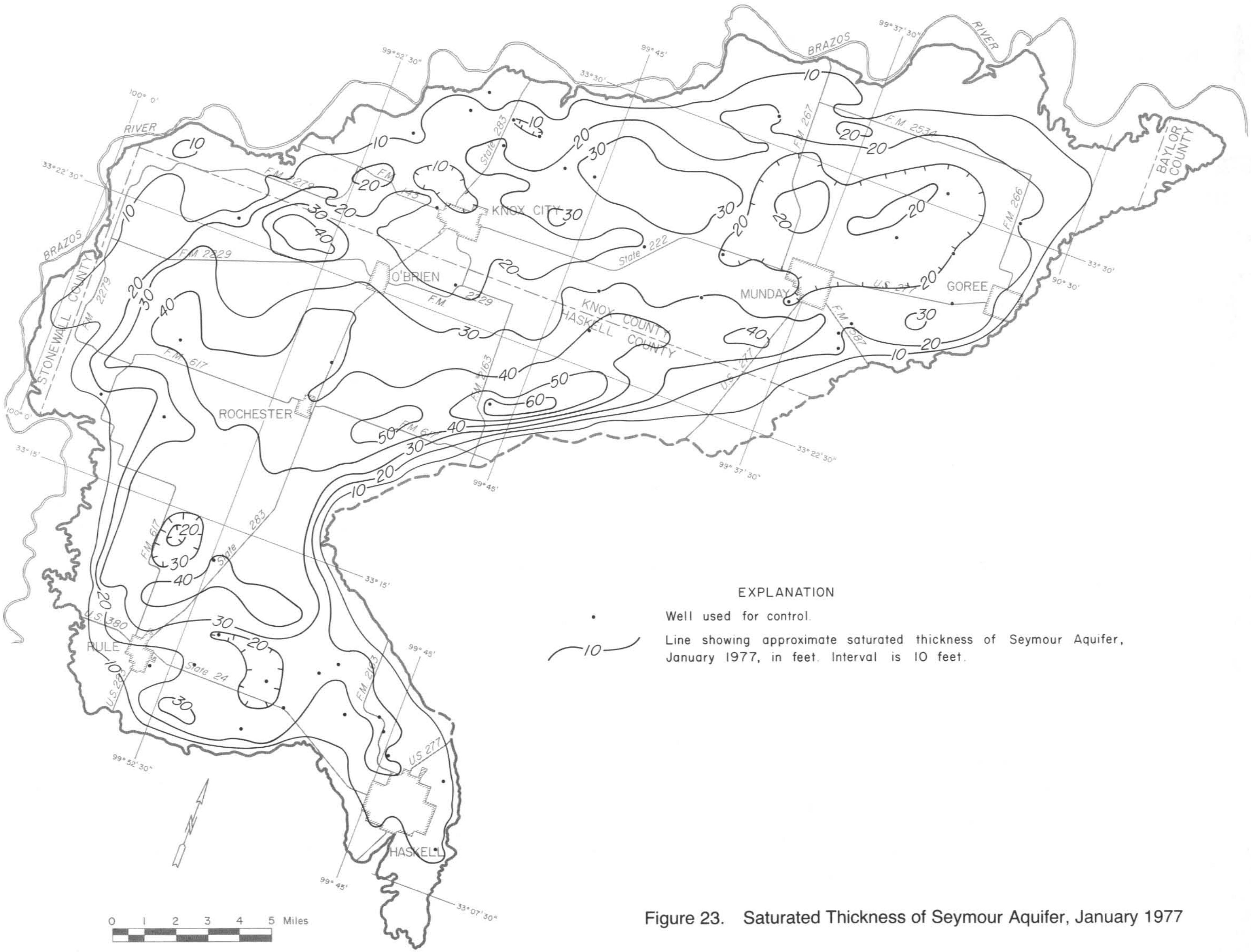


Figure 22. Altitude of Water Table for Seymour Aquifer, January 1977



EXPLANATION

• Well used for control.

—10— Line showing approximate saturated thickness of Seymour Aquifer, January 1977, in feet. Interval is 10 feet.

Figure 23. Saturated Thickness of Seymour Aquifer, January 1977

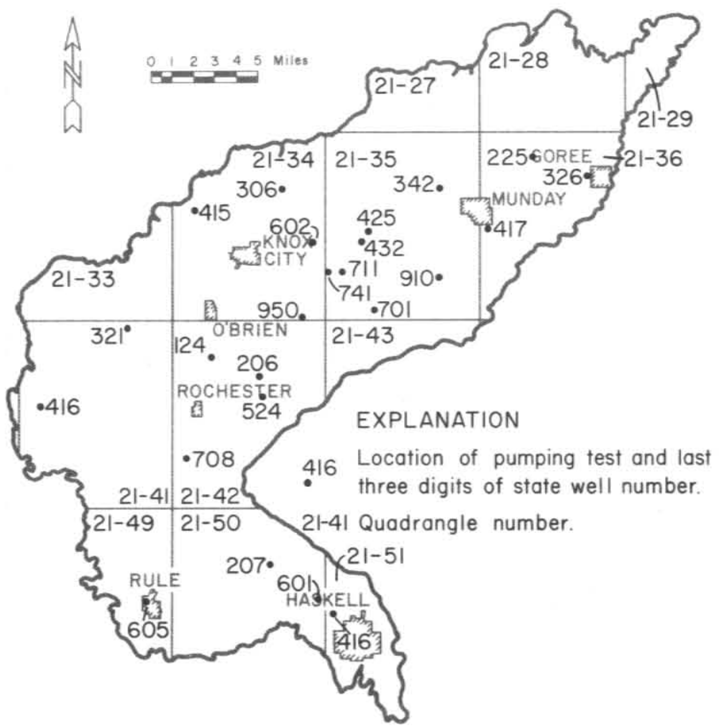


Figure 24. Locations of Pumping Tests

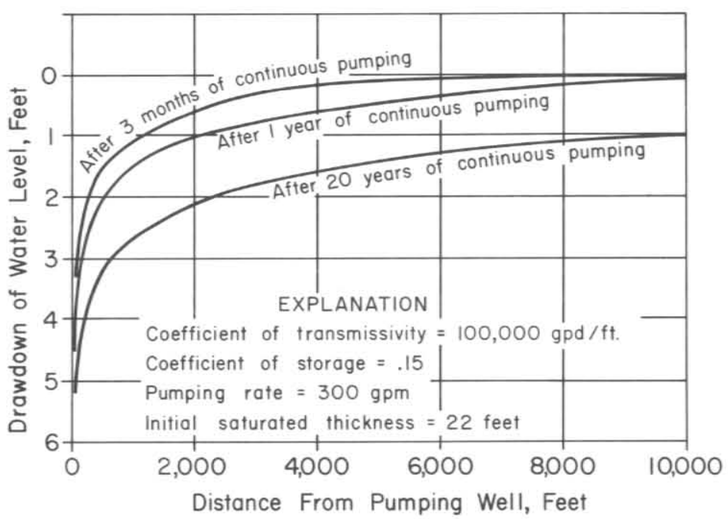


Figure 25. Drawdown Due to Pumping 300 Gallons Per Minute

aquifer and cannot contribute to the Seymour. Some water pumped for irrigation and municipal use infiltrates and returns to the aquifer, but these amounts are relatively small. The only other possible source of recharge to the Seymour is leakage from underlying Permian formations. This probably occurs in some areas, but amounts are very small and insignificant.

Table 2. Estimated Water in Storage, 1977

Mapped Saturated Thickness Interval (feet)	Area (acres)	Volume of Water In Storage[1] (acre-feet)	Drainable Volume of Water In Storage[2] (acre-feet)
0–10	52,398	79,000	39,000
10–20	75,023	338,000	169,000
20–30	70,118	526,000	263,000
30–40	51,173	537,000	269,000
40–50	22,351	302,000	151,000
50–60	2,948	49,000	24,000
60–70	523	10,000	5,000
Total	274,534	1,841,000	920,000

[1] Based on a porosity of 30 percent. This is the approximate amount of water the aquifer contains.

[2] Based on a storage coefficient of 15 percent. This is the approximate amount of water that would drain from the aquifer by gravity drainage, if the entire saturated thickness could be drained.

Recharge from precipitation is not uniform over the study area. Considerably more recharge occurs in the sand hills area, and in other areas where the land surface consists of sandy materials, than in those areas where clay soils predominate. Three indicators of significant recharge areas are sandy soils, large water-level rises during past wet periods, and better water quality.

Figure 28 shows the principal areas where sandy soils occur and most of the infiltration to the Seymour takes place. The areas are some distance from areas of natural discharge from the Seymour. Consequently, there is no large amount of rejected recharge from the aquifer. Most of the recharge that occurs goes into storage in the aquifer and results in water-level rises unless pumped out.

Significant water-level rises occur in the main recharge areas of the Seymour due to precipitation. The hydrograph for well LP 21-42-409 depicted in Figure 29, shows water-level rises as a result of the early spring and summer rains which occurred in 1975 and 1977. Ogilbee (1962) reports that water levels near Rochester rose over 2 feet from February to May 1957 in response to spring rains of about 11 inches, and that during the same time period, water levels in other wells in the Rochester-O'Brien area rose from 1½ feet to 2½ feet. These rises indicate that over 20 percent of the precipitation reached the Seymour as recharge.

Estimates of the amount of recharge based on the historical pumpage and water levels in the aquifer for the past 20 years indicate that total infiltration from precipitation and return flow from irrigation is 2.2 inches per year plus an amount equivalent to the average annual natural discharge from the aquifer. Most of this infiltration is from precipitation. Return flow is only a small part of the infiltration due principally to the relatively low amounts of irrigation water applied. Moreover, if reasonably large quantities of return flow were occurring, there would have been significant water quality changes, and such changes have not been experienced in the area.

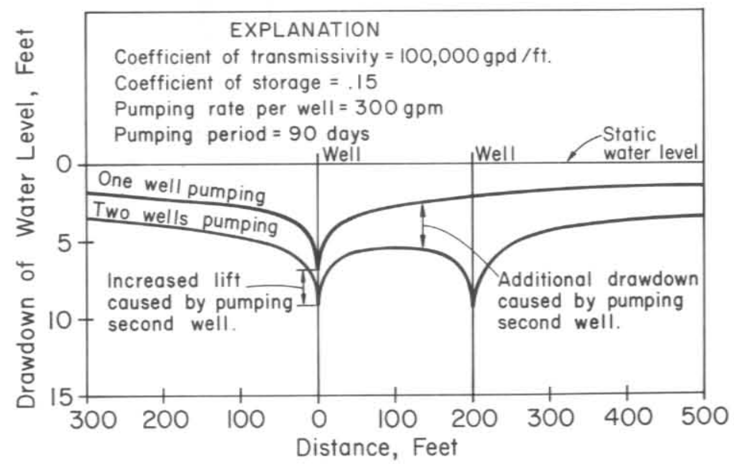


Figure 26. Interference Between Two Pumping Wells

Table 3. Results of Pumping Tests

Well Number	Pumping Rate (gpm)	Year of Test	One-Hour Specific Capacity (gpm/ft)	Saturated Thickness (feet)	Coefficient of Transmissivity (gpd/ft)	Field Coefficient of Permeability (gpd/ft²)
HASKELL COUNTY						
21-34-950	357	1957	113.7	29	75,000	2,600
21-35-701	422	1976	73.8	42	130,000	3,100
21-41-321	215	1976	36.0	14	34,000	2,400
21-41-416	95	1976	29.3	17	130,000	7,600
21-42-124	136	1976	54.8	27	33,000	1,200
21-42-206	590	1957	61.5	30	220,000	7,300
21-42-524	769	1976	72.7	53	240,000	4,500
21-42-708	257	1976	21.5	39	45,000	1,200
21-49-605	429	1976	105.0	18	320,000	17,800
21-50-207	95	1957	31.6	9	32,000	3,600
21-50-601	255	1957	56.8	16	135,000	8,400
21-51-416	112	1957	77.2	6	90,000	15,000
KNOX COUNTY						
21-34-306	146	1956	28.9	14	107,000	7,600
21-34-415	181	1956	85.8	13	177,000	13,600
21-34-622	335	1976	39.3	22	88,000	4,000
21-35-342	63	1976	20.0	11	19,500	1,800
21-35-425	255	1957	29.2	25	23,000	900
21-35-432	543	1957	95.6	26	83,000	3,200
21-35-711	917	1956	175.0	27	97,000	3,600
21-35-741	355	1956	19.2	35	50,000	1,400
21-35-910	356	1956	66.3	36	60,000	1,700
21-36-225	258	1976	16.7	19	98,000	5,100
21-36-326	191	1976	19.1	20	25,000	1,200
21-36-417	540	1957	40.9	39	79,000	2,000
Average:	328		57	24	100,000	4,200

Natural Discharge

Natural discharge from the Seymour occurs through seeps and springs, evapotranspiration by plants, evaporation from the water table, and leakage to the Permian. Seeps and springs occur along the edges of the aquifer. The more important springs are mapped on Figure 30. Spring flows range from less than 1 gallon per minute to an aggregate of a few hundred gallons per minute for springs along Wild Horse Creek, the largest group of springs in the area. Seeps and springs along Rice Springs Branch, China Branch, and Union Creek are small, and most natural discharge in these areas is by evapotranspiration. Most of the other springs flow only a few gallons per minute, but a few flow 20 to 30 gallons per minute. Many seep areas occur along the edge of the formation, particularly in the small drainageways and along the bluffs overlooking the Brazos River on the northern and western boundaries of the aquifer.

It is estimated that the total ground-water discharge by evapotranspiration is a large part of the total natural discharge from the aquifer and is considerably larger than that from springs and seeps. The main areas of evapotranspiration occur in many places along the edge of the Seymour and along the principal creeks. They are mapped on Figure 30. The areas are marked by dense plant growth, mainly native grasses, willows, and mesquites. In addition, there are many small scattered areas away from the edge of the Seymour which are covered by dense growths of mesquite. These areas are also mapped on Figure 30, and represent former pasture areas, primarily. The depth to water under these areas is not deep enough to preclude mesquites from developing root systems to sufficient depths to draw from the water table. Some evapotranspiration probably occurs in these areas, but the amount is unknown.

Direct evaporation from the water table occurs only in small amounts and in limited areas due to the depth of the water table. In only a few localities is the depth to water less than 10 feet, and no areas are known to exist where the water table is less than about 4 feet. For depths to water ranging from 4 to 8 feet, it has been estimated by White (1932) that direct evaporation is on the order of 2 to 5 percent of pan evaporation. This is equivalent to 0.12 to 0.3 feet per year.

Leakage from the Seymour to the adjacent underlying Permian rocks is very small due to the geologic character of the Permian, and the amount is not believed to be significant quantitatively.

Direction and Rate of Ground-Water Movement

The general direction of movement of water in the Seymour aquifer is shown on Figure 31. The map approximates the natural direction of flow, unaffected by pumping from wells. Basically, the movement of the ground water is from higher to lower elevations and from recharge areas to discharge areas. The flow is outward from the highest points on the water table along the ground-water divide near and northeast of Rule. One segment of the flow is from this divide to the southeast toward Haskell. North of the Rule ground-water divide, the flow is toward the north, northwest, or northeast. The direction of flow tends to be perpendicular to the water-table contours shown on Figure 22.

Based on the contours of the water table and the permeabilities for the formation indicated by pumping tests, it is estimated that the natural rate of movement of water in the Seymour, where unaffected by pumping, ranges locally from approximately 200 to 5,000 feet per year. It is estimated that over several miles, the average rate of movement is typically between 800 and 1,200 feet per year.

Pumpage

Before large withdrawals for irrigation began in the 1950's, the water from the Seymour was used primarily for municipal, domestic, and livestock purposes. These withdrawals have been estimated for 10-year intervals on the basis of population:

Year	Pumpage (acre-feet)
1900	200
1910	400
1920	400
1930	900
1940	1,200

Table 4 shows the estimated pumpage for irrigation and public supply for 1950–1976. During this period, it is estimated that pumpage by industrial, livestock, and private wells in urban areas was less than 1,000 acre-feet per year.

The irrigation pumpage was estimated based on the amount of electricity used for irrigation each year. This information was obtained from three electric utility companies which serve the area, B-K Electric Cooperative, West Texas Utilities, and Stamford Electric Cooperative. Tests were conducted on 45 wells to determine the amount of water that wells pumped per unit of power consumed. These tests are referred to as power tests, and the results are shown in Table 5. Based on the power tests, it is estimated that a sprinkler system well averages approximately 970 gallons per kilowatt hour used, while an open discharge well averages approximately 2,330 gallons per kilowatt hour used. These values are similar to those obtained in adjacent areas of the Seymour (Price, 1978 and Preston, 1978). Historical use of sprinklers was studied in order that the amount of pumpage by sprinkler wells and open discharge wells could be estimated. The irrigation pumpage by wells powered by butane and natural gas was estimated based on the number of wells. Pumpage for municipal usage was obtained from individual towns or from records of the Texas Department of Water Resources. As shown in Table 4, the municipal use is small and usually less than 5 percent of the irrigation pumpage. There is no industrial pumpage at present. Very small amounts were used in the past for water-flooding purposes.

The amounts of annual pumpage for irrigation vary greatly. These variations are due primarily to large differences in the timing and amounts of precipitation, but are due also to type of crop, cost of labor and power, and other factors. Figure 29 shows the variation in monthly precipitation and amounts of electricity sold by B-K Electric Cooperative for irrigation during 1975, 1976, and 1977.

Table 4. Estimated Pumpage of Ground Water From Seymour Aquifer, 1950–1976

Year	Irrigation (acre-feet)	Public Supply (acre-feet)	Total (acre-feet)
1950	100	1,200	1,300
1951	900	1,200	2,100
1952	6,700	1,200	7,900
1953	9,900	1,200	11,100
1954	16,800	1,200	18,000
1955	34,800	1,200	36,000
1956	63,800	1,200	65,000
1957	46,800	1,300	48,100
1958	34,500	1,800	36,300
1959	17,900	1,600	19,500
1960	54,600	1,800	56,400
1961	36,200	1,600	37,800
1962	60,200	1,900	62,100
1963	56,800	1,800	58,600
1964	64,400	1,500	65,900
1965	53,000	2,100	55,100
1966	51,100	2,000	53,100
1967	51,600	1,900	53,500
1968	26,500	1,700	28,200
1969	32,000	1,700	33,700
1970	41,900	1,900	43,800
1971	51,200	1,700	52,900
1972	34,800	1,500	36,300
1973	24,000	1,600	25,600
1974	63,600	1,600	65,200
1975	25,100	1,600	26,700
1976	39,100	1,700	40,800

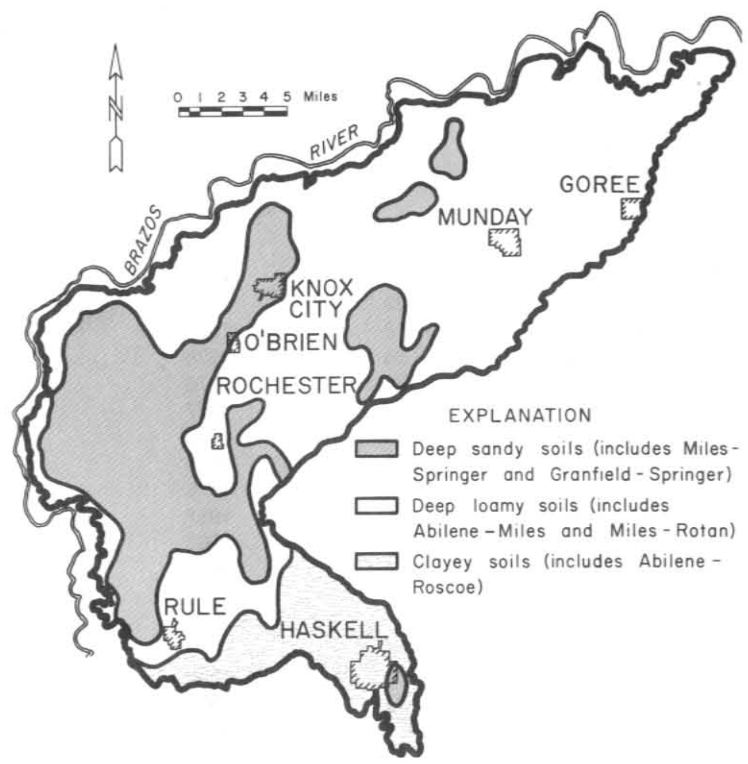


Figure 28. General Soil Map

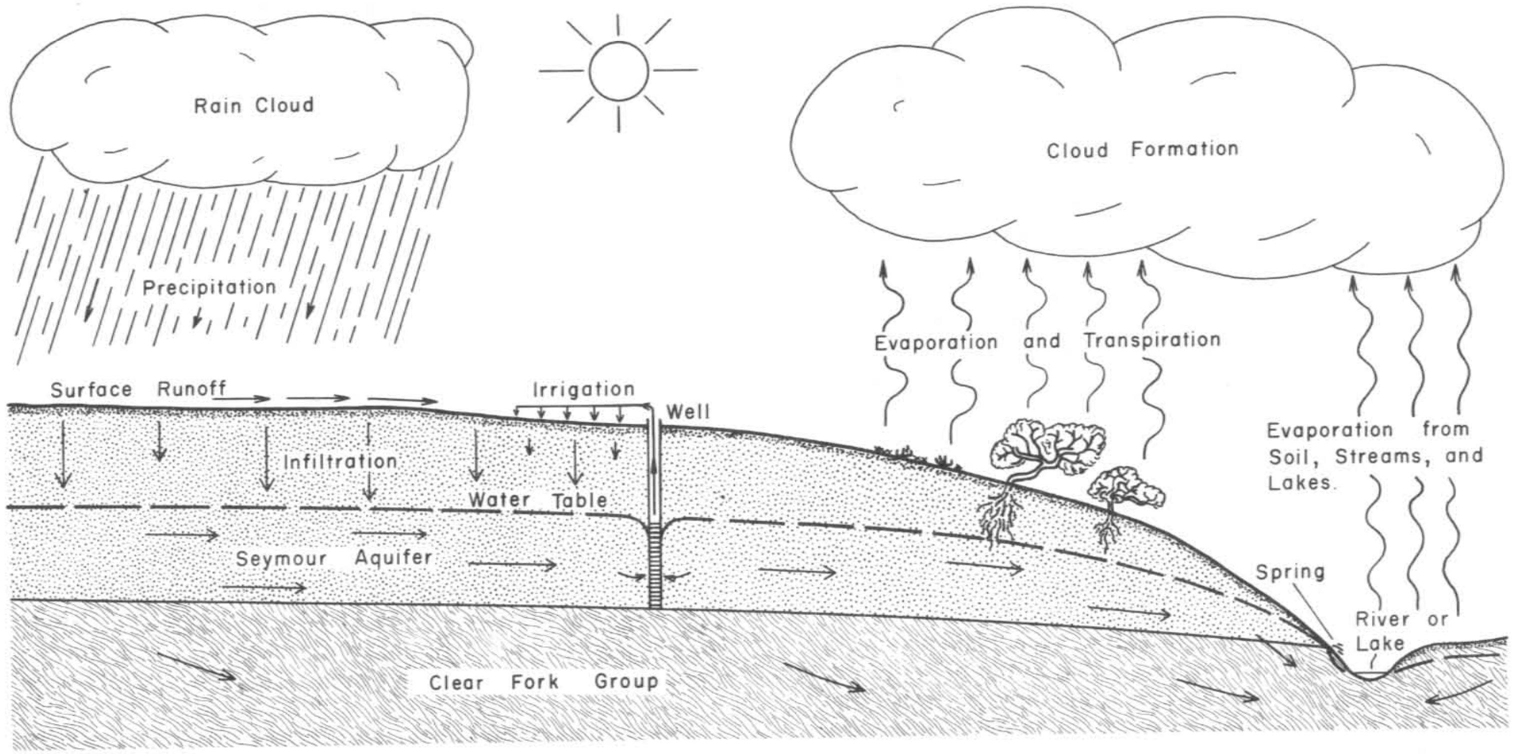


Figure 27. Schematic Diagram of Hydrologic Cycle

Fluctuations of Water Levels

Early water levels in the Seymour were substantially lower than current levels. Gordon (1913) based on work done in 1906 and 1907, reports:

> In places in the upland area also the beds are destitute of water, many wells extending through the gravels into the Permian beds called "Birdseye" by the drillers. The localization of the water in the gravels may be due to collection in basins in the unevenly eroded surface of Permian.

In 1934, Bandy made a two-day investigation consisting largely of interviews with local residents and reported in part as follows:

> Mr. Hudspeth, manager of the City Water Works of Rochester connected with the Water plant for seven years, stated that the water level [in] 1926 in the city well (sheet water in fine gravel) stood at 45 feet below the ground level. At this date it stands at 35 feet, 4 feet of this rise having occurred during the last two years. Pumps and motors had to be moved on this account. Mr. Hudspeth was raised 5 miles west of Rochester. Twenty five years ago the water on his home place was 70 to 75 feet below the surface, the water was hard and gip so much that water was hauled for domestic uses. Now this same well has water standing 45 feet from the ground level and the water is soft and fresh. Laundry work is done without breaking the water. This is a rise of 20 to 25 feet in twenty five years.

A. M. Allen, a resident of the vicinity for 33 years and a well digger in his youth states that he dug a well on his father's place in 1906. The well was located in a canyon near the Brazos River and a well was made at 16 feet. The water level gradually rose until 1918 when it began to run over the top of the well which it still does. Please note that 1917 and 1918 were the driest years of all history of the county and this drouth affected all west Texas. A well dug on the B. E. Carr place 8 miles west of Rochester was dug to a depth of 78 feet where water was found that rose to a depth of 4 feet. The water was very hard. Now the water stands 13 feet from the top and is very soft and fresh. He dug a well in a canyon to a depth of 44 feet near Jud and obtained water to a depth of less than 10 feet in the well. Water is now running over the top of the well.

J. H. Wolf, a resident since 1906 stated that one well on his place one mile west of Rochester stood 75 feet below the top and the water was gip. Now the same well is soft and fresh, water standing at 47 feet from the top. Another well was dug 108 feet finding gip water, this well now has an abundance of soft water at 45 feet. Numerous others were interviewed and their statements all tended to show the same thing: that the rise of ground water in this area is no myth, but a fact, that the rise has been about a foot per year with some little acceleration during the last few years, and the water has changed from hard, gip and salt water to soft, fresh water.

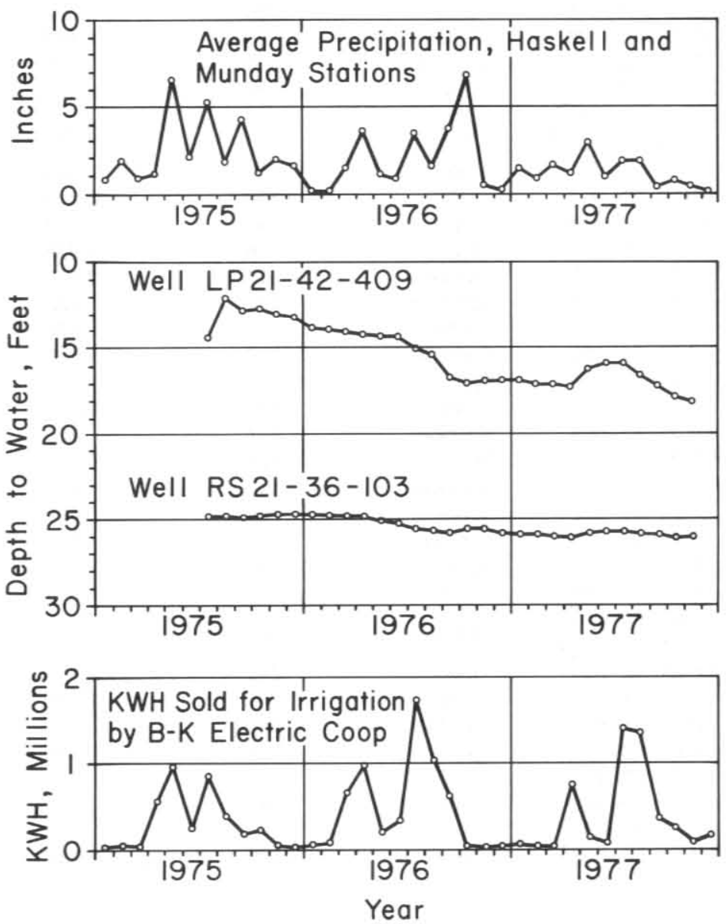


Figure 29. Precipitation, Water Levels, and Electricity Used for Irrigation, 1975–1977

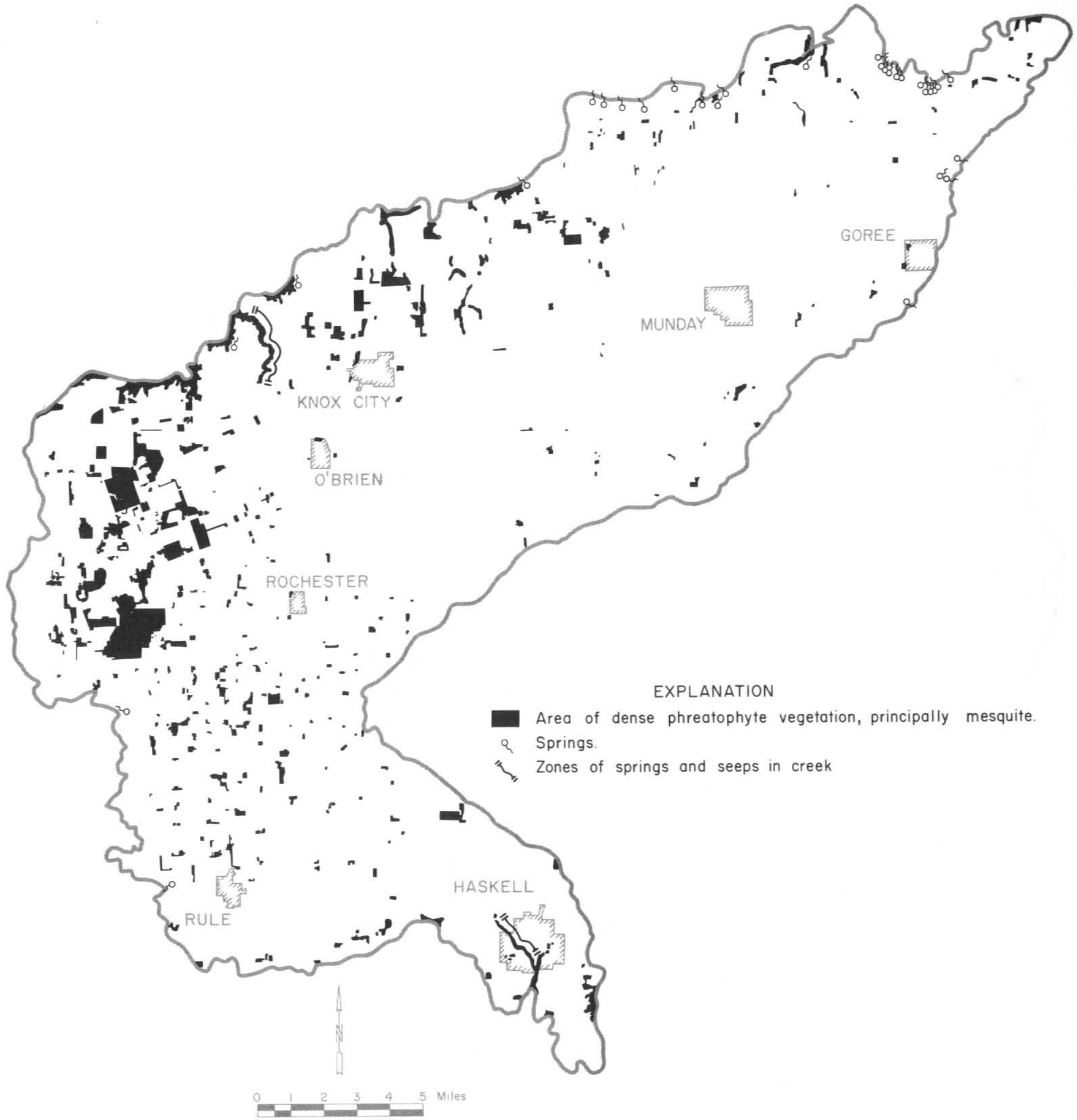


Figure 30. Areas of Natural Discharge From Seymour Aquifer

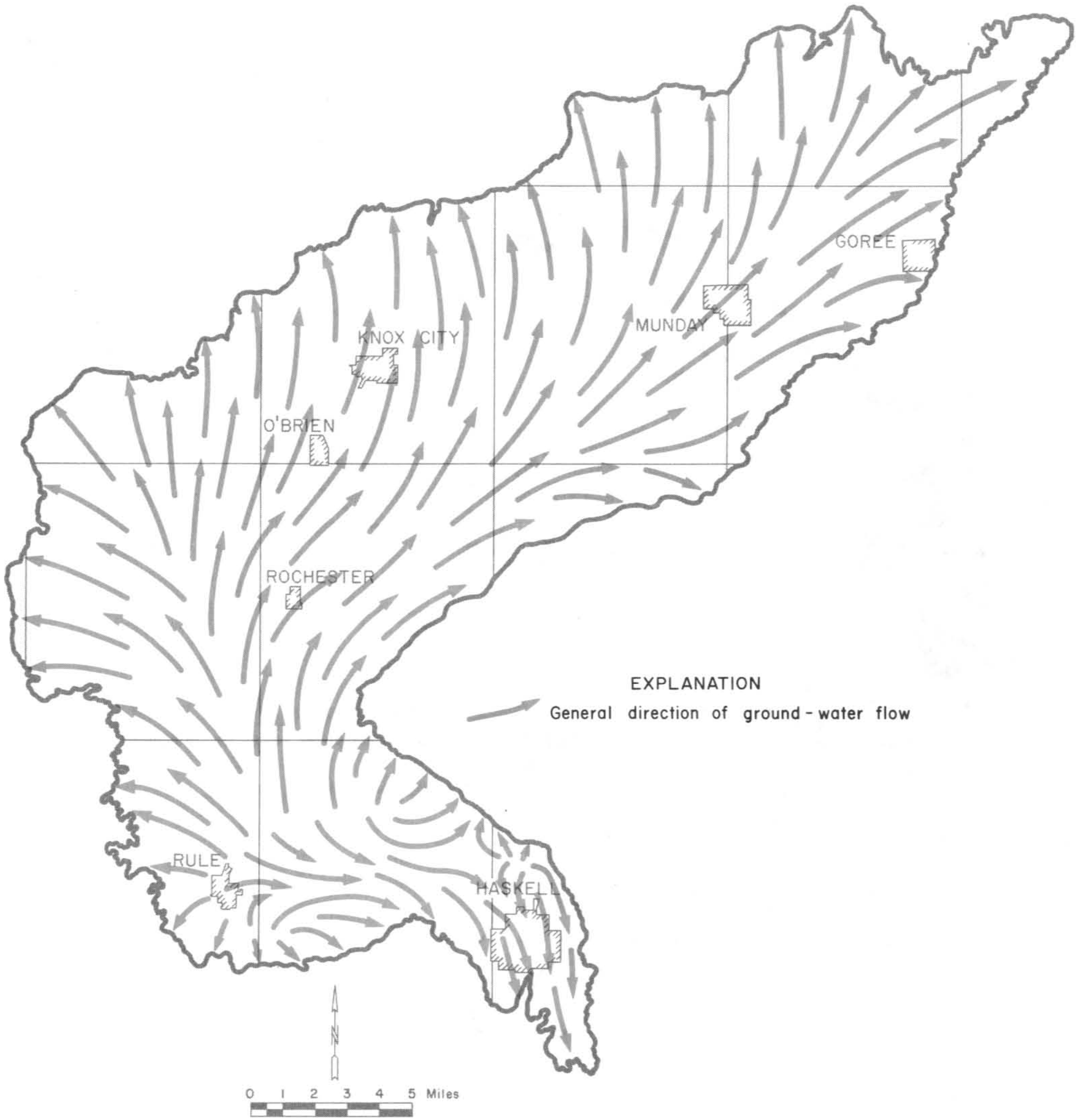


Figure 31. Direction of Ground-Water Flow in Seymour Aquifer

Table 5. Results of Power Tests

Well Number	Type of Discharge*	Pumping Rate (gpm)	Gallons Per Unit of Power (gal/kwh)
RS 21-27-804 RS 21-27-806	Open	289	2,173
RS 21-28-723	Open	102	1,545
RS 21-28-834	Open	273	2,647
RS 21-33-939	Open	609	1,934
RS 21-34-211	Open	80	988
RS 21-34-322	Sprinkler	152	1,707
RS 21-34-443 RS 21-34-444	Sprinkler	175	531
RS 21-34-533	Sprinkler	155	931
RS 21-34-622	Open	335	1,801
RS 21-34-920	Open	98	1,690
RS 21-34-929	Open	128	2,331
RS 21-35-130	Open	382	3,937
RS 21-35-318	Open	330	2,377
RS 21-35-342	Open	63	1,280
RS 21-35-547	Open	58	308
RS 21-35-548	Open	120	2,352
RS 21-35-720	Open	125	1,113
LP 21-35-734	Sprinkler	330	955
RS 21-36-201	Open	276	2,642
RS 21-36-217 RS 21-36-231	Open	385	2,094
RS 21-36-225	Open	258	3,690
RS 21-36-417	Open	360	2,254
RS 21-36-434	Open	30	1,323
RS 21-36-524	Open	178	2,918
LP 21-41-107	Open	514	3,274
LP 21-41-321	Sprinkler	215	622
LP 21-41-328	Sprinkler	258	629
LP 21-41-401	Sprinkler	256	1,113
LP 21-41-416	Sprinkler	95	657
LP 21-41-608	Open	710	2,360
LP 21-41-625	Sprinkler	347	895
LP 21-41-910	Sprinkler	196	652
LP 21-41-916	Sprinkler	134	672
LP 21-41-922	Sprinkler	104	452
LP 21-42-229	Sprinkler	222	1,116
LP 21-42-245	Sprinkler	185	814
LP 21-42-250	Open	370	3,519
LP 21-42-313 LP 21-42-336	Open	387	3,521
LP 21-42-334	Open	242	3,142
LP 21-42-425	Sprinkler	280	1,328
LP 21-42-516	Sprinkler	242	938
LP 21-42-524	Sprinkler	769	3,387
LP 21-42-710	Sprinkler	167	428
LP 21-50-559	Sprinkler	67	593
LP 21-50-652 LP 21-50-653 LP 21-50-654	Open	429	3,351

*Open refers to row irrigation.

As a follow-up to the two-day investigation, Bandy and others inventoried wells in northwestern Haskell County about a month later. Their original notes contain numerous reports of early water levels together with water-level measurements taken in 1934. The exact location of the wells could not be determined during the present investigation, but the records indicate generally the water-level rises occurring in the vicinity of O'Brien and Rochester prior to 1934.

Figure 32 summarizes the data reported by Bandy's survey. The records indicate large water-level rises prior to the mid-1930's. Mainly, the cultivation of the land caused the rising water levels. Prior to cultivation, the area was covered with tall, thick native grasses. Cultivation increased the recharge to the Seymour by decreasing the amount of water lost formerly by evapotranspiration, especially during the growing season of April through October when a large part of the precipitation occurs. Other factors which contributed to the increase in recharge were row-cropping which leaves a large percentage of the sandy soils exposed and contour farming. In more recent times, additional contributing factors have included terracing which has been a common practice in the area since the 1940's, land leveling, and deep plowing. All of these activities, in conjunction with the presence of sandy soils, have increased infiltration to the ground-water reservoir.

Available records indicate that water levels in the Seymour continued to rise during the 1940's, but only slightly. Since the 1950's, water levels have fluctuated in response to pumpage and precipitation cycles.

Average water levels for all Seymour observation wells are summarized for Haskell and Knox Counties on Figure 33. The graphs indicate that beginning in the early 1950's, water levels declined substantially due to drought conditions and the increase in irrigation withdrawals. The average water level in Knox County has changed little during the last 10 years. Water levels in Haskell County have risen substantially over the same time period. The average rise has been approximately 7 feet.

Tables 12 and 13 give past water-level measurements in observation wells. Hydrographs for individual observation wells at representative locations in the Seymour aquifer are shown on Figures 34 and 35. The hydrographs indicate the water-level fluctuations which have occurred in each area. Water levels in the Goree, Munday, and Haskell areas have changed little over the past 5 years. The largest water-level rises in the past decade have been in the Rochester, Rule, and O'Brien areas. The past 5- to 10-year period has been a period of above average precipitation and slightly lower than average ground-water pumpage.

Figure 36 shows the change in water levels from the winter of 1956–1957 to the winter of 1976–1977. Over this 20-year period, a net water-level decline occurred in most wells located to the northeast of a line approximately mid-

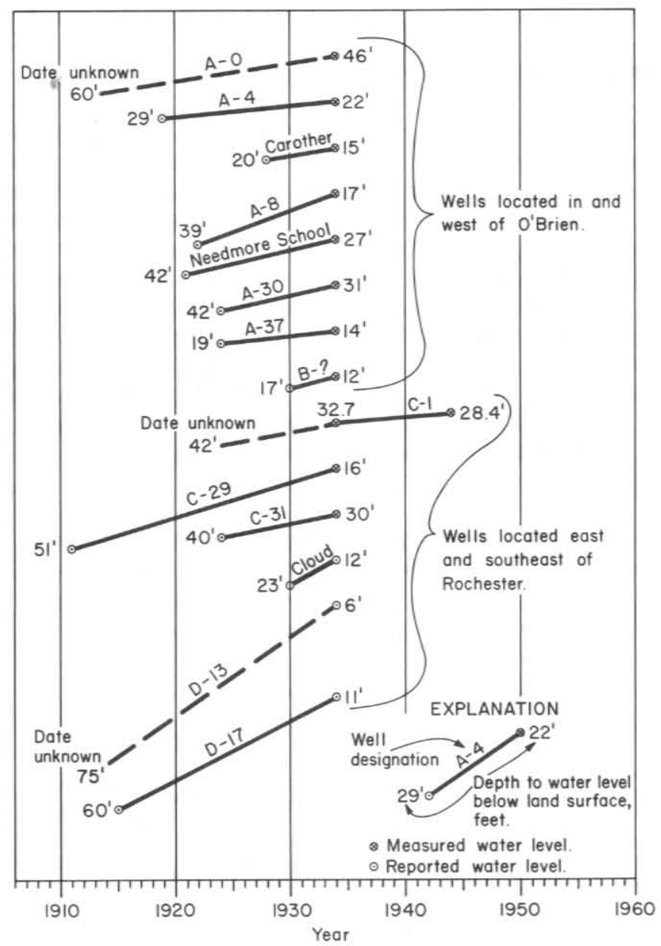


Figure 32. Reported Water-Level Rises in Seymour Aquifer

way between Knox City and Munday. Generally, substantial water-level rises have occurred in those wells located to the southwest of this line. Net water-level declines have averaged approximately 4 feet in the Munday and Goree area over the past 20 years. Water-level rises have averaged 4 to 10 feet over the same period in various areas between Knox City and Haskell.

Areas marked by water-level rises outnumber areas where water-level declines have occurred, and a significant amount of water has been added to storage in the aquifer. It is estimated that the volume of water in storage increased by about 113,000 acre-feet from 1956 to 1976.

Availability of Water

For the 20-year period 1957–1976 inclusive, pumpage from the Seymour totaled approximately 902,000 acre-feet, plus an additional small amount by domestic and livestock wells. Water levels during the same period rose in the southwestern part of the aquifer and declined in the northeastern part. On balance, it is estimated that storage increased in the aquifer by about 113,000 acre-feet. Thus, about 1,015,000 acre-feet was available for pumping over the 20-year period without a change in storage in the aquifer. This amount is equivalent to slightly more than 50,000 acre-feet per year.

Precipitation was above average at Munday and Haskell for the period 1957–1976 and accordingly, recharge to the Seymour was also above average. The precipitation averaged about 26.3 inches for the period, in comparison to a long-term average of 24.5 inches. Proportionally, it is estimated that an average of about 47,000 acre-feet per year is available for pumping from the Seymour under average precipitation conditions.

Quality of Water

All ground water contains dissolved minerals. The concentration and type of constituents present depend on the source of the water and the details of the surface and subsurface environments through which the water has traveled. The chemistry of ground water can be complex.

Essentially, all fresh ground water originates as precipitation which is relatively free of dissolved minerals. When precipitation strikes the ground, it comes in contact with many different soluble materials. The types of soluble materials at the land surface and in the subsurface control the amount of mineral matter incorporated by the water. Time and temperature are important also in determining which minerals are dissolved by water. In addition, the activities of man, particularly waste disposal, can have important effects on ground-water quality.

Dissolved minerals in water may be beneficial, undesirable, or even harmful. For this reason, it is important to know the kinds and amounts of dissolved minerals present in a ground-water supply, and how they effect the water's use.

1975–1977 Sampling Program

To define the existing chemical content of water from the Seymour aquifer, over 1,100 water samples were collected from wells and springs during 1975–1977; most were collected in 1976. Samples were obtained from all municipal wells, from approximately one-third of the existing irrigation wells, and from 247 domestic and stock wells. In selecting wells for sampling, consideration was given to obtaining a representative areal distribution. Also, efforts were made to resample, if possible, all wells which had been sampled previously in order to detect changes in chemical quality. The results are included in Tables 14, 15, and 16.

About 200 samples were obtained for special constituents or from special sources. The results of these analyses are given in Tables 17 through 27.

Laboratories

The laboratory of the Texas Department of Health performed all chemical analyses in accordance with Environmental Protection Agency standards (U.S. Environmental Protection Agency, 1974). Relatively complete chemical analyses were made on approximately 70 percent of the samples. The constituents determined included silica, calcium, magnesium, sodium, bicarbonate, sulfate, chloride, fluoride, nitrate, dissolved solids (calculated), total hardness, specific conductance, and pH. Partial chemical analyses were made on about 20 percent of the samples. Typically, these analyses included specific conductance, chloride, sulfate, nitrate, and fluoride determinations. Determinations of special constituents including pesticides, oil and grease, nitrite, nitrogen cycle, boron, iron, and potassium were made also by the Texas Department of Health's laboratory in Austin. Forty-one samples were submitted to the Bureau of Economic Geology of the University of Texas for nitrogen isotope determination. Techniques described by Kreitler (1975) were used.

Sample Collection, Preservation, and Methodology

Irrigation wells and public supply wells were sampled as close to the pump discharge manifold as possible. The wells were sampled a few minutes after commencement of pumping or soon after arrival if the wells were pumping already. Usually, domestic and stock wells were sampled from pressure tanks. Typically, specific conductance was measured in the field repeatedly during pumping and prior to sampling to determine if water quality variations occurred with pumping time and to preclude sampling until uniform quality was obtained from the well. Only on rare occasions was there any difference between specific conductance measurements taken seconds after commencing pumping and those taken later.

Early in the investigation, duplicate samples were obtained from 27 wells distributed over the project area. One set of samples was refrigerated and delivered to the laboratory. The other set was not cooled. Results of complete analyses on both sets indicated no significant difference in the results of the two sets of samples. Because of these findings and recommendations from the laboratory, all later samples for complete or partial chemical analyses were collected, kept at room temperature, and delivered to the laboratory weekly. Sampling and preservation techniques used for all samples are summarized in Table 6.

Special sampling was done to assist in interpreting the results of past analyses and to learn of natural variations in the formation. Samples were bailed from selected wells from near the total depth of the well and from just below the static water level using a Kemmerer bailer. The results of these analyses are given in Table 19. The bailed samples indicate little stratification of the water in the formation, except in those wells affected by oil field brines.

For several wells, a series of consecutive samples was obtained on start-up directly from open discharge. As shown in Table 20, the results of the consecutive samples show no significant variation in water quality after the first 10 to 20 seconds of pumping.

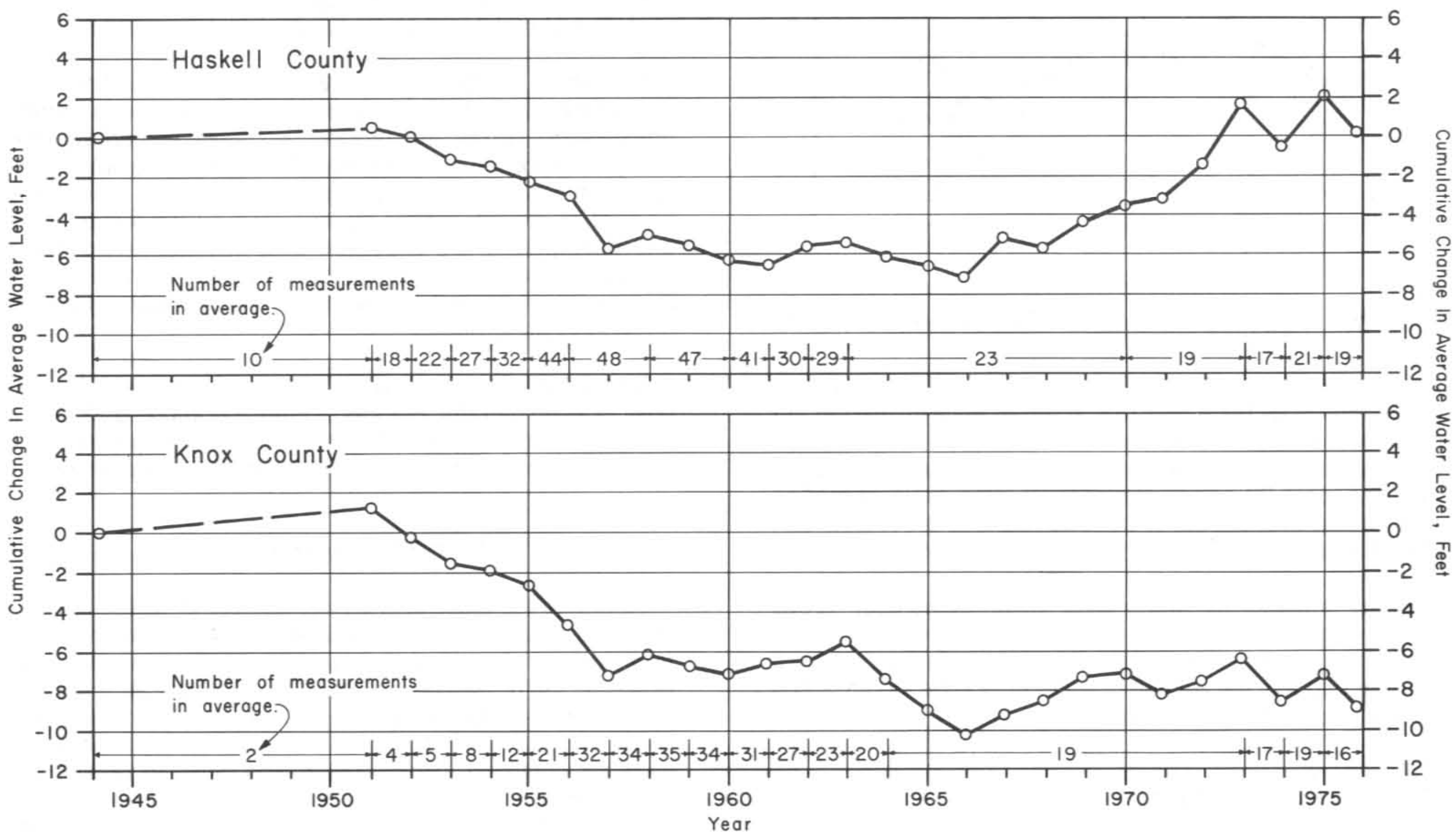


Figure 33. Cumulative Change in Average Water Levels, 1944–1976

Previous Sampling Programs (1907–1974)

As a part of the current study, a careful search was made for past chemical analyses of Seymour water. The files of the Texas Department of Water Resources (and predecessor agencies), the U.S. Geological Survey, the Texas Railroad Commission, and the Texas State Department of Health yielded the most analyses. Accurate well locations for over 1,100 previous chemical analyses were determined in the field. These analyses are included in Tables 14, 15, and 16.

Figure 37 shows the distribution through time of the available chemical analyses on water samples collected since 1907. The earliest years for which more than a few chemical analyses are available are 1936, 1944, and 1956. Only two analyses are available before 1936, and only a few are available in any of the years from 1937 to 1944 or from 1945 to 1956. Between 1960 and 1972, a large number of analyses were made by the Texas Railroad Commission, and most consisted of chloride determinations only.

Approximately 180 of the past analyses were made by the U.S. Geological Survey, over 100 by the Texas Department of Health, approximately 700 by the Texas Railroad Commission, and approximately 160 by various private laboratories and Texas A&M University.

The methods of analysis used by the Texas Department of Health and the U.S. Geological Survey are considered approximately equal in precision and satisfactory for most purposes. The precision of the analyses and the techniques

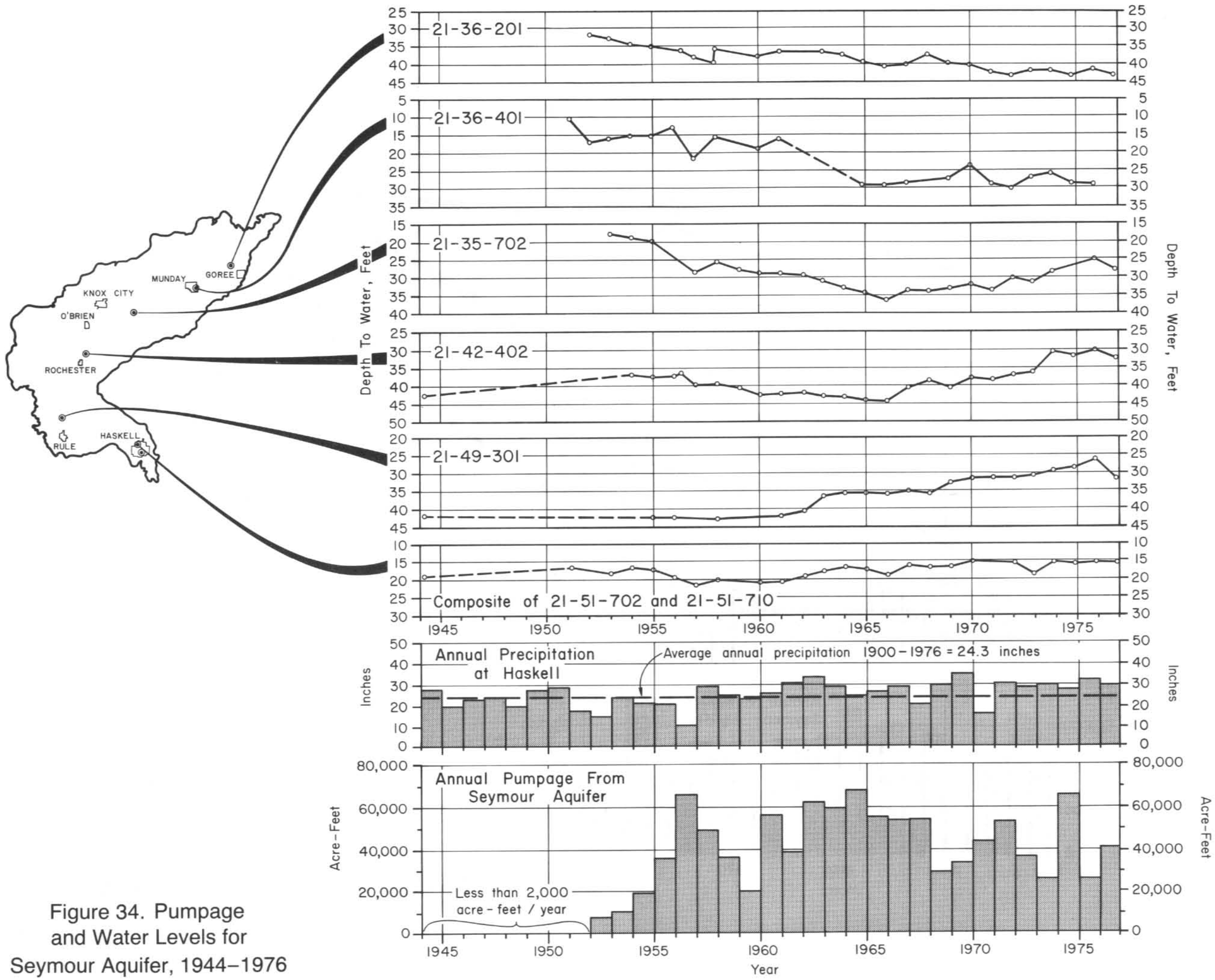


Figure 34. Pumpage and Water Levels for Seymour Aquifer, 1944–1976

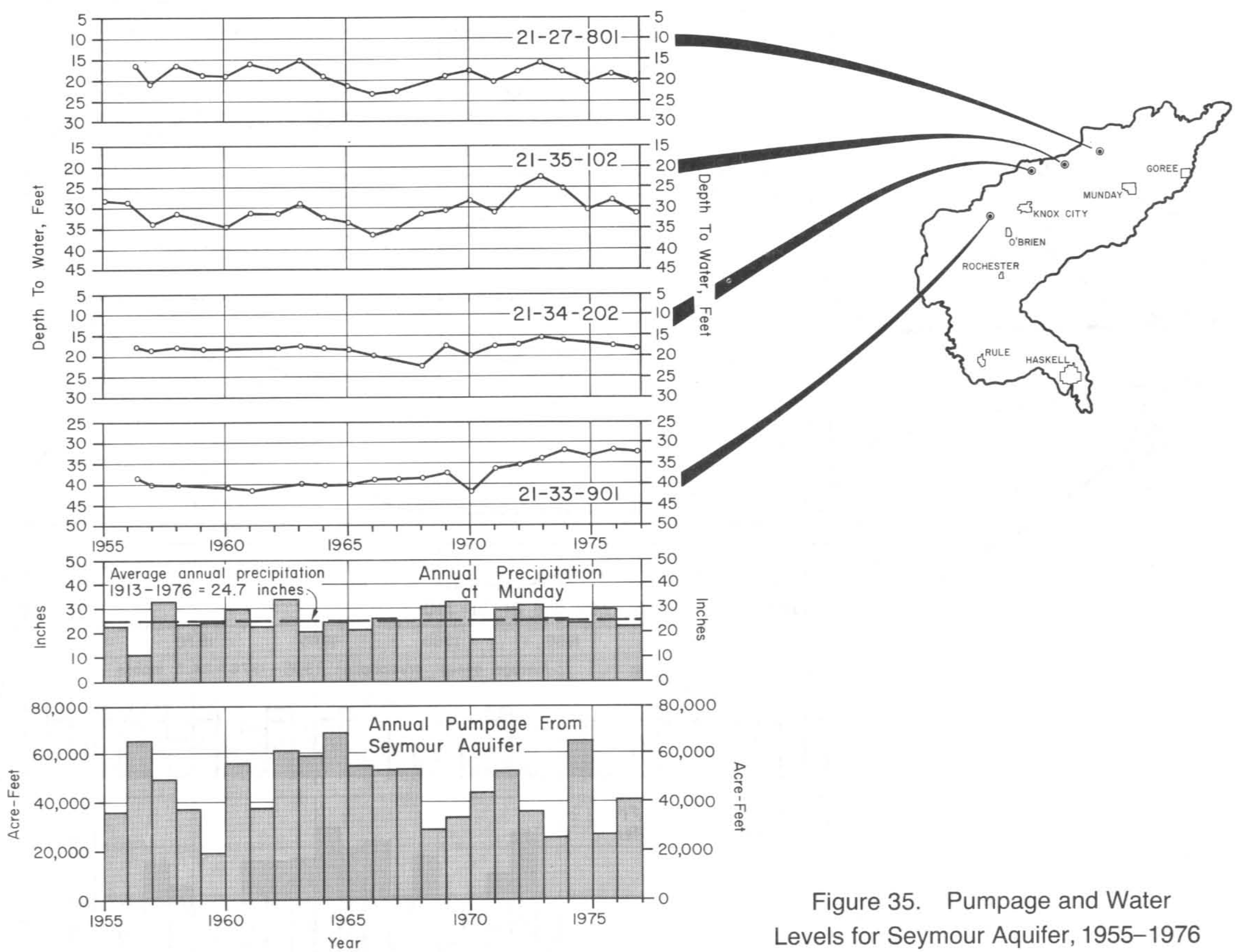


Figure 35. Pumpage and Water Levels for Seymour Aquifer, 1955–1976

Figure 36. Change in Water Levels, 1956–1976

used by the private laboratories and Texas A&M were not investigated. The chloride analyses by Texas Railroad Commission personnel were made using techniques that are not as precise as the techniques used for those samples analyzed by laboratories of the Texas Department of Health or the U.S. Geological Survey. The Railroad Commission analyses were made normally to detect large differences in chloride concentration or particularly high values. They are satisfactory for these purposes, but not for detailed comparisons with other chloride analyses. From a review of the methods used by Railroad Commission personnel and from studying the analyses, it appears that the results are accurate generally within approximately 50 milligrams per liter (mg/l) for chloride concentrations up to approximately 1,000 mg/l.

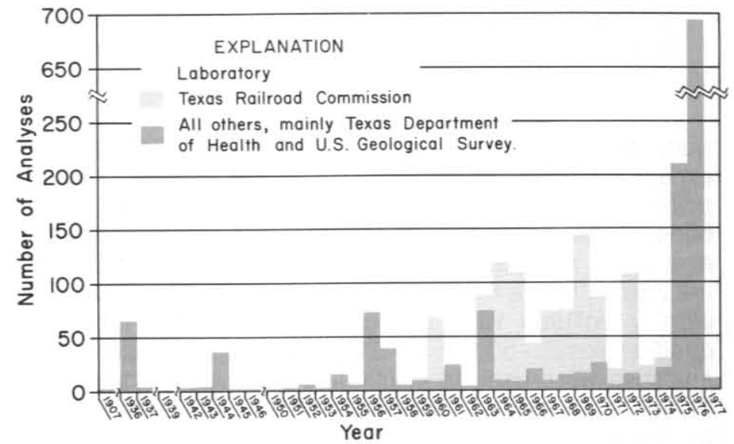


Figure 37. Available Chemical Analyses

Chemical Content of Water

The water in the Seymour Formation is characterized by a wide variability in quality. Large differences in chemical quality occur in adjacent wells. Also, there is a large difference between those areas having the best quality and those having the worst quality. The variance in water quality is due to the wide range in geologic and hydrologic conditions in the Seymour.

The sources, significance, and representative values of selected chemical constituents and properties of Seymour water are summarized in Table 7. Tables 14, 15, and 16 give the results of all complete and partial analyses on wells and springs. A series of water quality maps (Figures 38, 39, 40, 43, 44, and 45) summarize the dissolved solids, chloride, sulfate, nitrate, fluoride, silica, bicarbonate, calcium, magnesium, and sodium content of water from wells tapping the Seymour. The maps are based on the analyses of samples collected during 1975–1977. The maps include averages of the data by small areas. The averages are calculated for individual 2½-minute quadrangles or for combinations of 2½-minute quadrangles. The averages include all the ana-

Table 6. Water Sampling and Preservation

Type Sample	Method Sampled	Sample Container	Fixing Agent	Cooled To 4°C
Complete water analyses	Pumped	1-liter plastic	None	No
Partial water analyses	Pumped	1-liter plastic	None	No
Nitrogen cycle	Pumped	1-liter glass	H_2SO_4	Yes
Nitrogen isotope	Pumped	1-liter glass	None	Yes
Bailed	Kemmerer bailer	1-liter plastic	None	No
Pesticides	Pumped	1-liter glass w/Teflon lid	None	No
Oil and grease	Pumped	1-liter glass	H_2SO_4	Yes
Oil field brine	Storage tank valve	1-liter plastic	None	No
Consecutive from pumping wells	Pumped	1-liter glass	None	No
Formation extracts	Filtered	1-liter plastic	None	No
Creeks	Grab	1-liter plastic	None	No
Sewage effluent:				
a) Nitrogen cycle	Grab	1-liter glass	H_2SO_4	Yes
b) Complete water analysis	Grab	1-liter plastic	None	No

lyses available on samples obtained during 1975–1977, except for those analyses showing the effects of nitrate pollution from septic tanks or chloride pollution from oil field brine. These analyses, if recognizable, were omitted in averaging, so that the averages would better approximate the typical, native mineral content of the Seymour water. To identify polluted wells is not difficult except in parts of quadrangles 21–50 and 21–51. In these quadrangles, all the analyses were used in calculating the average data, even though some of the analyses probably indicated pollution from oil field brine.

The following sections of the report summarize the occurrence and concentrations of the principal constituents in Seymour water. The water quality maps portray the data in a graphic manner. For the exact results of individual analyses or for detailed studies of local areas, see Tables 14, 15, and 16.

Dissolved Solids Content

Figure 38 summarizes the dissolved solids content of the Seymour water based on the 1975–1977 analyses. The dissolved solids content was not determined in the laboratory. It represents a calculated sum based on complete analysis of each water sample. For those samples having only partial analyses, the dissolved solids content, as shown on Figure 38, was estimated based on correlation of specific conductance with the calculated dissolved solids content of complete analyses.

The dissolved solids content of water from individual wells ranges from a low of 300 mg/l to over 3,000 mg/l. Most values are between 400 and 1,000 mg/l. Areas having the lowest dissolved solids content are principally in the western part of the area. They coincide with the significant recharge areas having sandy soils as indicated on the soil map (Figure 28).

Areas where the Seymour water contains higher dissolved solids content are in the vicinity of Munday, in an area extending northwest from Haskell, and in a small area west of Knox City. Numerous values are between 1,500 and 3,000 mg/l. Other scattered localities exist where the dissolved solids content is in excess of 1,500 mg/l. They are mostly outside the area of more significant recharge. Some of the localities having higher mineralization are affected by pollution from oil field brine, but most represent natural occurrences of more mineralized water.

Chloride Content

The chloride content of water from the Seymour aquifer varies within wide limits. Figure 39 summarizes the available analyses for samples collected during 1975–1977. The chloride content of water from individual wells ranges from less than 10 mg/l, for a few wells north of Rule, to over 750 mg/l. For approximately 75 percent of the wells sampled, the chloride content is less than 250 mg/l. The lowest chloride values are in the same areas having the lowest dissolved solids values. The highest values are in the vicinity of Haskell, in several areas in the general vicinity of Munday, and at a few scattered localities. Some of the higher chloride values represent natural mineralization in the Seymour or possibly the effect of Permian inflow. Others represent pollution from oil field brine or septic tanks.

Sulfate Content

Sulfate content for individual wells ranges from less than 20 mg/l to over 1,000 mg/l (Figure 40). About 75 percent of the analyses indicate water containing less than 250 mg/l. The regional sulfate distribution is similar to that of dissolved solids and chloride. Some of the wells, exhibiting water with sulfate contents in excess of 500 mg/l, are believed to draw from both the Seymour and underlying Permian deposits or to be in areas where the Permian may be leaking into the Seymour aquifer.

Chloride/Sulfate Ratio

Figure 41 shows the average ratio of chloride to sulfate content by area. The average ratio is near 1 for large areas of the Seymour, even though average chloride and sulfate concentrations vary widely from areas of lower to areas of higher mineralized water. The average chloride/sulfate ratio tends to be significantly less than 1 in recharge areas where overall mineralization is low and also in areas where Permian formations are believed to contribute to the Seymour. The average chloride/sulfate ratio is considerably greater than 1 only in quadrangles 21–50 and 21–51.

The chloride/sulfate ratio is a useful indicator of pollution from oil field brines because oil field brines have very high chloride content relative to sulfate content. Consequently, the mixture of even small quantities of oil field brine with natural water results in a significant increase in the chloride/sulfate ratio. For individual wells and springs showing effects of pollution from oil field brines, the chloride/sulfate ratio ranges from about 1.3 to over 35; values of 2 to 10 are common.

The chloride/sulfate ratio is also an indicator of the influence of Permian water. Chloride/sulfate ratios are low for Permian waters which are high in sulfate content. Mixture of such waters with Seymour water results in low chloride/sulfate ratios. Individual wells believed to be drawing from both the Permian and Seymour typically have chloride/sulfate ratios of less than 0.3 and higher chloride and sulfate content than normal for a local area.

Nitrate Content

Nitrogen occurs in most natural waters predominantly as nitrate. Sometimes nitrogen is present in water in other forms including ammonia, nitrite, and organic nitrogen. To check Seymour waters for the occurrence of nitrogen in forms other than nitrate, 20 samples were collected for nitrogen cycle analyses. The results, shown in Table 24, indicate that the nitrogen present is in the form of nitrate except in some wells which exhibit small amounts of nitrite.

Nitrate and nitrite analyses were performed on most all of the water samples collected during 1975–1977. Of 898 analyses, 744, or 83 percent, had nitrite contents of 0.06 mg/l or less. The results of the analyses showing more than 0.06 mg/l nitrite are listed in Table 25 together with nitrate results. Some nitrite values are as high as 15 mg/l, but most are less than 1 mg/l. All wells showing values of more than 1 mg/l are irrigation wells or domestic or stock wells of large diameter. No values larger than 0.06 mg/l were reported for any of the public supply wells.

Table 7. Representative Values, Sources, and Significance of Selected Chemical Constituents and Properties of Seymour Water

Constituent or Property	Representative Value	Source or Cause	Significance
Silica	18–35 mg/l	Dissolved from most all rocks and soils, commonly less than 30 mg/l.	Forms hard scale in pipes and boilers. Carries over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron	Typically < 0.2 mg/l	Dissolved from most all rocks and soils. May be derived also from iron pipes, pumps, and other equipment.	On exposure to air, oxidizes to reddish-brown precipitate. More than about 0.3 mg/l stains laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. Texas Department of Health (1977) drinking water standards recommend that iron not exceed 0.3 mg/l. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium and Magnesium	50–220 mg/l 10–110 mg/l	Dissolved from most all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; prevent formation of soap lather (see Hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium and Potassium	40–350 mg/l 3–10 mg/l	Dissolved from most all rocks and soils. Found also in oil field brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. High sodium content may limit the use of water for irrigation.
Bicarbonate	300–450 mg/l	Caused by action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Produces alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon-dioxide gas. In combination with calcium and magnesium, causes carbonate hardness.
Sulfate	35–500 mg/l	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Present in some industrial wastes.	In water containing calcium, forms hard scale in steam boilers. In large amounts in combination with other ions, gives bitter taste to water. Texas Department of Health (1977) drinking water standards recommend that the sulfate content not exceed 300 mg/l.
Chloride	20–675 mg/l	Dissolved from rocks and soils. Present in sewage and found in large amounts in oil field brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. Texas Department of Health (1977) drinking water standards recommend that chloride content not exceed 300 mg/l.
Fluoride	0.3-2.4 mg/l	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	In drinking water, reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, may cause mottling of the teeth depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual (Maier, 1950). Texas Department of Health (1977) drinking water standards set a maximum limit of 1.6 mg/l for Haskell and Knox Counties.
Nitrate	20–120 mg/l	Derived from soil, fertilizers, sewage, and decaying organic matter.	Concentration much greater than the local average may suggest pollution. Texas Department of Health (1977) drinking water standards set a maximum limit of 45 mg/l. Waters of high nitrate content have caused methemoglobinemia (a sometimes fatal disease in infants) and therefore should not be used in infant feeding (Maxcy, 1950). Encourages growth of algae and other organisms which produce undesirable tastes and odors.
Boron	Typically < 1.0 mg/l	A minor constituent of rocks and of natural waters.	Excessive amount will make water unsuitable for irrigation. Wilcox (1955) indicated that a boron concentration of as much as 1.0 mg/l is permissible for irrigating sensitive crops; as much as 2.0 mg/l for semitolerant crops; and as much as 3.0 mg/l for tolerant crops. Crops sensitive to boron include most deciduous fruits and nut trees and navy beans; semitolerant crops include most small grains, potatoes and some other vegetables, and cotton; and tolerant crops include alfalfa, most root vegetables, and the date palm.
Dissolved Solids	440–2,000 mg/l	Chiefly mineral constituents dissolved from rocks and soils.	Texas Department of Health (1977) drinking water standards recommend that dissolved solids not exceed 1,000 mg/l.
Total Hardness as $CaCO_3$	250–800 mg/l	In most waters, nearly all the hardness is due to calcium and magnesium.	Consumes soap before a lather can form. Causes soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Waters of hardness up to 60 mg/l are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, very hard.

Table 7. Representative Values, Sources, and Significance of Selected Chemical Constituents and Properties of Seymour Water—Continued

Constituent or Property	Representative Value	Source of Cause	Significance
Specific Conductance	700–2,900 mmhos/cm at 25°C (mmhos/cm)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
pH (hydrogen ion concentration)	7.1–8.0	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. Generally, corrosiveness of water increases with decreasing pH. However, excessively alkaline waters may also attack metals.
Percent Sodium	30–60 percent	Sodium in water.	A ratio (using equivalents per million) of the sodium ions to the total sodium, calcium, and magnesium ions. A sodium percentage exceeding 50 percent is a possible indication of a sodium hazard. Continued irrigation with this type of water may impair the tilth and permeability of the soil.
SAR (sodium adsorption ratio)	Typically < 10	Sodium in water.	A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil (U.S. Salinity Laboratory Staff, 1954). Defined by the following equation: $SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$ where Na^+, Ca^{++}, and Mg^{++} represent the concentrations in milliequivalents per liter (meq/l) of the respective ions. Used in conjunction with specific conductance to evaluate waters for irrigation purposes.
RSC (residual sodium carbonate)	Typically < 1.25 meq/1	Sodium and carbonate or bicarbonate in water.	As calcium and magnesium precipitate as carbonates in the soil, the relative proportion of sodium in the water is increased (Eaton, 1950). [Defined by the following equation: $RSC = (CO_3^{--} + HCO_3^-) - (Ca^{++} + Mg^{++})$ where CO_3^{--}, HCO_3^-, Ca^{++}, and Mg^{++} represent the concentrations in milliequivalents per liter (meq/l) of the respective ions.] Used to evaluate waters for irrigation purposes.

Note: Explanations modified from Klemt, et al (1976)

The measurable nitrite values are believed to result from organic matter in the wells creating an environment conducive to the reduction of nitrate in and near the well bore to nitrite. Very low nitrite values are indicated for wells protected from surface contamination and runoff.

Figure 43 summarizes the nitrate content based on the 1975–1977 analyses. The nitrate content for individual wells ranges from 8 mg/l to 935 mg/l. Most values are between 30 and 90 mg/l. The average nitrate content for 2½-minute quadrangles is between 40 and 70 mg/l, generally. The highest nitrate values, which occur mostly in parts of quadrangles 21-50 and 21-51, average between 111 and 154 mg/l.

There are 23 widely-scattered domestic and stock wells which show nitrate contents in excess of 150 mg/l. These wells represent approximately 9 percent of the domestic and stock wells sampled during this investigation. Of the 23 wells, nine wells have nitrate contents between 150 and 200 mg/l, eight between 200 and 300 mg/l, five between 300 and 400 mg/l, and one has 935 mg/l. It is believed that all are affected by septic tank, barnyard, or similar wastes.

Only a few irrigation wells in the Haskell area in quadrangles 21-50 and 21-51 show nitrate contents in excess of 150 mg/l. The highest nitrate contents for irrigation wells, outside of the Haskell area, range from approximately 90 mg/l to 130 mg/l.

Nitrate values for wells furnishing municipal needs have the following ranges:

	Number of Wells	Range in Nitrate Content (mg/l)
Aspermont	3	56-57
Benjamin	2	41-51
Goree	3	40-53
Haskell	11	71-148
Knox City	3	75-78
Munday	4	50-60
O'Brien	1	118
Rochester	1	63
Rule	4	40-73
Weinert	2	50-52

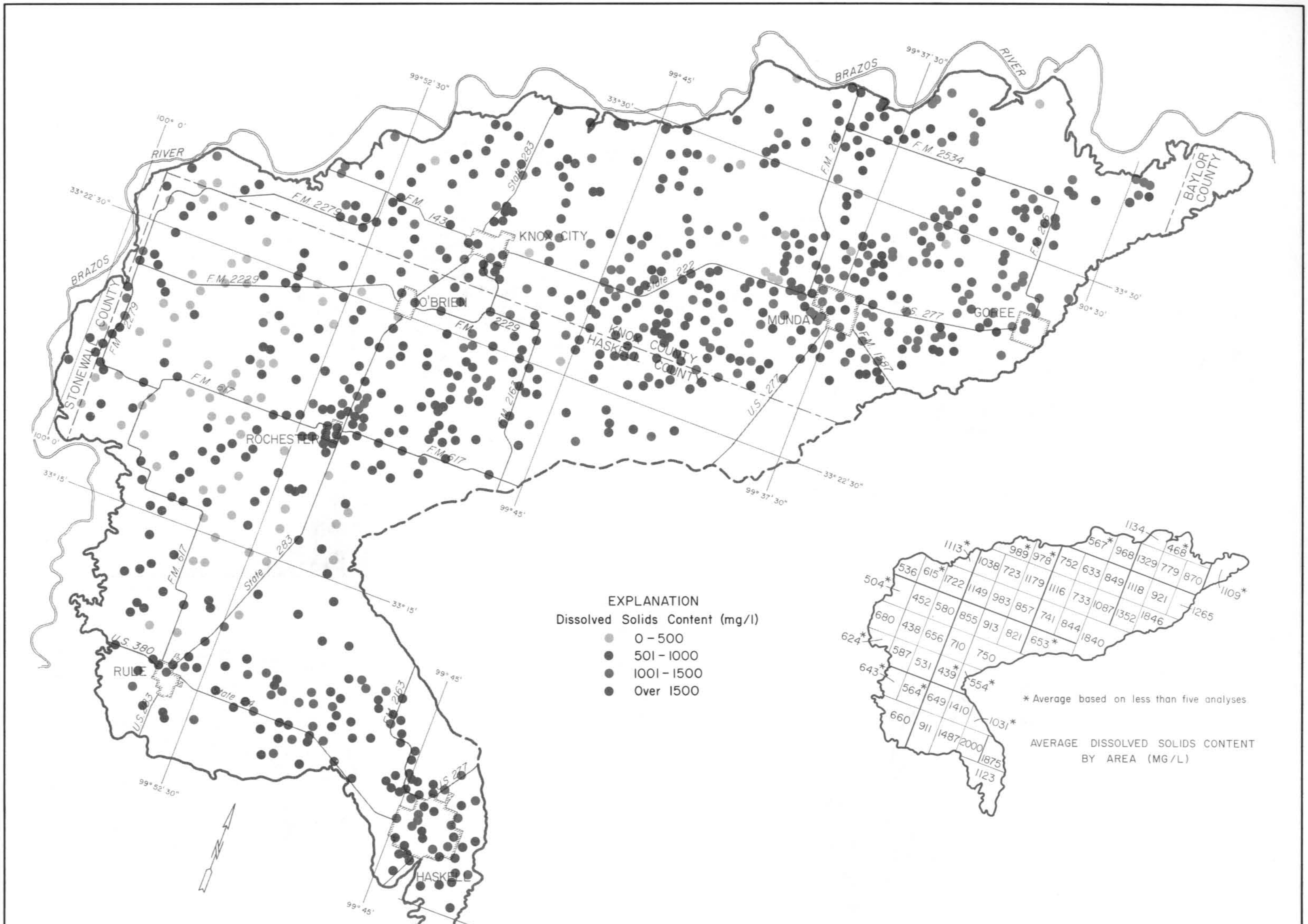


Figure 38. Dissolved Solids Content of Water From Seymour Aquifer, 1975–1977

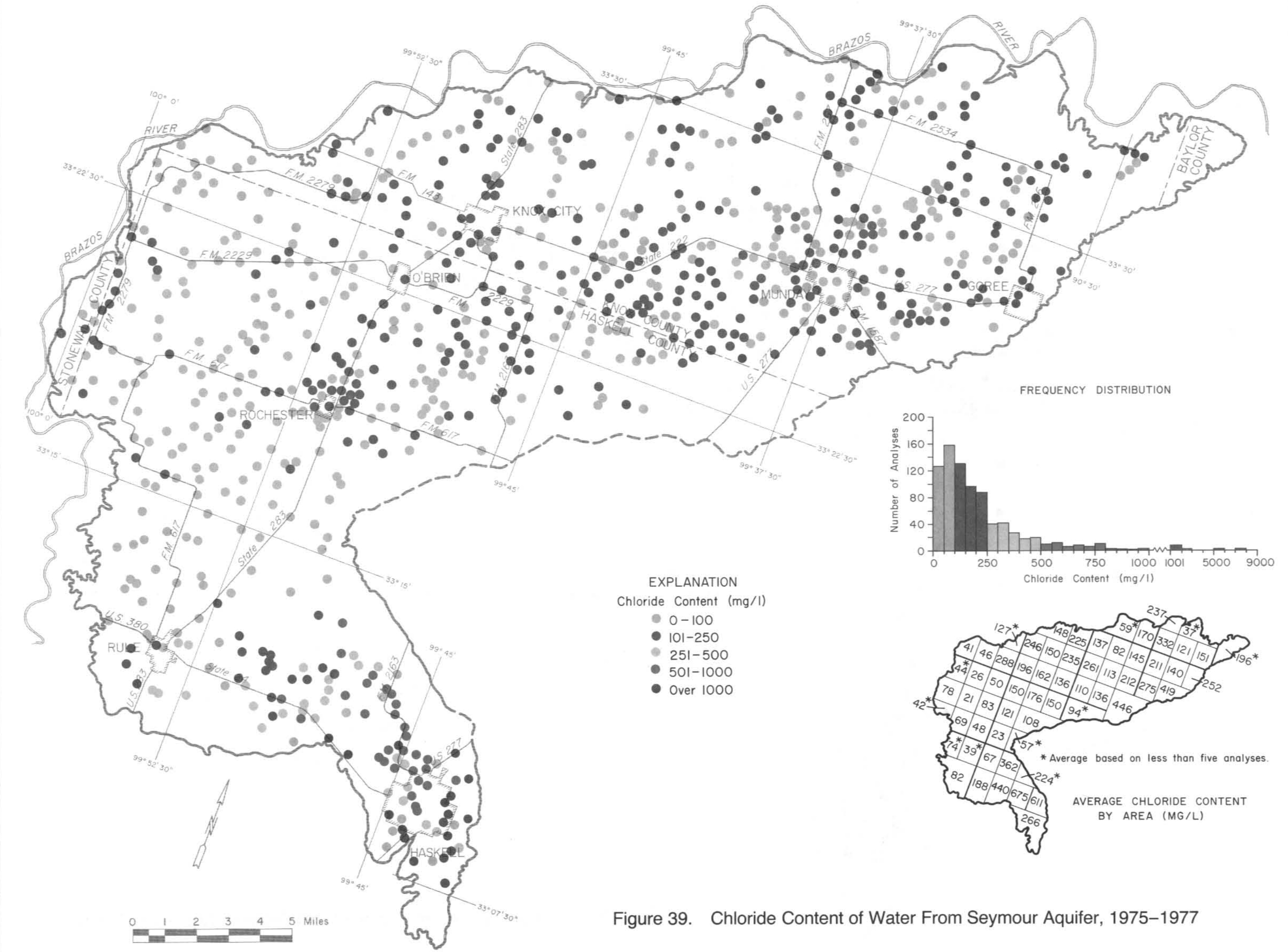


Figure 39. Chloride Content of Water From Seymour Aquifer, 1975–1977

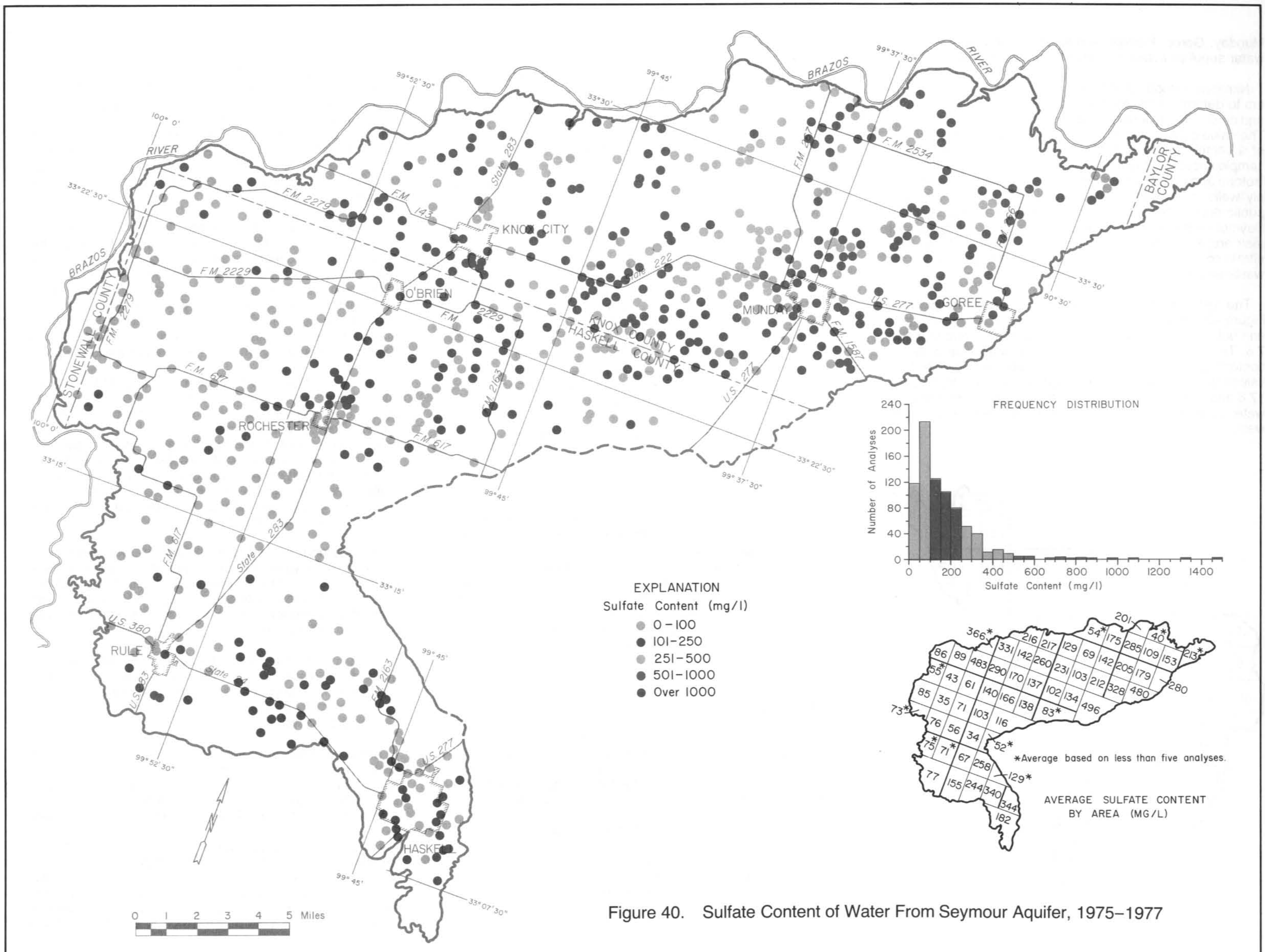


Figure 40. Sulfate Content of Water From Seymour Aquifer, 1975–1977

Munday, Goree, Haskell, and Knox City will have alternate water supplies available from Millers Creek Reservoir.

Nitrogen isotope values have been used by various workers to determine the source of nitrate in natural water (Kohl and others, 1971; Jones, 1973; and Kreitler, 1975 and 1978). The value determined is del N15 which is a ratio of N15/N14 of a sample to the N15/N14 of a standard. Ground-water samples from 37 Seymour wells were subjected to nitrogen isotope analysis. Samples were obtained from 6 public supply wells, 16 irrigation wells, and 15 domestic wells. The public supply and irrigation wells were scattered over the Seymour aquifer and contained nitrate contents typical for their areas. All domestic and stock wells sampled had high nitrate contents, indicating pollution from domestic or animal waste sources.

The results of the nitrogen isotope analyses are given in Figure 42 and in Table 18. The del N15 values for irrigation and public supply wells range from 2.6 to 11.4 and average 7.6. These values are within the range indicative of water containing nitrate derived from cultivated soils. The del N15 values for the 15 domestic and stock wells range from 7.3 to 17.6 and average 10.9. This is within the range indicative of water containing nitrate derived from domestic and animal wastes.

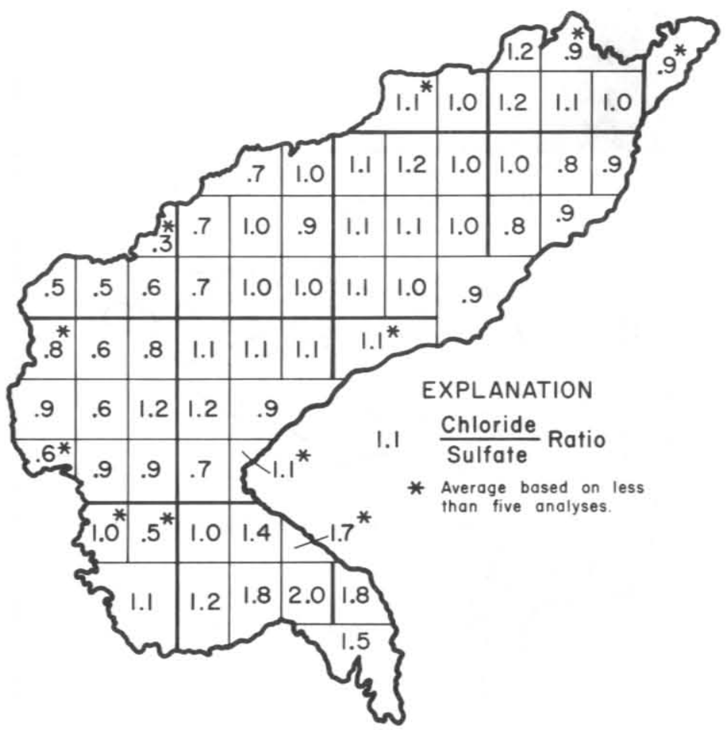


Figure 41. Average Chloride/Sulfate Ratio by Area

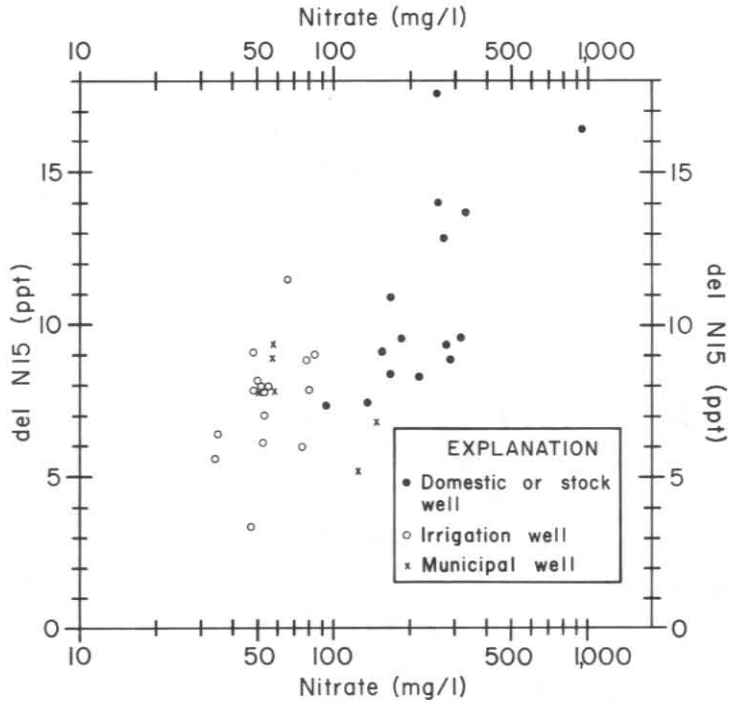


Figure 42. Nitrate vs. del N15 Analyses

Fluoride Content

Figure 44 summarizes the fluoride content of the Seymour water based on the 1975–1977 analyses. The fluoride content for individual wells ranges from 0.2 to more than 3.5 mg/l. Most values are between approximately 0.4 and 2.0 mg/l. Approximately 70 percent of the analyses indicate water containing less than 1.6 mg/l. The lowest values are typically in the Rule-Rochester area. Generally, the higher values are at scattered locations or in quadrangles near the edge of the aquifer including 21-29-4, 21-34-3, 21-34-6, 21-36-3, and 21-51-7.

Other Constituents

The average silica, bicarbonate, calcium, magnesium, and sodium contents of Seymour water are shown on Figure 45. The silica and bicarbonate values vary within reasonably narrow limits. The other constituents vary considerably, but lower values are typically in and near recharge areas.

Suitability of Water for Use

Standards for the chemical suitability of water depend on the proposed use of the water. Irrigation, public supply, and domestic purposes are the most important for the Seymour.

Irrigation

The chemical quality of water is an important factor to be considered in evaluating its usefulness for irrigation. Whether water can be used successfully for irrigation depends on many factors including the total concentration of dissolved salts and the concentrations and relative proportions of individual constituents. Among other factors to be considered are the nature and composition of the soil and subsoil, amount of water used, methods of application, type of crop, and climate.

Typically, the suitability of water for irrigation is evaluated with respect to four factors (U.S. Salinity Laboratory Staff, 1954): the total concentration of soluble salts; the relative proportion of sodium to calcium and magnesium; the amount of boron (or other elements toxic to plants); and under some conditions, the bicarbonate content as related to calcium and magnesium content. These four conditions have been termed, respectively: the salinity hazard, the sodium (alkali) hazard, the boron hazard, and the bicarbonate ion hazard.

The salinity hazard is evaluated normally in terms of specific conductance. A widely used diagram for this purpose is by the U.S. Salinity Laboratory (1954), reproduced as Figure 46. Specific conductance is plotted on one axis of the graph and is used to rate the degree to which a particular water may give rise to salinity problems. The specific conductance of much of the Seymour water is between 750 and 2,000 mmhos/cm which is in the high salinity hazard portion of the graph, even though the Seymour water is generally satisfactory for irrigation.

The Seymour water has been used for irrigation continuously for many years, and no widespread salinity problems have developed. The salinity hazard has been reduced, most likely, due to the generally sandy, permeable, and well-drained soils and the cultivation of crops which have a relatively high salt tolerance.

The sodium adsorption ratio (SAR) is used to evaluate the sodium (alkali) hazard. The sodium adsorption ratio for water from the Seymour is typically less than 10. This indicates normally that the water can be used for irrigation in almost all soils with little danger.

The boron content of the Seymour water is typically less than 1.0 mg/l. The water is considered good to excellent according to the most widely used standards for rating the suitability of irrigation water for various crops on the basis of boron concentration (U. S. Salinity Laboratory Staff, 1954).

The bicarbonate ion hazard is evaluated by calculating the residual sodium carbonate (RSC: Defined as twice the amount of carbonate or bicarbonate a water would contain after subtracting an amount equivalent to the calcium plus the magnesium content.). Values for the Seymour water are typically less than 1.25 meq/l which is considered a safe level.

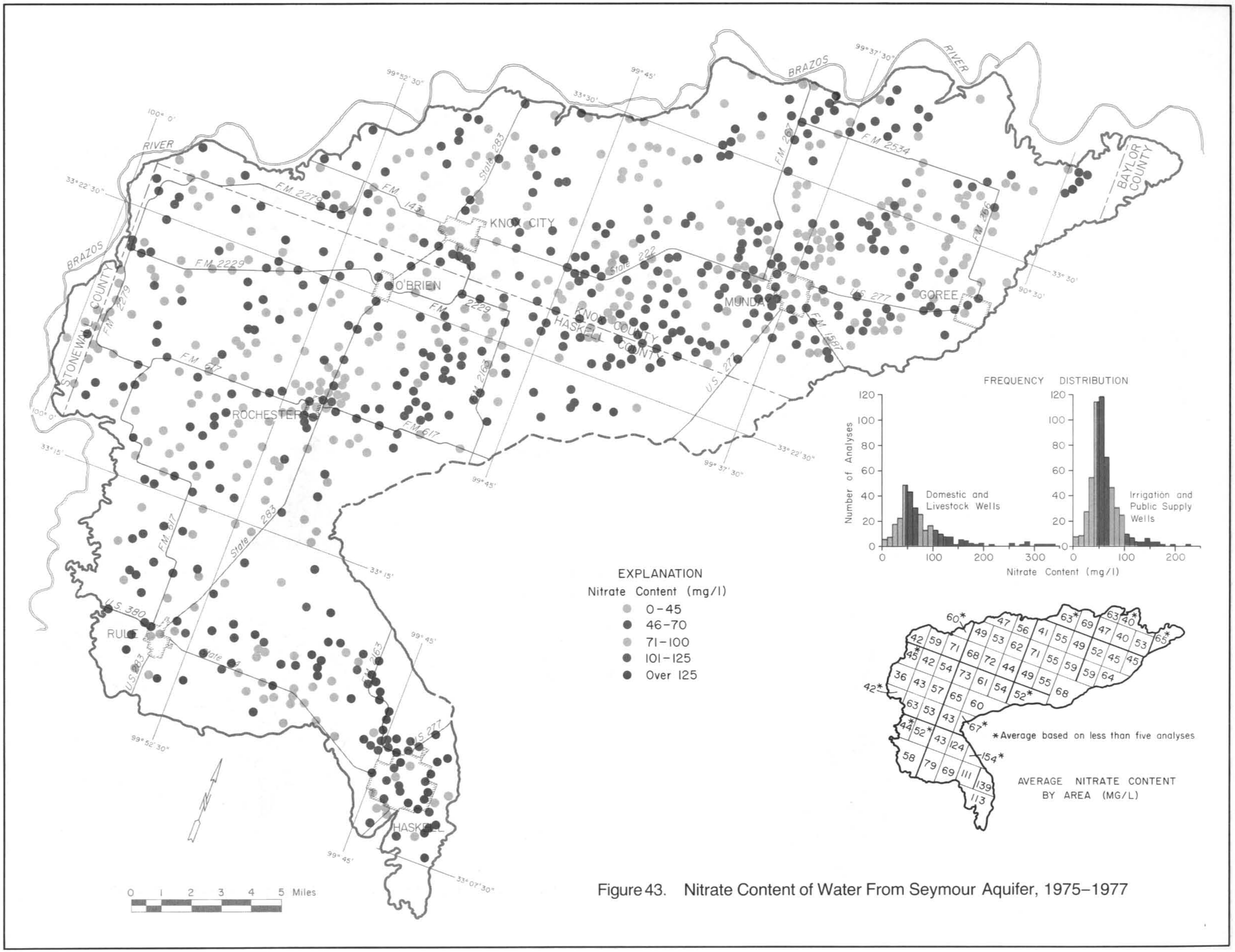


Figure 43. Nitrate Content of Water From Seymour Aquifer, 1975–1977

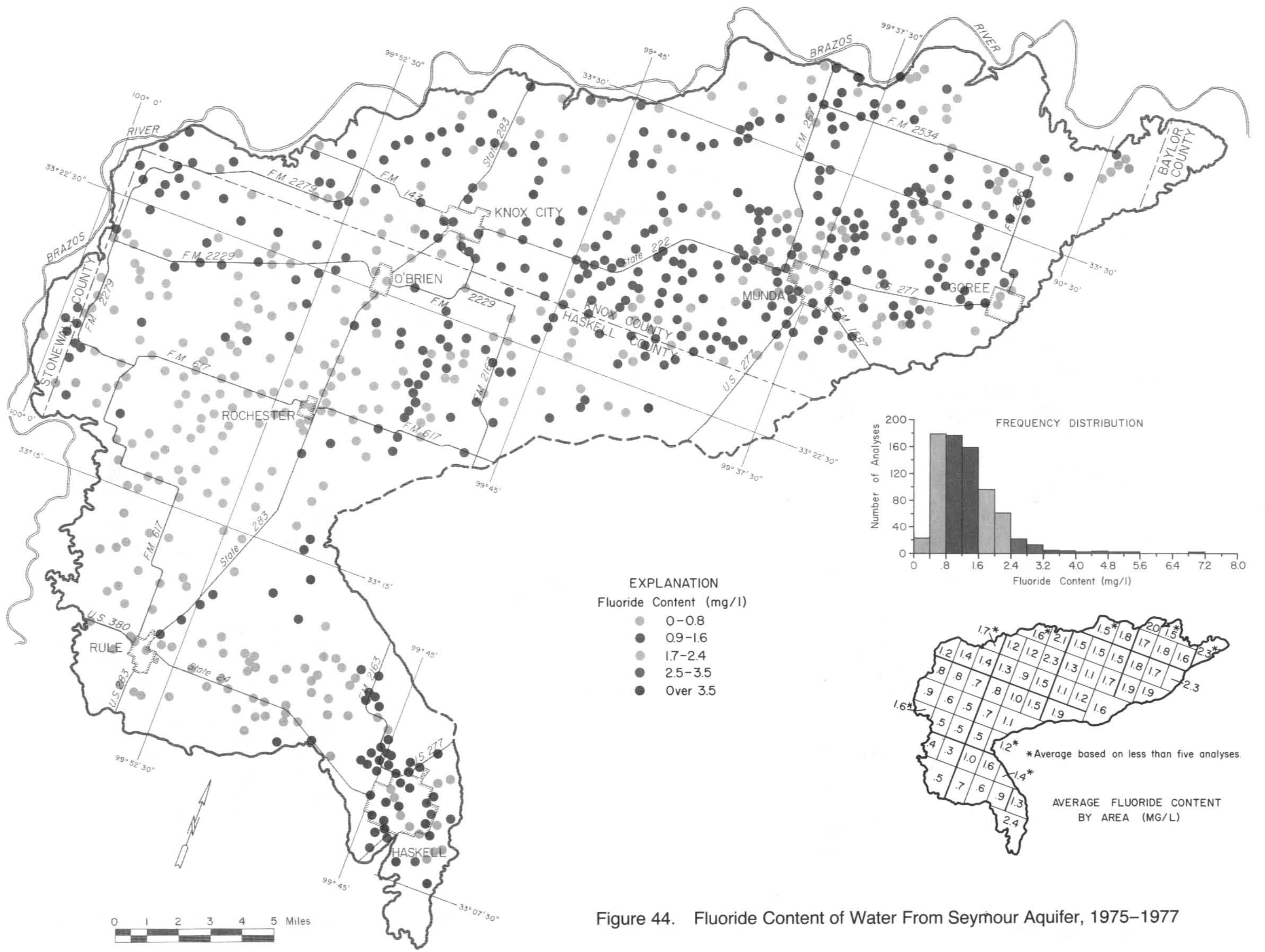


Figure 44. Fluoride Content of Water From Seymour Aquifer, 1975–1977

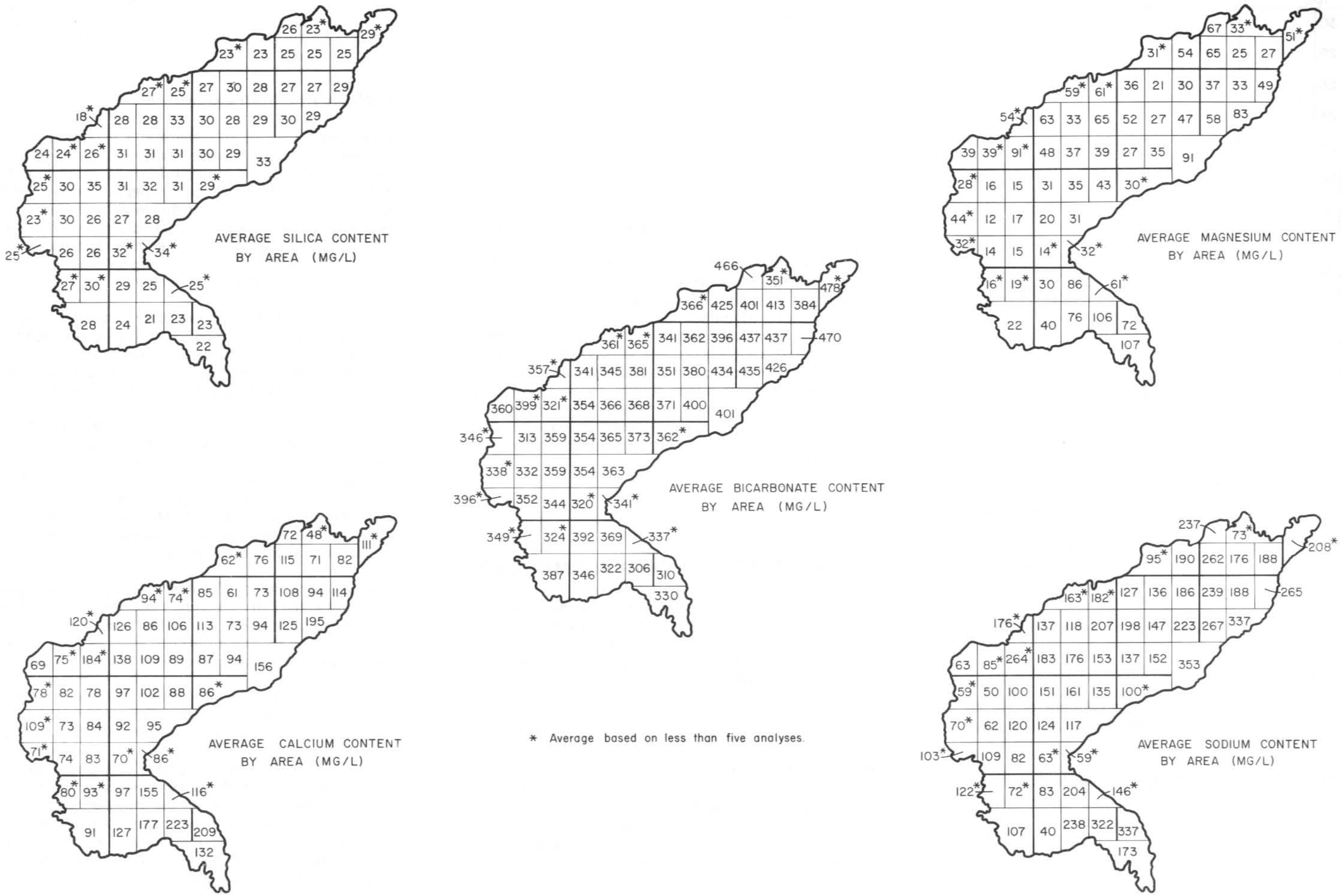


Figure 45. Average Silica, Bicarbonate, Calcium, Magnesium, and Sodium Content of Water From Seymour Aquifer, 1975–1977

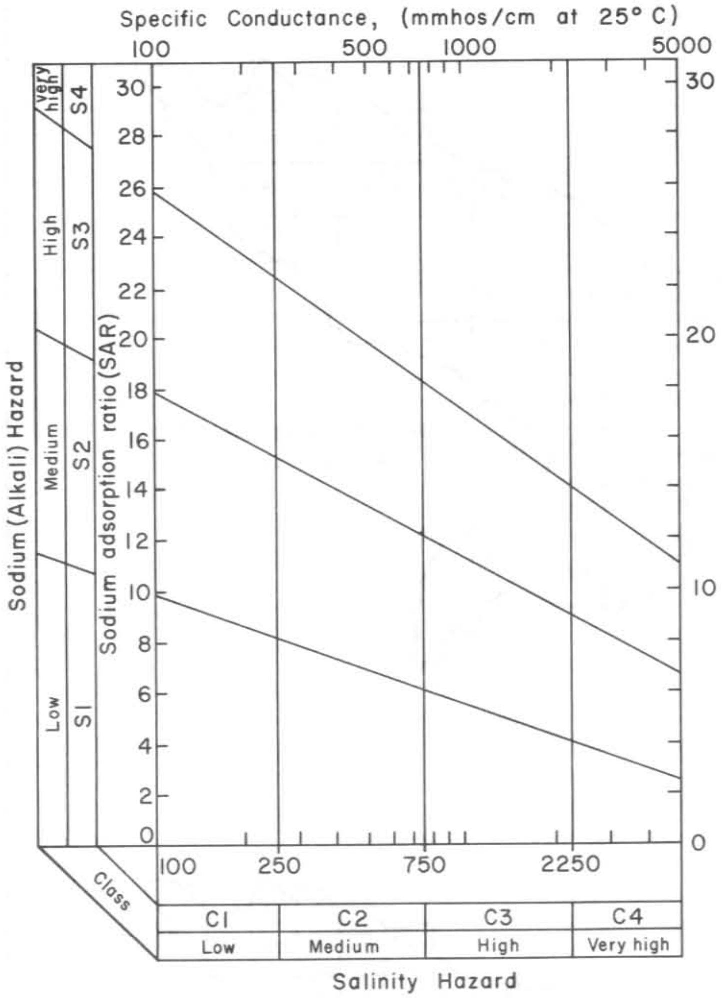


Figure 46. Diagram for Classification of Irrigation Waters

Public Supply

Current standards of the Texas Department of Health (1977) for the inorganic chemical suitability of drinking water include the following limits:

Maximum Limits for Inorganic Constituents

Constituent	Limit (mg/l)
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as NO_3)	45.
Selenium	0.01
Silver	0.05
Fluoride (based on an annual average maximum daily air temperature between 70.7 and 79.2°F.)	1.6

Recommended Limits for Inorganic Constituents

Constituent	Limit (mg/l)
Chloride	300
Copper	1.0
Hydrogen sulfide	0.05
Iron	0.3
Manganese	0.05
Sulfate	300
Total dissolved solids	1,000
Zinc	5.0

In some areas and individual localities, the water from the Seymour contains constituents in excess of the recommended limits. Those items which more commonly exceed the limits include nitrate, fluoride, and, less commonly, dissolved solids, sulfate, and chloride. Figures 38, 39, 40, 43, and 44 show the locations which both comply with and exceed the recommended maximum limits for dissolved solids, chloride, sulfate, nitrate, and fluoride content. Most samples for which analyses of other limiting constituents are available meet the recommended limits for public supply. However, no analyses are available for the trace metals. From general experience in other areas, it is considered unlikely that trace metals are present in the Seymour water in amounts exceeding the maximum limits.

GROUND WATER IN OTHER FORMATIONS

Some water occurs in the shallow Permian formations adjacent and beneath the Seymour and in younger terrace and alluvial deposits adjacent to the Seymour. The Permian occurrences are not important from a quantitative standpoint, and the other units are not connected to the Seymour.

Younger Terrace and Alluvial Deposits

The younger terrace and alluvial deposits occur in the floodplain and associated terraces along the Brazos River. The limited areas of these deposits are shown on Figure 13. The deposits occur at elevations lower than the Seymour Formation according to comparisons of topographic maps and the elevation of the base of the Seymour. They are not connected to the Seymour or related to its hydrology.

The terrace and alluvial deposits are composed of sands, gravels, silts, and clays. Their maximum thickness is estimated to be approximately 40 feet. Moderate water supplies are available locally, but only a few wells draw water from the younger terrace or alluvial deposits. The pumping rate of one irrigation well was measured at 220 gpm.

The water in the terrace and alluvial deposits tends to be much more mineralized than the Seymour water. Three analyses range in chloride content from 740 mg/l to 2,560 mg/l, in sulfate content from 855 mg/l to 2,300 mg/l, and in dissolved solids content from 2,691 mg/l to 5,562 mg/l.

Shallow Permian Rocks

Records for about 70 wells and 4 springs drawing from Permian rocks were obtained during the present investigation. The wells range in depth from 20 to 90 feet, but are mostly between 30 and 50 feet in depth. Slightly over half of the wells are large-diameter dug wells; the rest are drilled wells which have casings of 6 inches or less in diameter. The wells are dispersed widely over the study area and are evidence of the difficulty in obtaining satisfactory quality and quantities of water from the Permian.

Over half of the Permian wells furnish water used only for livestock purposes. The remaining wells are used for domestic supply, even though most yield poor quality water not used normally for drinking. Well yields are low, and only small supplies are available from the Permian rocks.

In investigating the Permian water quality, previous chemical quality data were obtained, and sampling of additional wells was done for those areas located within approximately 5 miles of the edge of the Seymour aquifer. The data obtained indicate a wide range in quality for Permian waters. Very little of the water is fresh. Most is slightly to moderately saline and normally contains moderate to large concentrations of both sulfate and chloride.

Sulfate contents for 26 out of 43 analyses are in excess of 500 mg/l with 17 in excess of 1,000 mg/l. The sulfate content ranges up to 2,730 mg/l. The higher sulfate values are more common for those Permian wells located in the western parts of the area for which Permian data were obtained.

The chloride contents of Permian samples range from less than 100 to 3,760 mg/l. Approximately 25 percent of the wells sampled have chloride contents in excess of 500 mg/l.

The shallow Permian rocks have very poor water-bearing characteristics. Most of the rocks are shales which are essentially impermeable. Even the thin sandstone, siltstone, gypsum, and limestone zones have low permeabilities, and little water moves through the Permian. Essentially, the Permian is separate from the Seymour aquifer because of the great difference in permeability.

Minor leakage from the Permian to the Seymour and from the Seymour to the Permian probably occurs locally. The amounts are unimportant quantitatively, but enough leakage from the Permian to the Seymour may occur in some areas to affect water quality. Principal areas where this may occur are along the extreme southeastern border of the aquifer, southeast of Munday, and in a few small areas located near the boundary between the younger and older Seymour deposits. The largest of these is located approximately 3 miles west of Knox City. The water quality in these areas appears abnormally high in both sulfate and chloride content. The most likely source appears to be the Permian.

Rises in water levels in the Permian formations adjacent to the Seymour aquifer over the last 10 to 20 years were noted during this investigation. The rise in water levels has been caused by the same factors which are responsible for the rise in water levels in the Seymour, namely, above normal precipitation and farming practices. In many localities where water levels have risen sufficiently to cause salty spots on the land surface, the soil is damaged and unproductive. The soil salinization is due to naturally saline water in the Permian or evaporation from the water table which causes a concentration of dissolved salts.

There have been numerous complaints reported regarding salty land. All are on the Permian outcrop outside the Seymour area. None were found or reported on the Seymour. Typically, local residents blame oil field injection operations for the problem. However, the hydrology, location of the areas, and number of complaints preclude the oil field activities being the cause of most of the complaints. The salty land condition is a natural problem for which no economic solution is available.

POLLUTION AND THE SEYMOUR AQUIFER

Introduction

The Seymour is the only source of fresh water throughout the area of its occurrence. No alternative fresh supplies exist from deeper formations, and essentially no surface water supplies exist on the Seymour, except those which must be piped in from long distances. A large number of users are dependent on the Seymour water supply for municipal, irrigation, domestic, and stock purposes. Consequently, the prevention of pollution and protection of this significant water source are important to both present and future users.

This section of the report deals primarily with ground-water pollution caused by mineralized water. Some information is presented on pollution from hydrocarbons including pesticides, but hydrocarbon pollution is of little significance in the area. Information on biological pollution (bacteria and viruses) is not included. Normally, these micro-organisms are removed by adsorption and filtration and do not travel great distances in sediments similar to the Seymour.

Susceptibility to Pollution

The Seymour aquifer is susceptible to pollution from both surface and near surface sources. Its infiltration potential, depth to the water table, thickness, geologic character, and rate of natural ground-water movement are all factors which render the aquifer susceptible to pollution. Infiltration potential is high due to the sandy character of the surface soils. The aquifer is not protected by overlying impermeable zones; consequently, pollutants can move from the surface or near surface to the water table. Because of the shallow water table, pollutants can reach the water table relatively quickly, and little attenuation may occur. The generally thin saturated thickness and absence of impermeable layers within the aquifer results in essentially the entire aquifer thickness being affected at a pollution site. The relatively high rate of natural ground-water movement and the coarse-grained character of the lower part of the formation result in pollution plumes which spread relatively fast and far. However, when a pollution source to the aquifer ceases to exist, these same characteristics become desirable. They cause the remaining pollutants to be flushed from the aquifer more quickly than if the sediments were finer-grained and the ground-water movement slower.

Movement of Pollutants

The basic principles of ground-water flow govern the movement of pollutants in the Seymour. When an undesirable fluid reaches the water table, ground-water pollution begins. The fluid may have leaked from an unlined waste pit, from a surface spill, or from other surface operations including sewage treatment plants, landfills and dumps, feedlots, or leaky storage tanks. Other sources of contamination discharge pollutants directly to the subsurface. These include septic tanks, leaky underground pipelines, defective injection wells, and improperly plugged holes.

Once a pollutant reaches the water table, local ground-water movement becomes the primary determining factor of the path the pollutant will take through the aquifer. When pollutants enter natural ground-water systems, only minor mixing normally occurs. Typically, a plume or track of polluted water is formed in the direction of ground-water flow. Pollution plumes are elongate in the direction of ground-water flow. Normally, they do not fan out from a source. The dispersal across the direction of flow is quite small in proportion to the distance of travel in the direction of flow. The direction and rate of movement of the pollutants is governed by the configuration and the slope of the water table (hydraulic gradient) and the permeability of the materials through which the pollutants move.

Natural ground water is constantly moving from areas of recharge to points of discharge. Pollutants contained in and moving with normal ground-water flow have the same flow pattern. In special cases, other factors can affect the flow pattern. For example, hydrocarbons tend to float on the water table, while brines tend to sink vertically under the influence of gravity, even though the direction of ground-water flow is essentially horizontal. Also, where pumping from wells changes water levels in an aquifer, the rate and direction of ground-water travel is modified. The hydraulic gradient near pumping wells is toward the wells, and flow lines converge toward pumping wells. Consequently, pollutants can be drawn toward and reach pumping wells.

Typically, ground-water contamination is discovered when a pollutant reaches a pumping well. Because of the relative slow movement of ground water, there can be a lag of years or even decades between the time a pollutant enters an aquifer such as the Seymour and when it arrives at a pumping well or at a natural discharge point such as a spring. Ground-water pollution may go undetected until a pollution source has been active a relatively long time or until considerable damage has been done. Discoveries of pollution caused by sources which no longer exist can continue for years and even decades after the sources have been inactive. Normally, it takes very long periods of time for an aquifer to be flushed of a pollutant by natural flow.

Past Pollution Complaints

There have been many complaints related to water pollution in the area. As a part of the present study, a tabulation was made of the number of complaints and the type of problems that have occurred in the past. Records of the Texas Railroad Commission and the Texas Department of Water Resources (including predecessor agencies) were checked. Table 8 lists the complaints to these state agencies from 1951 through 1977 in two categories, those mentioning some type of observed water problem and those objecting to oil field activities or other industrial operations as a source of pollution. Through the years, there has been an increase in the number of both types of complaints. About half of the complaints concern some type of water problem, primarily salty well water. The other half of the complaints are related to oil field activities.

Pollution Source Inventory

A detailed inventory was made of the more important pollution sources, the potential causes of pollution, and the methods of waste disposal on the Seymour. The inventory included current sources and, to the extent possible, past sources. The individual items inventoried are listed in Table 9 and mapped in Figures 48, 49, and 54. No detailed inventories were made of those sources listed in Table 9 for which the number of sources is not given. These items were not inventoried because to do so was impossible, cost prohibitive, or because initial evaluation indicated the source was insignificant.

Table 9 lists those pollution sources which have affected wells as indicated by water sampling. Also, the relative impact of the various sources on the Seymour is given. By far, the largest pollution impact on the aquifer has been from the former disposal of oil field brine into unlined surface pits. Moderate effects are indicated for brines leaking from improperly plugged and abandoned holes and from faulty injection wells. Impact from septic tanks is considered moderate, inasmuch as more than 9 percent of the domestic wells sampled show effects of pollution from sources high in nitrate content. All other sources are estimated to have a low impact.

Sources of Pollution and Indicated Water Quality Changes

Oil Fields

Many oil fields are present in the area, and oil activities are significant to the economy of the area. Most of the oil fields were discovered during the 1950's. Oil producers in the area are primarily independent operators, although a few major companies are represented. The 1976 production was slightly less than 3 million barrels. The cumulative oil production to January 1977 was about 131 million barrels. Production depths range from about 1,600 feet for the shallowest production (Tannehill) to over 5,800 feet for the deepest production (Strawn, Bend Conglomerate).

Figure 47 shows the locations of the oil fields on the Seymour. It also shows the locations of dry and abandoned oil tests, past or current producing oil wells, and past or current locations used for injection or disposal of salt water. There is a total of 2,446 locations shown, including 1,152 dry holes, 909 oil wells, and 385 injection or disposal wells.

Pollution from oil activities is due normally to either salt water or hydrocarbons. The amount of contamination of ground water by hydrocarbons is of almost no significance in the area. Though the potential for pollution appears to be large because of the large number of sources where crude oil or refined products are stored or piped (Figure 48), only three water wells in the area were reported to contain hydrocarbons. Two of the wells could be sampled, and results were negative.

Table 8. Number of Complaints to State Agencies Related to Water Pollution In and Near Area of Seymour Aquifer

Type of Complaint	Period					
	1951–1955	1956–1960	1961–1965	1966–1970	1971–1977	TOTAL
Water Problems:						
Salt in water from well	3	7	10	7	11	38
Oil in water from well					3	3
Salty spot or seep at land surface			2	3	2	7
Nitrate in water from well					1	1
Oil Field Operations:						
Disposal pit		2	4	2	1	9
Leaky well	1		5	8	12	26
Miscellaneous (mostly saltwater spills)		2	1	4	5	12
Other Industrial Operations:				1		1
TOTAL	4	11	22	25	35	97

In recent years, it has been a required practice to report hydrocarbon spills greater than five barrels to the Texas Railroad Commission. A summary of these reports is as follows:

Year	Number of Spills Reported	Amount Lost (bbls)
1970	0	---
1971	9	224
1972	1	20
1973	9	416
1974	3	75
1975	5	211
1976	2	108

Because the reports represent Haskell and Knox Counties in their entirety, only a part of the spills reported would be applicable to the Seymour. Some pollution due to spills or leaks of hydrocarbons has occurred in the past and will occur in the future, but the estimated impact on the aquifer is very low.

Production of crude oil is accompanied by the production of salt water. Improper disposal of produced brines can result in significant pollution of fresh ground water. The amount of the salt water produced is quite variable. It reportedly ranges from less than 1 barrel of brine per barrel of oil to over 50 barrels of brine per barrel of oil for individual leases. The ratio of produced water to oil probably averages between 1 and 5 barrels of water per barrel of oil for individual fields. The ratio increases typically with the age of a field.

Chemical analyses of the oil field brines sampled during this investigation are shown in Table 26. All the waters are highly concentrated sodium chloride brines. Chloride contents range from about 63,000 to 139,000 mg/l. Because of these high chloride concentrations, even if only small quantities of brine are mixed with Seymour water, the resultant mixture can be very high in chloride content.

Sources

Sources or potential sources of brine pollution from oil field activities include unlined surface disposal pits, improperly plugged abandoned oil tests, faulty injection wells and oil wells, spills, and unplugged seismic and stratigraphic holes.

Disposal Pits

Unlined surface pits were a common method of disposal

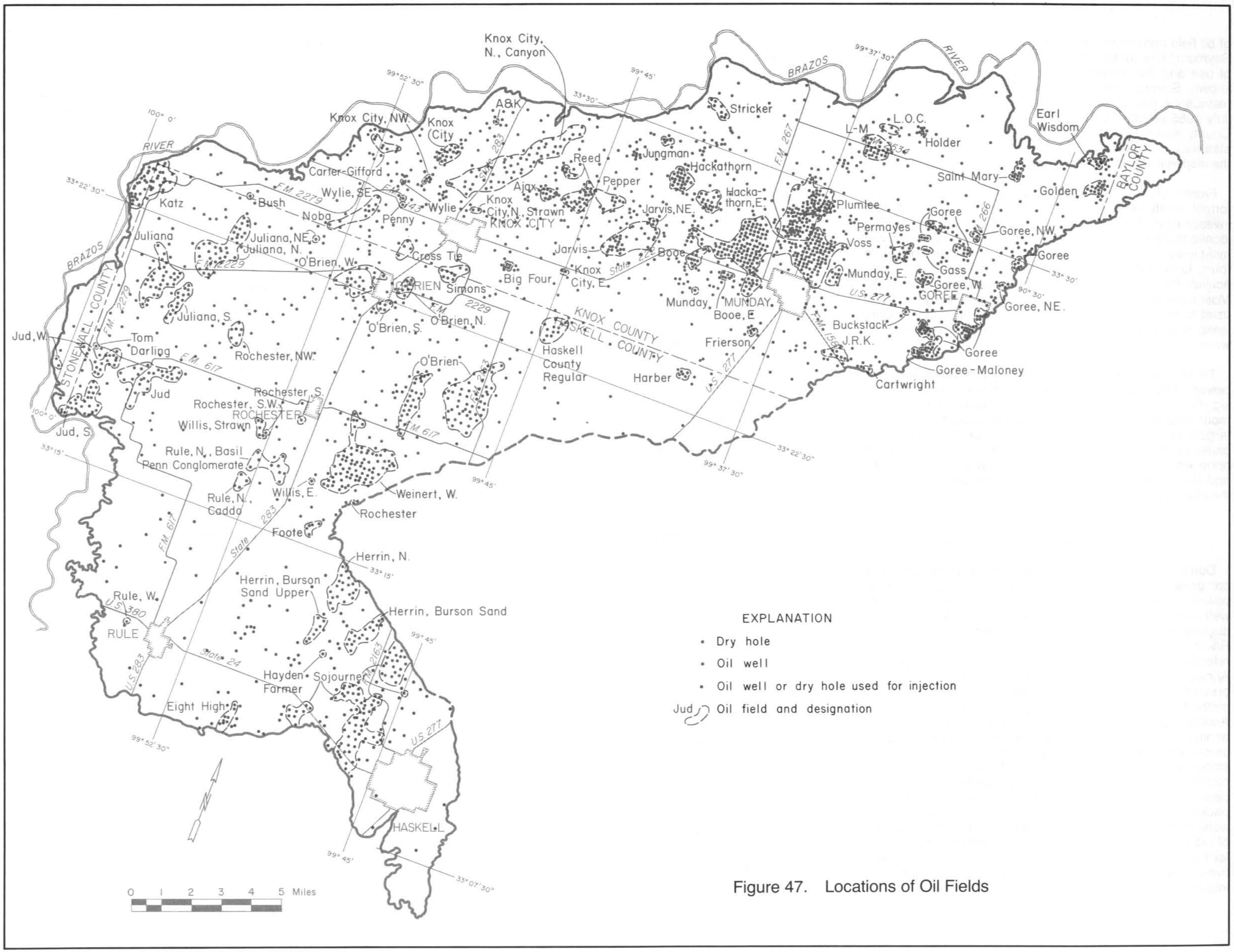


Figure 47. Locations of Oil Fields

of oil field brine in the earliest days of oil production on the Seymour. The number of pits was large, but the time periods of use and the amounts of disposed brine are largely unknown. Several fields in Haskell County were covered by restrictions issued by the Texas Railroad Commission in July 1955 prohibiting the use of unlined disposal pits. Knox County was subject to an order effective June 1966, and a statewide order banning the use of unlined surface pits for the disposal of brine was effective January 1969.

From a study of past aerial photographs (Table 32), 258 former locations of disposal pits were mapped during this investigation. The locations are shown on Figure 49. The locations are believed to include a few lined surface pits, but most were unlined. During 1975–1977, 23 disposal pits were found to exist in the area. Apparently none were being used actively for the disposal of oil field brine; only two were lined. Most were considered by operators to be "emergency" pits used to collect fluids in the event of pipeline or tank battery leaks or equipment failure. Several of the pits contained salt water.

Those existing and former disposal pits which have received large quantities of oil field brine are considered very significant with respect to ground-water pollution of the Seymour aquifer. The surface pits are considered to have the largest pollution impact of any source on the aquifer because of the numerous pit locations, the large quantities of brine which apparently were placed into some of the pits, and also partly due to the number of water wells which show the effects of oil field pollution.

Injection Wells and Abandoned Holes

Due to the ban on unlined surface pits, and because many companies recognized originally the danger of ground-water pollution due to surface pit disposal, the use of injection wells has been common in the area. Three different types of disposal or injection wells have been permitted by the Texas Railroad Commission in the past. The three kinds are referred to as annular, long string, and tubing and packer. Annular disposal is the poorest type with respect to the prevention of ground-water pollution. The tubing and packer method is the best and currently is the only type allowed. Annular disposal consists of injecting salt water into the annulus (bradenhead) between the surface casing and the production casing on operating or abandoned oil wells. Long string injection is the injection of fluids down the production casing of abandoned oil wells or injection wells. Tubing and packer injection is done by injection through tubing and packer set inside the production casing of abandoned oil wells or specially constructed injection wells. The advantage of tubing and packer injection is that by monitoring pressures for the tubing, production casing, and surface casing, positive indications are obtained if the injected fluids are going into zones other than the intended injection zone.

Table 9. Summary of Pollution Sources and Relative Impact on Seymour Aquifer

Sources (Actual and Potential)	Number in Area	Number of Sites For Which Water Sampling Indicates Affected Well(s)	Estimated Relative Impact on Aquifer[1]
Industrial, Oil			
Pipelines, Crude & Product	See Figure 48	1 Reported	3
Petroleum Storage Facilities:			
Existing[2]	44		3
Destroyed[3]	10	1 Reported	3
Tank Batteries:			
Existing[4]	248		3
Destroyed[3]	152		3
Disposal Pits:			
Existing[5]	23		2
Destroyed[6]	258	Numerous	1
Abandoned Oil Tests (dry holes)	1,152	14 Known	2
Injection Wells	385	7 Known	2
Oil Wells	909		3
Seismic Holes and Stratigraphic Holes	—		3
Spills:			
Brine	12	Few	3
Oil	—		3
Industrial, Other			
Former Slaughterhouse Disposal Pit	1	1 Known	3
Former Delinting Plant Disposal Pit	1		3
Fertilizer Storage	7		3
Aerial Spraying Service	6	1 Known	3
Rural Domestic			
Septic Tanks and Cesspools	—	More than 9 percent of domestic wells	2
Municipal			
Sewage Effluent	5		3
Landfill or Dump	3		3
Agricultural			
Crop Applicants:			
Fertilizers	—		3
Pesticides	—		3
Return Flow	—		3
Animal Wastes:			
Abandoned Feedlot	1		3
Barnyards	—		3
Miscellaneous			
Evapotranspiration	See Figure 30		3

[1] 1—High 2—Moderate 3—Low
[2] Including gas stations and bulk stations present in 1975–1977
[3] Not present in 1975–1977
[4] Present in 1975–1977
[5] Including lined and unlined brine disposal pits and emergency pits present in 1975–1977
[6] Including abandoned and destroyed, lined and unlined, brine disposal pits and emergency pits not present in 1975–1977

To generally appraise the time periods and amount of disposal that may have occurred by the various types of injection in the past, a tabulation of Texas Railroad Commission injection permits was made. Figure 50 shows the number of permits and the time period during which the various types of permits were issued. Frequently, permits covered more than one well and, consequently, the total number of permits is smaller than the total number of injection wells shown in Table 9. The overall permit history indicates a gradual decreasing potential for ground-water pollution due to injection activities.

Even with properly designed and constructed injection wells, brine disposal is not without real or potential problems with respect to ground-water pollution. Most of the problems result from the use of pressure for injection and the nature and amount of earlier exploration, especially the inadequate plugging of abandoned oil tests, oil wells, and injection wells. There are 1,152 recorded abandoned, dry holes in the area. Oil wells and wells used for injection purposes total approximately 1,300. In the absence of proper plugging or construction, more than 2,400 sites exist where vertical pathways can occur between the deeper subsurface formations and the Seymour aquifer.

Based primarily on investigations of saltwater pollution complaints by Texas Railroad Commission personnel, there are about 21 known occurrences where either improperly plugged dry holes or injection wells were the source of pollution of water wells in the area. In 14 cases, the source of the pollution appeared to be improperly plugged abandoned holes and in seven cases, faulty injection wells were believed to be the cause. Essentially then, approximately 1 percent of the abandoned oil tests and 2 percent of the injection wells are indicated to have caused ground-water pollution. Undoubtedly, additional instances are yet to be discovered. Probably, the actual percentages which have caused pollution are a few times larger than is indicated presently. Improperly plugged and faulty wells are considered to have a moderate pollution impact on the aquifer, but are believed to be less significant than the former use of unlined surface pits.

Other Sources

Improperly plugged seismic holes, stratigraphic holes, and improper surface casing in oil wells can be responsible under some conditions for ground-water pollution. Formation pressure in shallow Permian strata in excess of Seymour pressure is required, as well as a connection between these zones. No cases of pollution due to such sources were found during this study. These sources are not considered particularly important in regard to the Seymour aquifer.

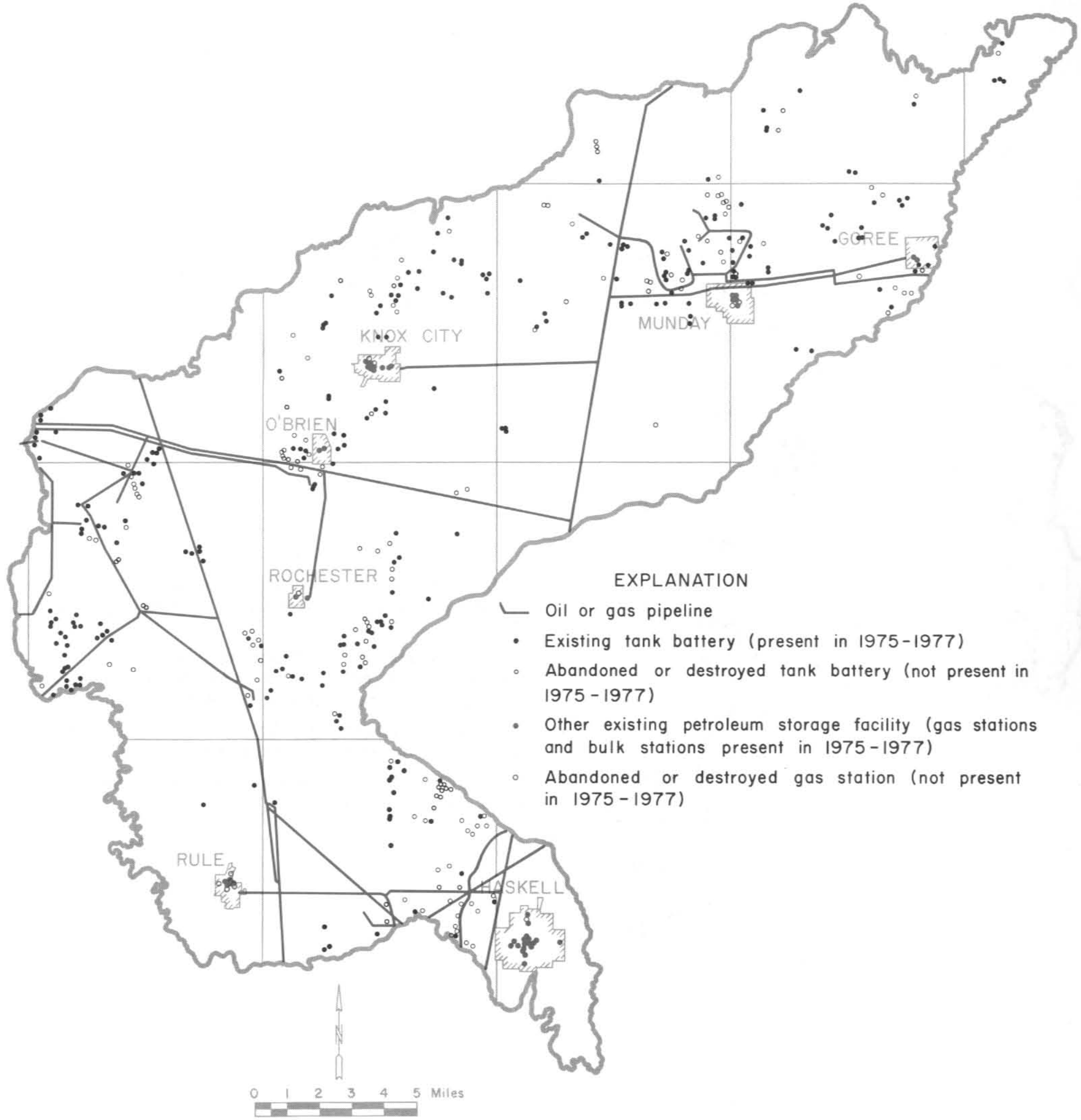


Figure 48. Locations of Pipelines, Tank Batteries, and Other Petroleum Facilities

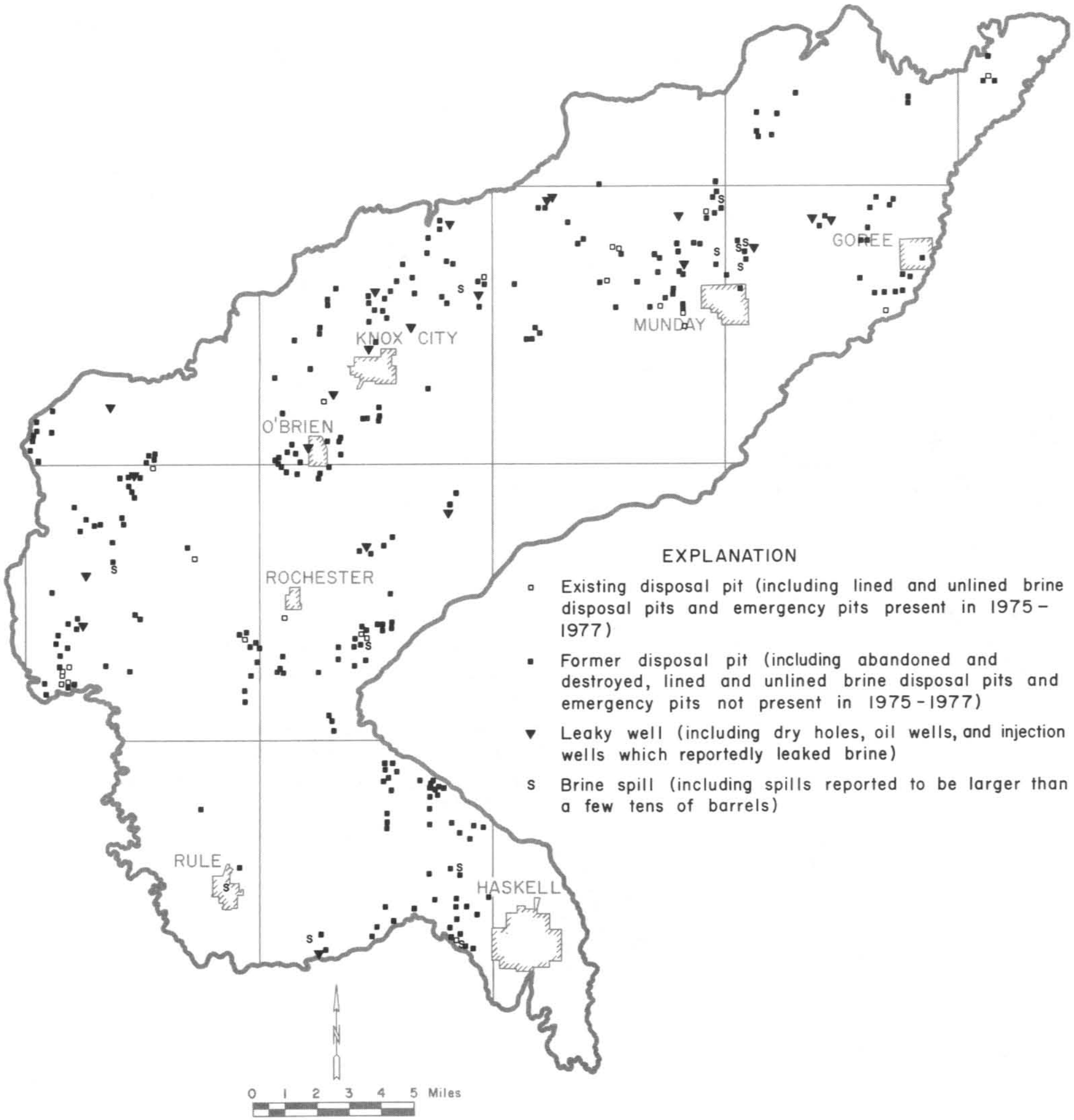


Figure 49. Locations of Disposal Pits, Leaky Wells, and Brine Spills

Production and Disposal of Produced Brine

Few records are available on the amounts of brine produced and methods of disposal except from inventories conducted by the Texas Railroad Commission for 1956, 1961, and 1967. Data from these inventories for the oil fields on the Seymour are given in Table 33. The table indicates the discovery date of the field and the date of the first injection well permit according to permit files. Presumably, surface pits may have been used between the time of discovery of the field and the time of the first permitted injection well. The table also shows the total cumulative oil production to January 1977. This information is useful in estimating the total amount of brine that may have been produced by the field. Typically, those fields producing the smallest amount of oil produced the smallest amount of brine.

Total reported brine production and disposal methods for all fields partly or entirely on the Seymour are as follows:

Disposal Method	Reported Brine Production (bbls/day)		
	1956	1961	1967
Pits	1,033	209	0
Injection	7,749	15,206	16,259
Trucked	329	0	1,003
Miscellaneous	0	135	0
Total	9,111	15,550	17,262

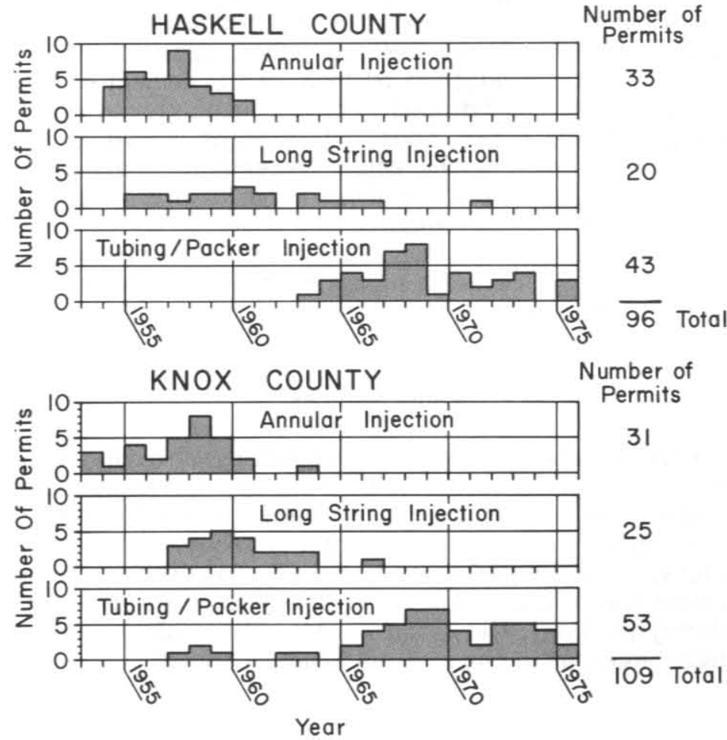


Figure 50. History of Injection Permits

Potential pollution sources are listed by field in Table 33. The table also shows by field the estimated impact on the Seymour of all brine disposal activities. The ratings are based on the apparent or reported amounts of brine disposed of into pits and the number of leaky wells and spills.

Though Table 33 reflects general conditions, some of the information shown is partly inaccurate because of the records on which it is based. For example, for some of the fields, the first injection well permit date is later in time than the reported use of injection wells according to the 1956 inventory. Such inconsistencies are due to either inaccurate reporting or incomplete records.

Recognition of Oil Field Brine Pollution

Several criteria are useful in recognizing oil field brine pollution in water samples from the Seymour aquifer. When oil field brines are mixed with the native Seymour water, the chloride content of the water increases. The sodium content increases also, as it is the largest other single constituent in oil field brine. However, the concentrations of calcium, magnesium, and sodium are subject to modification by base-exchange reactions with Seymour sediments. When such reactions occur, calcium and magnesium are substituted for part of the sodium. This results in polluted water containing abnormally higher amounts of calcium and magnesium in relation to sodium than would be predicted based on straight mixing of Seymour water with oil field brine. For this reason, calcium, magnesium, and sodium normally are secondarily used as indicators of oil field brine pollution, and the chloride increase is considered to be the primary indicator.

The ratio of chloride to sulfate content is also an important indicator. It is useful in separating wells affected by oil field brine pollution from those affected by other highly mineralized waters. The chloride/sulfate ratio will be higher in Seymour water affected by oil field brines. Oil field brines are extremely high in chloride content and are not high in sulfate content. Thus, mixtures show an increase in chloride content which is not accompanied by a proportional increase in sulfate content. This indicates oil field brine pollution. Conversely, naturally poor quality Seymour water having high chloride content is normally also high in sulfate content. Typically, the chloride/sulfate ratio will vary only within reasonably narrow limits within a local area, even though chloride concentrations may vary considerably. Thus, high chloride content and a normal chloride/sulfate ratio for an area is indicative of naturally poor quality water and not oil field brine pollution.

Because of the large natural variation in amounts of chloride in Seymour water, chloride content alone cannot be used indiscriminately as an indicator of oil field brine pollution. The most common and widely recognized criteria for the recognition of brine pollution is the use of chloride content and chloride/sulfate ratios in conjunction with careful comparisons of analyses from nearby wells.

Locations Affected

Figure 51 shows the locations of water wells which have shown the effects of chloride pollution. The wells have had abnormally high chloride contents as well as abnormally high chloride/sulfate ratios. There are 152 separate locations shown on Figure 51 having atypical chloride contents. Nearly all of these wells are believed to be affected by brine pollution, although a few appear to be affected by septic tank pollution and a few probably have improved substantially in water quality since last sampled. Most are down gradient from oil fields with known or potential pollution sources and are about the proper distance from such sources considering normal ground-water movement rates.

In addition to the locations shown on Figure 51, there is a reasonably large but undetermined number of wells in the Haskell area and immediately to the northwest of Haskell, which are believed to have been affected by oil field brine pollution. The native water quality in the Seymour aquifer northwest of Haskell is considerably poorer than in most other areas. A determination of which wells are affected by oil field brine pollution and which have naturally mineralized water is more difficult in this area with the number of available analyses, especially to the same degree of certainty that is possible in other areas of the Seymour. Consequently, locations of affected wells are not shown east of a line on Figure 51 in quadrangle 21–50.

Undoubtedly, there are additional locations other than those shown on Figure 51 where the Seymour aquifer has been affected by oil field brine pollution. It is estimated that about 30 to 50 more locations could be found by sampling a large number of additional Seymour wells. Also, it is certain that additional pollution plumes exist which have yet to reach wells. More detailed investigations, including sampling of available wells and test drilling, will be required to more thoroughly define the present extent of oil field brine pollution.

Severity and Historical Trends

The general severity of the pollution is indicated partly by the chloride content of water from wells shown on Figure 51 as having atypical chloride contents. The following list shows this information:

Chloride Interval (mg/l)	Number of Wells
0 - 250	42
251 - 500	51
501 - 1,000	37
1,001 - 1,500	6
1,501 - 2,000	2
2,001 - 2,500	1
2,501 - 5,000	5
5,001 - 10,000	3
10,001 - 68,500	5
Total	152

About 43 percent of the wells have chloride contents less than 500 mg/l. About 14 percent have chloride contents between 2,500 and 68,500 mg/l. These values are common for areas experiencing pollution from oil field brine. The wells which are highly polluted are more directly in the path of movement from a source. The large number of wells which are affected only moderately either are affected by low volume chloride sources, or are on the edge of pollution plumes, or are in locations through which the main pollution plumes have already passed. This last reason appears to be the case at a reasonably large number of the locations, as chloride contents have been monitored at some locations and are lower at present than in the past.

Figure 52 shows typical results of monitoring the chloride content in wells affected by oil field brine pollution. Some show increasing pollution (higher chloride levels) during the earlier periods of record. Most show decreasing amounts of pollution during later periods, indicating the pollution source was not active for long periods of time and that the main pollution plume moved down gradient from the affected well.

Figure 53 shows data on the city of Rochester well LP 21-42-401. Water from this well had low chloride and sulfate contents in 1944 prior to any oil activities in the area. The chloride content was slightly below 50 mg/l. Prior to 1963, the well became moderately affected by a source high in chloride content and low in sulfate content. The chloride increased to over 300 mg/l in 1964. It has since declined to about 150 mg/l, but is still about three times higher than originally. The sulfate content throughout the period of record shows little change. No detailed studies have been made in the Rochester area, and the exact source of the pollution is unknown.

The results of chloride monitoring confirm two important aspects of brine pollution for the Seymour. First, individual sources have tended to exist for only a few to several years as opposed to much longer periods of time. Thus, because the average rate of natural ground-water movement in the Seymour is as fast as it is, pollution plumes from short-lived sources tend to move to and past nearby wells in relatively short periods of time. Secondly, the character of the formation and rate of ground-water flow tends to allow the pollution to clear at most sites after several years. Thus, the pollution tends to be more temporary than is normally the case in many other ground-water formations.

Other Industrial Activities

Other industrial activities in the area which have been sources of pollution include two locations used formerly to dispose of waste products (Figure 54). One was a cotton seed delinting plant in which sulfuric acid waste was placed in an unlined pit. Presently, no wells are known to be affected by the waste disposal in the delinting plant pit. The other location was an area (probably a pit) used reportedly for the disposal of slaughterhouse wastes. Water from one

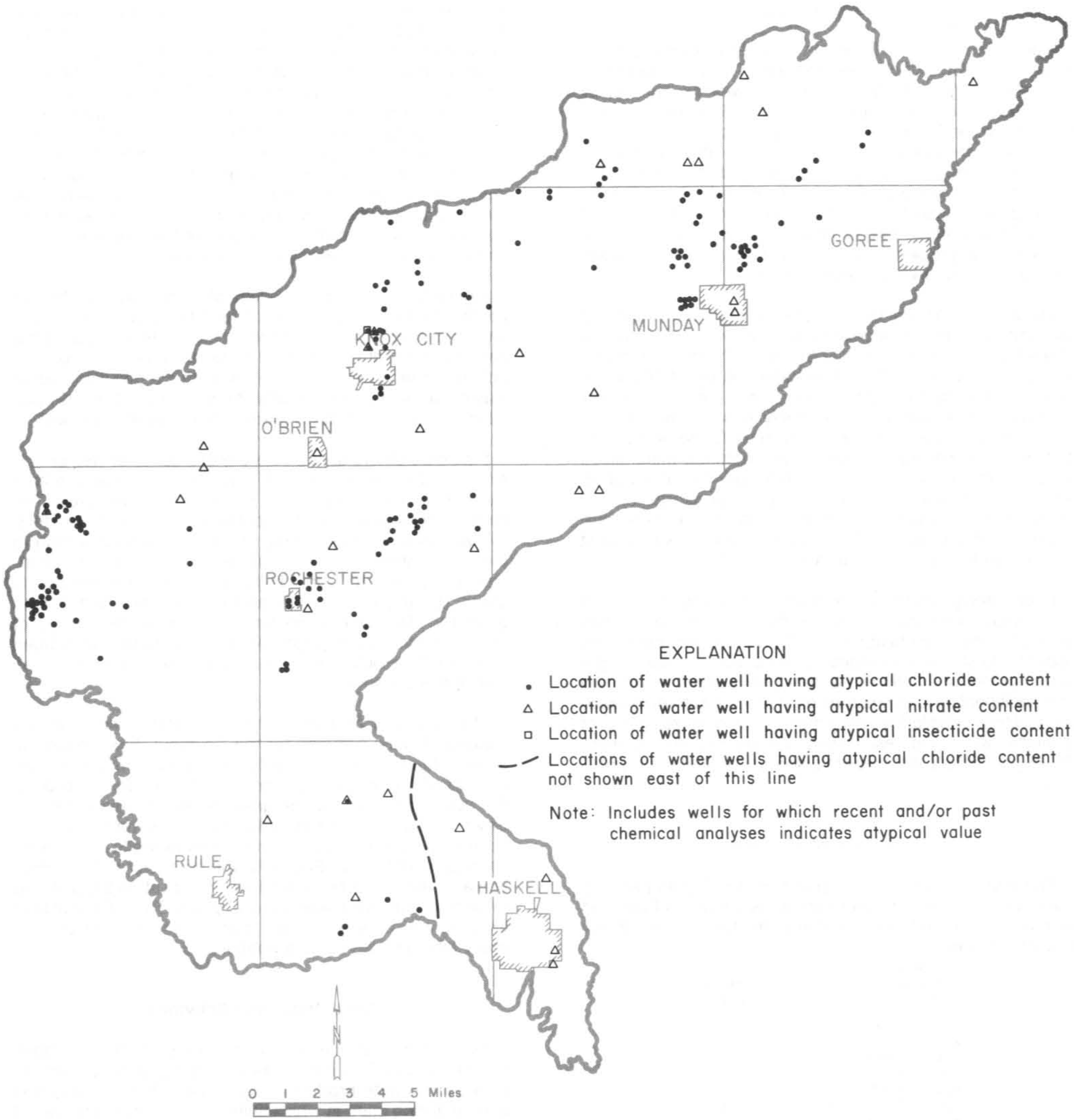


Figure 51. Locations of Water Wells Showing Effects of Pollution

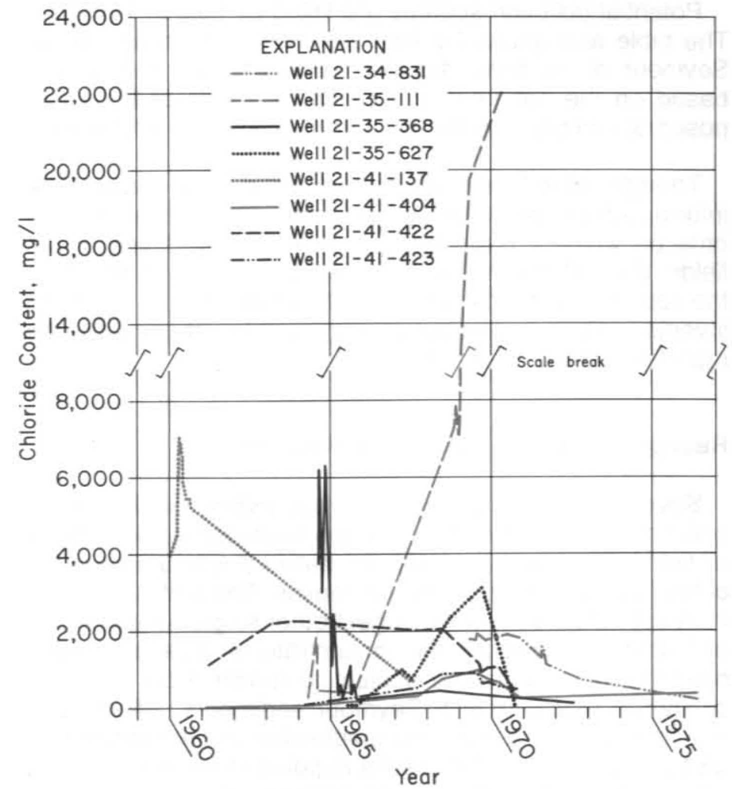


Figure 52. Chloride Content of Polluted Wells

well (LP 21-41-409) near the slaughterhouse disposal area has a nitrate content in excess of 900 mg/l. Only this one well is known to be affected by this source; the extent of the pollution is unknown.

There are seven fertilizer storage localities on the Seymour aquifer, but none appear to be sources of pollution. The potential exists, however, if large quantities of fertilizer are spilled on the surface, and infiltration carries dissolved constituents to the Seymour.

The six aerial spraying service facilities in the area are potential contributors to ground-water pollution, mostly from spills, handling and washing practices, and storage facilities. Results of sampling wells at the facilities are presented in the discussion of pesticides.

Septic Tanks and Cesspools

Effluent discharged from septic tank systems and cesspools can increase the concentration of minerals in ground water. Figure 55 shows a diagram of a typical septic tank and soil absorption system. Table 10 shows the normal range of mineral increases in domestic sewage.

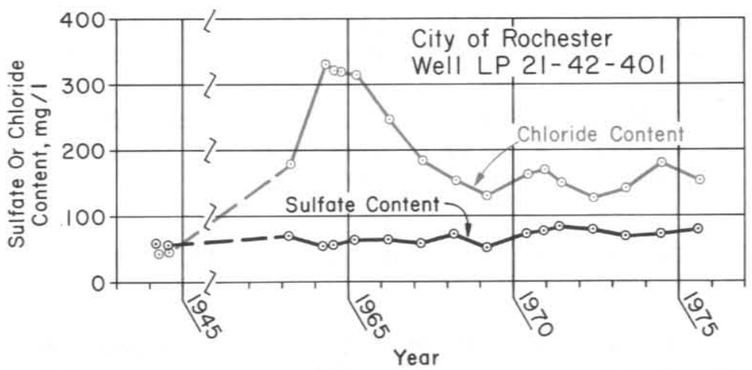


Figure 53. Historical Water Quality for Well LP 21-42-401

Table 10. Normal Range of Mineral Increase in Domestic Sewage (Feth, 1966)

Constituent	Range (mg/l)
Dissolved solids	100 - 300
Boron (B)	0.1 - 0.4
Sodium (Na)	40 - 70
Potassium (K)	7 - 15
Magnesium (Mg)	3 - 6
Calcium (Ca)	6 - 16
Nitrate (NO_3)	85 - 180
Sulfate (SO_4)	15 - 30
Chloride (Cl)	20 - 50
Alkalinity (as $CaCO_3$)	100 - 150

Nitrate is the principal pollutant found in ground water affected by septic tank discharge, although common salts can become objectionably high if recirculation via a domestic well is occurring. It is common to have some base-exchange reactions and phosphate depletion occurring to septic tank discharge prior to its reaching the water table. However, other common constituents such as chlorides, nitrates, sulfates, and bicarbonates are not removed from the water and can move downward to the Seymour aquifer.

The use of septic tanks and cesspools occurs at many widely scattered rural locations and also in unsewered areas in towns in the area. All the rural population and an estimated percentage ranging from 5 to 25 percent of the population of individual towns use septic tanks or cesspools, largely septic tanks.

Figure 51 shows those wells which have a high nitrate content in relation to surrounding ground-water quality. Nearly all are domestic wells. Approximately 9 percent of the domestic wells sampled during 1975–1977 had nitrate

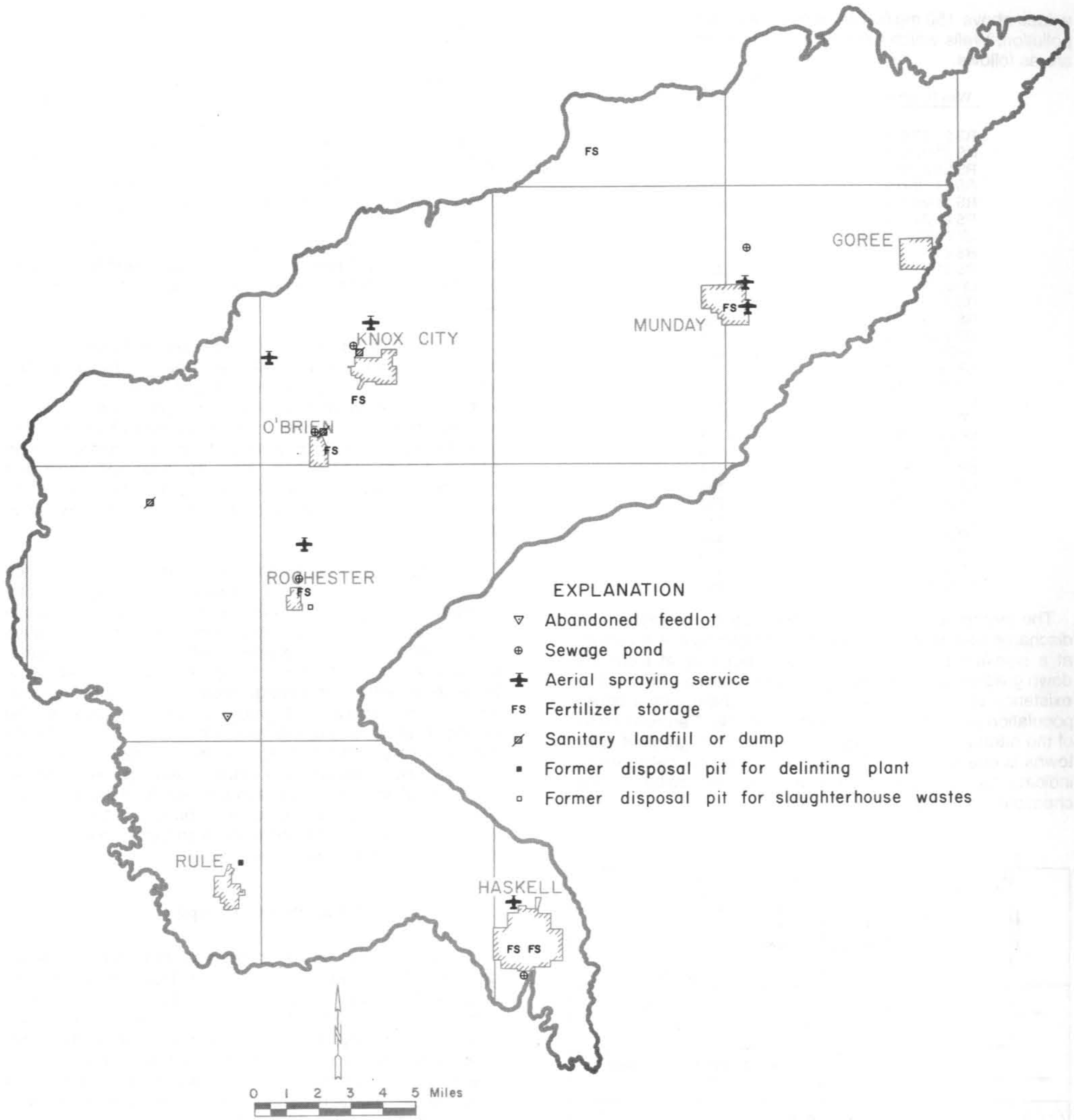


Figure 54. Locations of Other Known and Potential Pollution Sources

values above 150 mg/l. This is due principally to septic tank pollution. Wells which have nitrate content above 150 mg/l are as follows:

Well Number	Nitrate Content (mg/l)
RS 21-27-813	306
RS 21-27-938	155
RS 21-27-939	180
RS 21-28-409	172
RS 21-28-711	230
RS 21-29-408	163
LP 21-33-916	183
RS 21-34-513	154
RS 21-34-515	258
LP 21-34-947	386
RS 21-35-803	314
RS 21-36-401	183
RS 21-36-404	158
LP 21-41-202	222
LP 21-41-315	158
LP 21-42-106	273
LP 21-42-305	270
LP 21-42-409	935
LP 21-43-202	303
LP 21-43-203	199
LP 21-50-108	254
LP 21-50-202	165
LP 21-50-206	200
LP 21-50-304	174
LP 21-50-516	331
LP 21-51-412	178
LP 21-51-726	316
LP 21-51-739	281

The overall effect on the Seymour aquifer of septic tank discharge has been small. Locally, the effects are important at a significant number of locations, but only at locations down gradient and reasonably close to a source. Prior to the existence of municipal sewer systems, there was a larger population using septic tanks and cesspools. Certainly some of the nitrate content of Seymour water down gradient from towns is due to past septic tank discharge, but calculations indicate the amounts are low and not discernible in the chemical quality data.

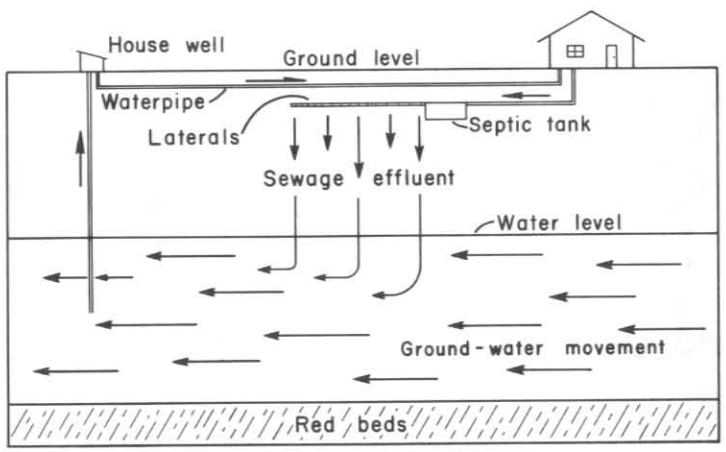


Figure 55. Contamination of a Domestic Ground-Water Supply From a Septic Tank

Sewage Treatment Plant Discharge

Five towns in the area discharge effluent on the Seymour Formation from sewage treatment plants. Munday, Rochester, and Haskell have oxidation ponds on the Seymour. However, the Haskell plant is located on the extreme edge of the aquifer and has little effect on the Seymour. Knox City and O'Brien discharge to surface drainage and to a surface depression, respectively. Goree and Rule have treatment plants, but they are located off the outcrop of the Seymour.

The discharge from the plants is disposed of by evaporation and seepage to the Seymour. Some is used for irrigation of farmland adjacent to the Munday, Rochester, and Haskell plants.

The chemical quality of the sewage effluent sampled during the present investigation is shown in Table 22. The analyses indicate a small mineral pickup when compared with the respective municipal water supplies. Also, as water moves through the various oxidation ponds at the Munday and Rochester plants, a general increase in mineralization occurs due to evaporation. Also, the analyses show that nitrogen removal is essentially complete in the ponds. The removal is due to algae and other plants in the oxidation ponds.

From a pollution standpoint, the sewage effluent areas are considered to have a low impact on the aquifer. The analyses show that the mineral content of the sewage effluent is not very concentrated in comparison to native ground water. Also, the volumes of effluent are small, particularly in comparison to the likely ground-water underflow beneath the effluent discharge areas. Comparative calculations of the amounts of ground-water flow beneath the discharge areas and of the maximum leakage rates indicate that only very small increases in mineralization of ground water are likely beneath the effluent seepage areas. Moreover, sampling of those wells in the vicinity of the treatment plants shows natural water quality variations in the Seymour are relatively large, essentially large enough to mask effects of the sewage plant discharge.

Landfills and Dumps

Landfills and dumps are sometimes sources of significant ground-water pollution because of leachate production which occurs when sufficient water from precipitation or surface drainage infiltrates and dissolves decomposition products. Normally, leachate from municipal landfills contains high concentrations of total dissolved solids, calcium, magnesium, chloride, iron, and nitrate. The amount of precipitation, surface-water runoff, and especially solid waste are important factors in determining leachate production from landfills and dumps.

Two landfills and a dump are located on the Seymour Formation. All receive small amounts of solid waste. They are:

Town	Location	Type	Date Started
Rochester	6 miles NW	Trench Landfill	1940's
O'Brien	1 mile N	Trench Landfill	1970
Knox City	1 mile NW	Dump	Old

Landfills for other towns in the area are located off the Seymour Formation.

The facilities are considered to have a low to negligible impact on the Seymour aquifer. The rate of natural ground-water flow beneath the solid waste disposal operations is likely to be large in relation to the amount and quality of leachate produced. Most probably, pollutants reaching the ground water from these facilities are diluted substantially by underflow. Even so, it is probably important to minimize infiltration at the sites and not to dispose of highly toxic wastes.

Agricultural Operations

The pollution of ground water can occur from a number of activities associated with agriculture. Agricultural chemicals which pose the largest threats are fertilizers and pesticides.

Fertilizers

Large quantities of fertilizers were not used on the Seymour Formation until the 1950's. Application rates of fertilizers have increased over the years. At present and in the past, more fertilizer has been used on irrigated farmland than on non-irrigated farmland. Current application rates for the major crops in terms of pounds of actual nitrogen per acre are about 30 to 50 pounds per acre for wheat and cotton and 80 to 120 pounds per acre for grain sorghum. Rates for coastal Bermuda grass and potatoes range from 150 to 400 pounds per acre, but the total acreage of these crops is only a few thousand acres.

Chemical analyses of water samples from areas of highest fertilizer applications (potatoes and Bermuda grass) do not show concentrations of nitrate indicating pollution from overfertilization. Also, analyses for public supply wells, having periods of record ranging up to approximately 25 years, do not show any long-term increases in nitrate content attributable to overfertilization.

The 1936 chemical quality data for Knox County lacks nitrate determinations (Figure 37). Consequently, very few chemical analyses are available with nitrate determinations prior to 1944, and later data for comparisons of nitrate content are limited. Comparisons between chemical analyses of samples taken in 1944 from a few wells with those taken in

1975–1977 from the same wells indicate no significant changes in nitrate values. Chemical analyses of samples taken in 1956 and again in 1975–1977 from the same 16 wells are available. The wells are distributed over the formation and consist of seven irrigation and nine public supply wells. The nitrate concentration in 12 of the wells was higher in 1975–1977 than it was in 1956. Increases range from 8 to 59 mg/l and average 18 mg/l. The average nitrate content for all 16 wells in 1956 was 54 mg/l and in 1975–1977 was 64 mg/l, an average change of 10 mg/l in about 20 years. The analyses indicate that overly large increases in nitrate content are not occurring. The data are considered inconclusive as to whether small increases are occurring. This is because the number of wells for which past comparative analyses are available is limited. Also, there are contributing factors which make it difficult to evaluate the long-term effect from fertilizers with available data. These mostly include the precision of analyses and the types and locations of wells for which data are available.

Wendt, et al (1976), based upon studies of test plots using various types of irrigation and methods of applying fertilizer, concluded that current fertilization practices are not causing major increases in the nitrate level in the Seymour. Kreitler (1978) has interpreted differences in nitrogen isotope values for the Seymour aquifer and for unfertilized cultivated areas in Runnels County, Texas, as indicating some contribution to the Seymour's nitrate content from fertilizers. However, a quantitative indication of percent contributed from fertilizer as opposed to natural soil nitrate from cultivation could not be made.

It appears a careful monitoring program will be necessary to evaluate long-term quality changes due to fertilization.

Return Flow

Contamination of ground water often results from return flow which is irrigation water that finds its way back into the aquifer. Dissolved minerals in water can undergo significant changes in concentration and composition as a result of irrigation operations.

Past chemical analyses were analyzed to determine if they indicate any large overall increases in concentrations of minerals in the Seymour water due to irrigation return flow. The available analyses indicate no large changes, but the numbers of past comparative analyses are too few to determine the occurrence of small changes. Present indications are that return flows are a minor part of the hydrologic system, quantitatively. Significant changes in mineralization of Seymour water from return flows are unlikely, except over many decades. A careful, long-term monitoring program will be required to determine effects on water quality from irrigation return flow.

Pesticides

Pesticide contamination of ground water from agricultural use is far less common than nitrate pollution. Pesticides are applied usually in very limited quantities and only a few times a year. Probably, the danger of pollution is more from spills, handling practices, and storage facilities than from land application.

Eleven water samples from wells were obtained for analysis of pesticides (Table 23). Wells sampled included those at all the flying services which apply pesticides commercially and a few miscellaneous wells. All sample results showed amounts less than or near detectable limits, except for one sample obtained from a well located at an aerial spraying service. The well sample (RS 21-34-532) showed 6.7 micrograms per liter of toxaphene which, although low, surpasses drinking water standards which specify a maximum level of 5.0 micrograms per liter. The occurrence of toxaphene in the well water indicates pollution from a close source, perhaps surface spills or washing of tanks and containers.

Animal Wastes

Nitrate pollution of the Seymour aquifer from feedlots and barnyards is considered unimportant. Reportedly, only one feedlot has been located in the area. It is currently abandoned. The number of barnyards and animals involved is small. The nitrate content at some localities probably is partly due to animal waste from present or past barnyards; however, there are no indications that the amounts are very significant to the aquifer.

Evapotranspiration in Areas of Natural Discharge

Evapotranspiration can cause concentration of minerals in ground water. This appears to occur only in a few areas of natural discharge mostly along and near the edges of the Seymour aquifer. These localities, however, are not very important to the water quality in the Seymour as the more mineralized water soon discharges from the aquifer by seeps and springs. Areas of evapotranspiration, which are away from the edge of the aquifer, show no recognizable effects on water quality. Accordingly, evapotranspiration is not considered an important water quality determinant.

Future Extent and Significance of Pollution

It is estimated that about 2 percent of the water in the Seymour aquifer is affected presently by pollution. The pollution is due principally to past pollution sources and activities and not to current practices. It is estimated that the relative importance of the various sources is approximately as follows:

Source	Type of Pollution	Estimated Percent of Existing Pollution
Oil Field Disposal Pits	Brine	75
Injection Wells and Unplugged Holes	Brine	20
Septic Tanks	Nitrate	4
All Others	Various	1

The portions of the aquifer affected by pollution will increase in the future due to the natural movement of ground water and to spreading effects caused by pumping wells. However, the portions of the aquifer affected by significant pollution will not become extremely large in the future. Significant pollution problems mostly will be confined to individual properties as opposed to large areas of the aquifer.

Existing pollution plumes from past and current pollution sources will continue to move in the direction of ground-water movement as depicted generally on Figure 31. Movement rates will be governed by local hydraulic gradients and permeabilities. Additional wells further from the original sources will be affected eventually. As each plume moves farther from its source, more lateral dispersion will occur. Intermittent pumping of irrigation wells will hasten the lateral dispersion. Very gradually, concentrations of pollutants will decrease.

Pollution plumes consisting of waters having only moderately higher concentrations than natural Seymour waters will tend to loose their identity before they travel long distances. This is the case for most septic tank pollution. However, plumes consisting of large quantities of highly concentrated pollutants can move long distances with little significant change in pollutant concentration. Accordingly, additional brine pollution will occur in the future at locations increasingly farther from original sources.

Some pollution plumes, mostly originating from past oil field activities, are presently relatively near and moving toward the edge of the aquifer. At such locations, the pollution will be discharged from the formation within a relatively short time and present no further threat to wells in the aquifer. However, other significant pollution plumes are located such that long to very long time periods will be required for the pollutants to either move to natural discharge points or be dispersed naturally and by pumping from wells.

To generally depict the minimum time required for the natural flushing of the aquifer from various locations, calculations have been made of travel times from various points in the aquifer to the edge of the aquifer. The calculations are based on an average hydraulic gradient (7.6 feet per mile) and permeability (4,200 gpd/ft^2), and a porosity of 30 percent. This results in a movement rate of 983 feet per year. Based on this rate, representative minimum travel times are shown on Figure 56 for several locations. The travel times to the edge of the aquifer from locations nearer the edge of the aquifer range up to about 20 years, whereas those from other areas range up to 140 years. Figure 56 is indicative generally of the minimum travel times from various points in the aquifer to areas of natural discharge assuming no pumping from wells. The effects of pumping will lengthen the time period required for the pollution to move to the edge of the aquifer. For short paths, the effects may be small. For the longest paths, the effects will be large, so large that some pollution plumes will be dispersed, diluted, and pumped from the aquifer before ever reaching the edge of the aquifer.

Methods of Controlling Pollution

The best way to deal with pollution and the Seymour aquifer is on the basis of prevention rather than correction. The Seymour, like most ground-water reservoirs, is slow acting. Correcting existing pollution can take years, or even decades, and is generally very costly. Thus, the elimination of current pollution sources is of particular importance.

Tanks, pipelines, and injection and water flood wells should be inspected and/or tested periodically. Quarterly checks are recommended for these potential sources, if they are not checked more frequently. Existing unlined waste disposal and "emergency" pits should be eliminated. Generally, elimination of septic tanks is impractical except in those areas where municipal sewer systems can be used. For wells in rural areas, the most practical way to cope with a water well showing the effect of septic tank discharge is to relocate the well. The well should be located generally up gradient from septic tanks and at a sufficient distance to avoid drawing in any septic tank discharge. Normally, 150 feet is sufficient for aquifers similar to the Seymour, but this depends on local conditions.

For past pollution sources, it is only possible to deal with the resulting pollution plumes either by removal or avoidance measures. Generally, pollution removal measures in the case of the Seymour involve pumping by wells to remove the pollutants from the aquifer. Typically, this is impractical due to the large volumes of water that must be pumped and the relatively long pumping times required. Occasionally, such pumping can be an effective way of dealing with pollution, but normally, only if there is some practical use for the pumped water such as water flooding. Typically, if the water is not used for water flooding and is so highly polluted that it cannot be blended with other water and used for irrigation, then disposal of the pumped water becomes an unbearable cost factor. Avoidance methods include relocating wells affected by pollution or selective pumping and blending to obtain a quality of water that can be used. These can be effective methods if the pollution is not severe or if the property involved is large, and large quantities of unpolluted water can be obtained.

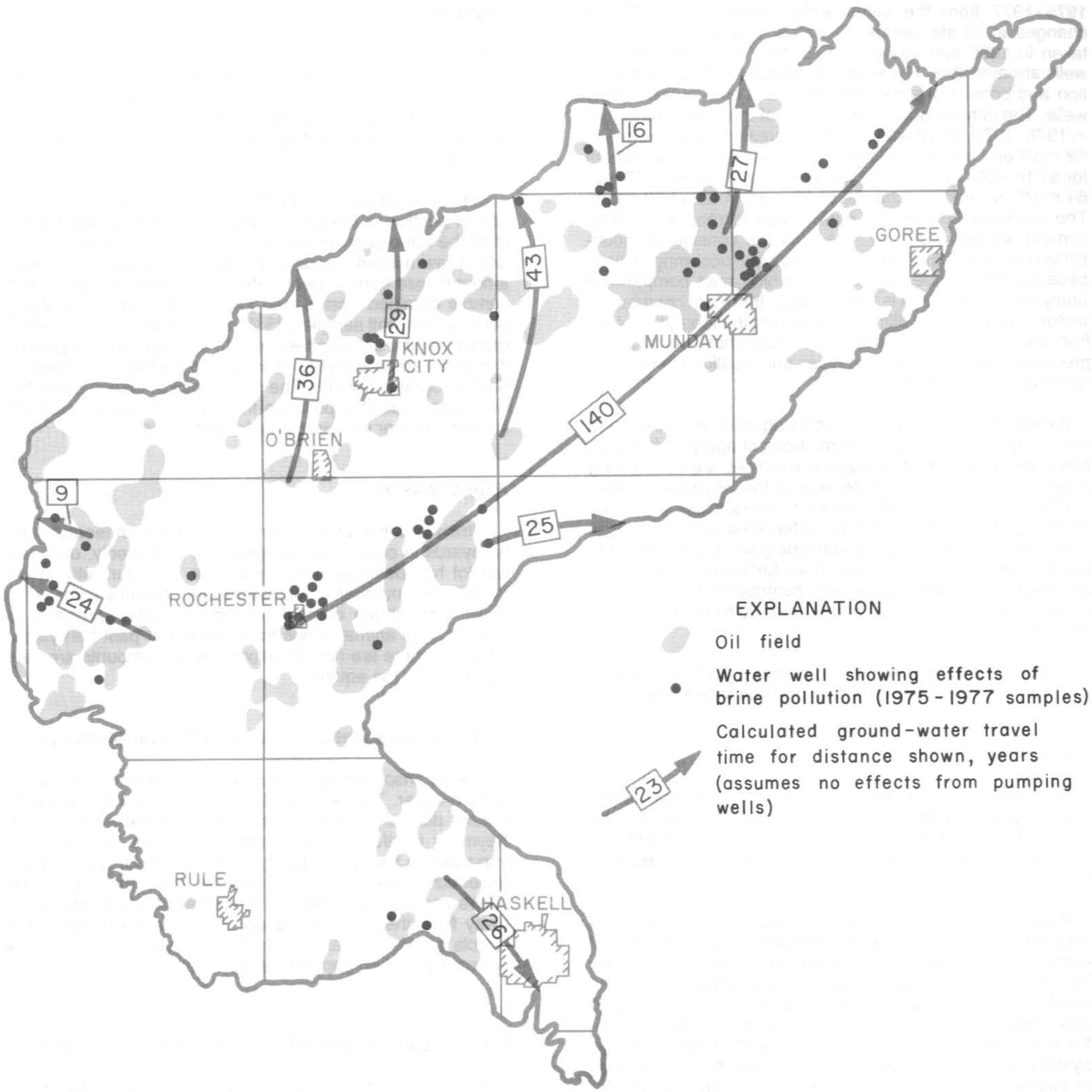


Figure 56. Calculated Travel Times for Pollution

RECOMMENDATIONS FOR MONITORING PROGRAM

At present, annual water-level measurements are made by the Texas Department of Water Resources in approximately 38 wells in the Seymour aquifer in Haskell and Knox Counties. It is recommended that the present program be modified to provide more representative coverage of the aquifer and to include those areas developed for irrigation which currently have no observation wells. It is recommended that the following wells be included in an annual water-level observation program:

RS 21-27-801
RS 21-27-913
RS 21-28-401
RS 21-28-813
RS 21-28-910
RS 21-29-405
RS 21-33-707
RS 21-33-901
RS 21-34-202
RS 21-34-501
RS 21-34-601
RS 21-35-102
RS 21-35-201
RS 21-35-301
RS 21-35-402
RS 21-35-602
RS 21-35-535
RS 21-36-103
RS 21-36-201
RS 21-36-303
RS 21-36-415
RS 21-36-501
LP 21-34-702
LP 21-34-902
LP 21-35-801
LP 21-41-138
LP 21-41-318
LP 21-41-501
LP 21-41-616
LP 21-41-801
LP 21-42-104
LP 21-42-201
LP 21-42-409
LP 21-42-502
LP 21-42-701
LP 21-43-109
LP 21-49-301
LP 21-49-502
LP 21-49-601
LP 21-50-106
LP 21-50-307
LP 21-50-401
LP 21-50-506
LP 21-51-710

The annual municipal pumpage survey of the Texas Department of Water Resources is satisfactory, but annual pumpage for irrigation purposes should be estimated and updated approximately at 5-year intervals.

It is recommended that the water quality of municipal wells be checked annually to determine any changes important for public supply purposes and to keep abreast of overall long-term quality. Other programs of water-quality monitoring can be instigated as needed to evaluate special concerns such as long-term effects of fertilizers and return flow, and specific local pollution problems. For all investigations of brine pollution problems, it is recommended that analyses include sulfate determinations as well as chloride determinations and that the locations of samples be noted on 7½-minute topographic maps.

BIBLIOGRAPHY

Abilene Geological Society, 1974, North Juliana Field, Haskell County, Texas, *Abilene* [Texas] *Geological Society Newsletter*, July 8, 1974.

Bader, J. S., and others, 1973, Selected References—Ground-Water Contamination—The United States of America and Puerto Rico, U.S. Geological Survey, Open-File Report 74-225.

Baker, R. C., Hughes, L. S., and Yost, I. D., 1964, Natural Sources of Salinity in the Brazos River, Texas—With Particular Reference to the Croton and Salt Croton Creek Basins, U.S. Geological Survey, Water-Supply Paper 1669-CC.

Bandy, W. A., 1934, Ground Water in Northwest Haskell County, Texas Board of Water Engineers, letter report.

Barnes, Jack R., 1957, Investigation of Salt Water Pollution in a Part of Haskell County, Texas, Jack R. Barnes, Engineer-Geologist, typewritten report, Austin, Texas.

Broadhurst, W. L., and Follett, C. R., 1944, Preliminary Report of the Ground-Water Resources Near Stamford in Jones and Haskell Counties, Texas, U.S. Geological Survey, Open-File Report.

Burnitt, S. C., 1963, Reconnaissance of Soil Damage and Ground-Water Quality, Fisher County, Texas, Texas Water Commission, Memorandum Report Number 63-02.

Busby, Frank E., Jr., and Schuster, Joseph L., 1973, Woody Phreatophytes Along the Brazos River and Selected Tributaries Above Possum Kingdom Lake, Texas Water Development Board, Report 168.

Carlson, Carl W., and others, 1976, Land Application of Waste Materials, Soil Conservation Society of America, Ankeny, Iowa.

Collins, A. Gene, 1975, Possible Contamination of Ground Waters by Oil- and Gas-Well Drilling and Completion Fluids, U.S. Energy Research and Development Administration, Bartlesville Energy Research Center, duplicated report.

Cronin, J. G., Follett, C. R., Shafer, G. H., and Rettman, P. L., Reconnaissance Investigation of Ground-Water Resources of the Brazos River Basin, Texas Water Commission, Bulletin 6310.

Crouch, Robert L., 1964, Investigation of Ground-Water Contamination in the Juliana and West Jud Oil Fields, Haskell and Stonewall Counties, Texas, Texas Water Commission, LD-0364-MR.

Dallas Morning News, 1975, *Texas Almanac and State Industrial Guide 1976–1977*, A. H. Belo Corporation.

Dalquest, Walter W., and others, 1959, A Guide to the Upper Permian and Quaternary of North Central Texas, North Texas Geological Society, September 26, 1959, Wichita Falls, Texas.

Dickerson, Charles H., and Prewitt, Robert H., Jr., 1952, Sojourner Field, Haskell County, Texas, *Geological Contributions*, Abilene [Texas] Geological Society.

Draper, Donald C., 1960, Investigation of Contamination Complaint in South-Central Knox County, Texas, Texas Board of Water Engineers, Contamination Report Number 7.

Eaton, F. M., 1950, Significance of Carbonates in Irrigation Waters, *Soil Science*, Volume 59.

Edwards, H. S., 1952, North Knox City (Canyon) Field, Knox County, Texas, *Geological Contributions*, Monroe G. Cheney Memorial Volume, Abilene [Texas] Geological Society.

Feth, J. H., 1966, Nitrogen Compounds in Natural Water—A Review, American Geophysical Union, *Water Resources Research*, Volume 2, Number 1, Washington, D.C.

Follett, C. R., 1955, Records of Water-Level Measurements in Haskell and Knox Counties, Texas, 1941–1955, Texas Board of Water Engineers, Bulletin 5503.

Follett, C. R., and Dante, John H., 1945, Ground Water in the Vicinity of Benjamin, Texas, U.S. Geological Survey, Open-File Report.

Fryberger, J. S., 1972, Rehabilitation of a Brine-Polluted Aquifer, U.S. Environmental Protection Agency, EPA-R2-72-014.

Frye, John C., and Leonard, A. Byron, 1963, Pleistocene Geology of Red River Basin in Texas, Bureau of Economic Geology, University of Texas, Report of Investigations Number 49.

Gard, Chris, 1955, Ground-Water Conditions in Knox and Haskell Counties, Texas Board of Water Engineers, interoffice report.

George, William O., and Hastings, Warren W., 1951, Nitrate in the Ground Water of Texas, Transactions, American Geophysical Union, Volume 32, Number 3, Washington, D.C.

Gordon, C. H., 1913, Geology and Underground Waters of the Wichita Region, North-Central Texas, U.S. Geological Survey, Water-Supply Paper 317.

Hem, John D., 1959, Study and Interpretation of the Chemical Characteristics of Natural Water, U.S. Geological Survey, Water-Supply Paper 1473 (Reprinted in 1971).

Holloway, Harold D., 1965, Investigation of Ground-Water Contamination, Rhineland Area, Knox County, Texas, Texas Water Commission, Bulletin 6521.

Huggins, L. P., and Turner, Samuel F., 1937, Knox County, Texas—Records of Wells, Drillers' Logs, and Water Analyses, and Map Showing Location of Wells, Texas Board of Water Engineers, duplicated report.

Jones, David C., 1973, An Investigation of the Nitrate Problem in Runnels County, Texas, U.S. Environmental Protection Agency, EPA-R2-73-267.

Klemt, William B., Duffin, Gail L., and Elder, Glenward R., 1976, Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas, Volume 1, Texas Water Development Board, Report 210.

Kohl, D. H., Shearer, O. B., and Commoner, B., 1971, Fertilizer Nitrogen: Contribution to Nitrate in Surface Water in a Corn Belt Watershed, *Science*, 174.

Kreitler, Charles W., 1975, Determining the Source of Nitrate in Ground Water by Nitrogen Isotope Studies, Bureau of Economic Geology, The University of Texas at Austin, Report of Investigations Number 83.

——— 1978, Nitrogen Isotope of Soil and Ground-Water Nitrate From Lockhart-Taylor and Seymour Alluvial Fan Aquifers, Bureau of Economic Geology, University of Texas at Austin, duplicated report.

Krusekopf, Henry H., Jr., 1972, Water Pollution Study, Knox County, Texas, Texas Railroad Commission, file report.

Lyerly, P. J., and Longenecker, D. E., 1957, Salinity Control in Irrigation Agriculture, Texas A&M University, Bulletin 876 (1962).

——— 1957, Control of Soluble Salts in Farming and Gardening, Texas A&M University, Bulletin 876 (1974).

Maier, F. J., 1950, Fluoridation of Public Water Supplies, *American Water Works Association Journal*, Volume 42, Number 1, Part 1, Denver, Colorado.

Maxcy, Kenneth F., 1950, Report on the Relation of Nitrate Nitrogen Concentrations in Well Waters and the Occurrence of Methemoglobinemia in Infants, Sanitary Engineering and Environment (App. D), National Research Council Bulletin, Washington, D.C.

McClung, Dan, 1956, Preliminary Report on the Baylor-Knox Shallow Producing Trend, *Geological Contributions*, Abilene [Texas] Geological Society.

McMillion, Leslie G., Sr., and Maxwell, Bruce W., 1970, Determination of Pollutional Potential of the Ogallala Aquifer by Salt Water Injection, National Technical Information Service, PB-202-227, U.S. Department of Commerce, Springfield, Virginia.

McNabb, James F., Dunlap, William J., and Keeley, Jack W., 1977, Nutrient, Bacterial, and Virus Control as Related to Ground-Water Contamination, U.S. Environmental Protection Agency, EPA-600/8-77-010.

McNeel, Fred, 1975, Investigation of Possible Chloride Contamination of the Seymour Aquifer, Knox and Baylor Counties, North-Central Texas—With Regard to Area Oil Field Operations, Texas Railroad Commission, duplicated report.

Ogilbee, William, and Osborne, F. L., Jr., 1962, Ground-Water Resources of Haskell and Knox Counties, Texas, Texas Water Commission, Bulletin 6209.

Oklahoma Water Resources Board, 1975, Salt Water Detection in the Cimarron Terrace, Oklahoma, U.S. Environmental Protection Agency, EPA-660/3-74-033.

Patt, Ralph O., and Hess, John W., 1976, Characterization of Nitrogen Sources Contaminating Shallow Ground Water in an Arid Basin, Las Vegas Area, Nevada, Water Resources Center, Desert Research Institute, University of Nevada System, Technical Report Series H-W, Hydrology and Water Resources, Publication Number 26.

Patton, L. T., 1930, The Geology of Stonewall County, Texas, University of Texas, Bulletin 3027.

Payne, Roy D., 1967, Pollution Control for Oil Field Brines, Texas Railroad Commission, duplicated report.

Preston, Richard D., 1978, Occurrence and Quality of Ground Water in Baylor County, Texas, Texas Department of Water Resources, Report 218.

Price, Robert D., 1978, Occurrence, Quality, and Availability of Ground Water in Jones County, Texas, Texas Department of Water Resources, Report 215.

Raschke, Alvin, 1966, Salt Water Disposal Pits in Knox County, Texas, Texas Railroad Commission, duplicated report.

Rawson, Jack, 1967, Study and Interpretation of Chemical Quality of Surface Waters in the Brazos River Basin, Texas, Texas Water Development Board, Report 55.

Rawson, Jack, Flugrath, M. W., and Hughes, Leon S., 1967, Sources of Saline Water in the Upper Brazos River Basin, Texas, U.S. Geological Survey, Open-File Report Number 108.

Robinson, T. W., 1958, Phreatophytes, U.S. Geological Survey, Water-Supply Paper 1423.

Stearman, Jack, 1960, Water Levels in Observation Wells in Haskell and Knox Counties, Texas, 1956–1960, Texas Board of Water Engineers, Bulletin 6009.

Stricklin, Fred L., 1961, Degradational Stream Deposits of the Brazos River, Central Texas, *Geological Society of America Bulletin*, Volume 72, January 1961.

Summers, W. K., and Spiegel, Zane, 1975, *Ground Water Pollution—A Bibliography*, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan.

Sundstrom, R. W., Broadhurst, W. L., and Dwyer, Mrs. B. C., 1947, Public Water Supplies in Central and North-Central Texas, Texas Board of Water Engineers, duplicated report.

Texas Department of Agriculture, 1975, 1975 Texas Cotton Statistics, Texas Department of Agriculture.

——— 1976, 1976 Texas Field Crops Statistics, Texas Department of Agriculture.

——— 1976, 1976 Texas Livestock Statistics, Texas Department of Agriculture.

——— 1976, 1976 Texas Small Grains Statistics, Texas Department of Agriculture.

Texas Department of Health, 1977, Drinking Water Standards Governing Drinking Water Quality and Reporting Requirements for Public Water Supply Systems, Division of Water Hygiene, Texas Department of Health, duplicated report.

Texas Railroad Commission, (various dates), A Survey of Secondary Recovery and Pressure Maintenance Operations in Texas, Texas Railroad Commission, Bulletins:

Years Covered	Texas Railroad Commission Bulletin No.
Beginning of operations to 1952	—
1952 to 1954	47
1954 to 1956	—
1956 to 1958	—
1958 to 1960	60
1960 to 1962	62
1962 to 1964	64
1964 to 1966	66
1966 to 1968	68
1968 to 1970	70
1970 to 1972	72

——— 1957, Saltwater Inventory for 1956, Texas Railroad Commission, computer tabulation.

——— 1976, Annual Report of the Oil and Gas Division, 1976, Texas Railroad Commission.

Texas Water Commission and Texas Water Pollution Control Board, 1963, A Statistical Analysis of Data on Oil Field Brine Production and Disposal in Texas for the Year 1961, From an Inventory Conducted by the Railroad Commission of Texas.

Texas Water Development Board, 1971, Inventories of Irrigation in Texas 1958, 1964, and 1969, Texas Water Development Board, Report 127.

U.S. Environmental Protection Agency, 1974, Methods for Chemical Analyses of Water and Wastes, Methods Development and Quality Assurance Research Laboratory, National Environmental Research Center, U.S. Environmental Protection Agency, EPA-625-/6-74-003.

——— 1975, Water Programs—National Interim Primary Drinking Water Regulations, *Federal Register*, Volume 40, Number 248.

U.S. Geological Survey, (various dates), 7 1/2-minute topographic maps:

Antelope Creek NW	1:24,000
Benjamin	1:24,000
Bomarton	1:24,000
Cedar Mountain	1:24,000
Dudleys Creek	1:24,000
Haskell	1:24,000
Hefner	1:24,000
Irby	1:24,000
Jud	1:24,000
Kiowa Peak	1:24,000
Kiowa Peak NE	1:24,000
Knox City	1:24,000
Knox City NW	1:24,000
Lake Stamford East	1:24,000
Lake Stamford West	1:24,000
Mattson	1:24,000
Munday East	1:24,000
Munday West	1:24,000
Old Glory	1:24,000
Pinkerton	1:24,000
Rhineland	1:24,000
Rochester	1:24,000
Rule	1:24,000
Sagerton	1:24,000
Weinert	1:24,000

U.S. Salinity Laboratory Staff, 1954, Diagnosis and Improvement of Saline and Alkali Soils, U.S. Department of Agriculture, Agriculture Handbook Number 60.

Walker, William R., and Cox, William E., 1976, Deep Well Injection of Industrial Wastes: Government Controls and Legal Constraints, Virginia Water Resources Research Center.

Weinburger, Leon W., and others, 1969, Animal Waste Management, Cornell University Conference on Agricultural Waste Management, Cornell University, Ithaca, New York.

Wendt, Charles W., Onken, Arthur B., and Wilke, Otto C., 1976, Effects of Irrigation Methods on Groundwater Pollution by Nitrates and Other Solutes, U.S. Environmental Protection Agency, EPA-600/2-76-291.

White, W. N., 1932, A Method of Estimating Ground-Water Supplies Based on Discharge by Plants and Evaporation From Soil—Results of Investigations in Escalante Valley, Utah, U.S. Geological Survey, Water-Supply Paper 659-A.

Wilcox, L. V., 1955, Classification and Use of Irrigation Waters, U.S. Department of Agriculture, Circular 969.

Wilson, Wynant S., 1956, The Weinert West Strawn Field, Haskell County, Texas, *Geological Contributions*, Abilene [Texas] Geological Society.

Woods, Calvin, and Hughes, J. Martin, 1973, Ground-Water Resources in the Seymour Formation, Haskell and Knox Counties, Environmental Engineering Division, Department of Civil Engineering, Texas A&M University.

APPENDIX

EFFECTS ON HUMANS AND ANIMALS OF NITRATE CONCENTRATIONS IN WATER SUPPLIES AS RELATED TO THE SEYMOUR AQUIFER

INTRODUCTION

In response to the concern of the citizens of Haskell and Knox Counties regarding the relatively high level of nitrate in their water supplies, a literature survey was conducted on the effects on humans and animals of high nitrate consumption. The purpose of the survey was to apply the knowledge which is currently known about nitrate consumption and its effects on humans and animals to the situation as it now exists in Haskell and Knox Counties.

The literature was compiled and reviewed by R. W. Harden & Associates with the help of Dr. Robert Darrow, Southwestern Medical School, using a computerized reference network. This paper is based on articles which were readily available and which are listed in the references and bibliography sections of this appendix. The bibliography is a comprehensive list of representative publications on health and nitrate-related topics. Due to the scarcity of some of the articles, not all were consulted as part of this review.

OCCURRENCE OF NITROGEN

Nitrogen occurs naturally and artificially. Humans and animals come into contact with several forms of nitrogen through water and food supplies. The occurrence of nitrogen in ground water is usually in the form of nitrate. Nitrate in ground water can result from natural mineral deposits, soil nitrate, and contaminating sources such as septic tanks, feedlots, sewage disposal plants, and fertilizers. Consumed in excessive amounts, nitrate can be hazardous to humans and animals because chemical processes of the body can change nitrate to nitrite, another form of nitrogen which can have adverse effects on health.

The following table shows the different ways in which the different forms of nitrogen can be expressed and also provides equivalent values and conversion methods.

Conversion Methods and Equivalent Values for Different Forms of Nitrogen

Nitrate as nitrate (NO_3) x .226 = nitrate as nitrogen (N)
Nitrate as nitrogen (N) x 4.43 = nitrate as nitrate (NO_3)

Example: 45 mg/l nitrate as nitrate
is equivalent to
10 mg/l nitrate as nitrogen

Nitrite as nitrite (NO_2) x .304 = nitrite as nitrogen (N)
Nitrite as nitrogen (N) x 3.29 = nitrite as nitrite (NO_2)

Example: 10 mg/l nitrite as nitrite
is equivalent to
3 mg/l nitrite as nitrogen

Normally, chemical analyses of ground water express the amount of nitrate present as nitrate or as nitrogen. In this review, amounts of nitrate are expressed in milligrams per liter (mg/l) of nitrate as nitrate.

NITRATE AS A HEALTH HAZARD

Methemoglobinemia

Methemoglobinemia is the major concern whenever excessive amounts of nitrate are consumed. It can occur in humans and animals. In humans, nitrate toxicity is related primarily to age and health, while in animals the toxicity is related primarily to the species involved. However, many variables such as body chemistry and diet affect susceptibility to methemoglobinemia. These variables are significant in evaluating the causes of this disease as they are the reasons why some animals and/or humans are affected by a given level of nitrate consumption while others are not affected by the same levels.

In condensed and simplified description, acute toxicity of nitrate occurs as a result of its reduction to nitrite, a process which occurs in the stomach and the mouth by bacterial action. Nitrite changes hemoglobin, the oxygen-carrying element in the blood, to methemoglobin, which cannot carry oxygen (Gass, 1978). The incapability of the methemoglobin to carry oxygen results in "cellular suffocation" referred to as methemoglobinemia. This illness is not usually serious if diagnosed by a doctor; however, an untreated case could result in death. Methemoglobinemia is treated with methylene blue, and in almost all instances a rapid recovery follows, usually within a few hours. In some cases, the condition is remedied by merely discontinuing ingestion of the contaminated water (Ridder and Oehme, 1974).

Methemoglobinemia in Humans

In 1945, Comly was the first to diagnose methemoglobinemia in humans resulting from the consumption of an excessive amount of nitrate. Since Comly's report, only about 2,000 cases have been reported world-wide (Shearer and others, 1972). Unfortunately, in recent years, little attention has been given to methemoglobinemia and consumption of high nitrates in medical literature (Miller, 1971). It is known, however, that the most dominant type of this illness is infantile methemoglobinemia. In general, infants of less than three months of age are most susceptible. The susceptibility of the infant to this disease is dependent on a number of factors, mainly the quantity of nitrate consumed, the duration of exposure to the nitrate, diet, and the general health of the child. Also, there is some evidence that bacterial contamination in a baby's formula might elevate the methemoglobin level of the child (Shearer and others, 1972).

Normal, healthy adults do not appear to be susceptible to methemoglobinemia with the exception of pregnant women and those people on dialysis machines (Ridder and Oehme, 1974 and Carlson and Shapiro, 1970). If the dialysate is made from water high in nitrates, methemoglobinemia can occur.

A symptom of methemoglobinemia in humans is a blue or brownish tint to the fingers, toes, and around the mouth which spreads eventually to the entire body. This symptom is often accompanied by headaches, shortness of breath, and general weakness. Blood samples taken from methemoglobinemia patients are often chocolate-brown in color (Bosch and others, 1950).

The exact concentrations of nitrate which cause methemoglobinemia are unknown. The problem is that this concentration seems to vary from person to person because of individual characteristics as previously mentioned. Statistics from Sattelmacher (1962) and Simon and others (1964) are summarized below.

Distribution of Reported Cases
of Infantile Methemoglobinemia by
Nitrate Concentration in the Water

Sattelmacher, 1962

	Reported Cases	Deaths	Nitrate Concentration in Water, mg/l Unknown	Known	0-40	41-80	81-100	>100
Numerical	1,060	83	593	467	14	16	19	418
Percent	100	7.8	56.0	44.0	3.0*	3.4*	4.1*	89.5*

Simon and Others, 1964

	Reported Cases	Deaths	Nitrate Concentration in Water, mg/l Unknown	Known	<50	50-100	>100
Numerical	745	64	496	249	11	29	209
Percent	100	8.6	66.5	33.5	4.4*	11.8*	83.8*

*Percent of cases with nitrate concentration known.

Currently, most state and federal agencies recommend a maximum nitrate concentration of 45 mg/l for drinking water. Since cases of methemoglobinemia have occurred where the nitrate concentrations were lower than 45 mg/l, some authors feel even this limit may not provide an adequate margin of safety (Gass, 1978).

Methemoglobinemia in Animals

As in humans, the exact nitrate concentrations which cause health problems in livestock are not known. A study by Emerick in 1964 concluded that 100 mg/l is well within the range that can be considered safe for all classes of livestock; higher nitrate levels have been used satisfactorily, but such use is not without inherent risks. As with humans again, the degree of susceptibility to methemoglobinemia by livestock depends on numerous variables including the type of animal, health, and the amount and speed of consumption of the contaminated water (Ridder and others, 1974). The nutritional quality of the animal's diet is important also: Rations high in vitamin A and carbohydrates seem to reduce the effects of nitrate while rations high in nitrate such as oat hay and corn stalks aggravate and/or cause nitrate toxicity (Ridder and Oehme, 1974).

Cud-chewing animals such as deer, goats, sheep, and especially cattle are much more susceptible to methemoglobinemia than are the single-stomach (monogastric) species such as pigs, dogs, and horses. Symptoms in cattle are generally shortness of breath, grinding of teeth, and a lowered blood pressure.

Pigs, being monogastric, are less likely to contract methemoglobinemia because their blood oxidation rate is much slower, resulting in a slower process of transition of hemoglobin to methemoglobin (Ridder and others, 1974). Pigs also seem to be unable to transform nitrate into the more dangerous nitrite form; accordingly, they are susceptible only to nitrite formed prior to consumption as in some moist feeds (Ridder and Oehme, 1974). In cases where methemoglobinemia is contracted by a pig, it terminates rapidly in death (Smith and Beutler, 1966). Treatment is difficult because pigs frequently show no external signs of the condition, and there is a lack of response to methylene blue treatments (Ridder and Oehme, 1974 and Smith and Beutler, 1966). Nitrate ingestion by swine also causes erosion of the gastric mucous which usually causes the actual death of the pig before the methemoglobinemia.

The effect of methemoglobinemia on poultry is a function of the age of the affected animal. Results of studies show that as the level of nitrate in feed increased to 200 mg/l, there were corresponding decreases in water and feed consumption, and growth of poults. The same level of nitrate had very little affect on feed and water consumption, blood methemoglobin, and mortality of chicks. In a study of layers, levels up to 300 mg/l nitrate failed to consistently affect rate of lay, egg quality, daily water consumption, and mortality. In general, 300 mg/l nitrate seems to be safe for poultry, and chicks, poults, and layers have been recorded to tolerate doses of nitrate in excess of 1,300 mg/l (Adams and others, 1966).

Chronic Nitrate Toxicity in Humans and Animals

Chronic nitrate toxicity due to long-term, low-level nitrate intake is recognized, but documented reports are inconsistent. Some controversial signs of chronic nitrate toxicity reportedly observed are vitamin A deficiency in humans, cattle, swine, chickens, and dogs; thyroid dysfunction in cattle, poults, chicks, and humans; reduced rates of growth in cattle, poults, chicks, and swine; reproduction difficulties, lowered milk production, diarrhea, and shortened life span in cattle; and arthritic conditions and iron deficiencies in swine (Ridder and Oehme, 1974).

Attention has been given to the possible formation of nitrosamines, some of which may be carcinogenic (cancer-causing) in humans and animals, as a result of nitrate consumption (Gass, 1978 and *The Lancet*, 1968).

The literature reviewed was inconsistent regarding which of the above ailments were related directly to what levels of nitrate consumption. However, all articles stated consistently that further studies are needed to better define the nature and consequences of chronic nitrate toxicity.

CONCLUSIONS

In regard to what levels of nitrate are safe for humans and animals, the results of the reports reviewed differ somewhat because of variations in research design and study environments. Generally, the literature indicates that nitrate concentrations of 45 mg/l and 100 mg/l are considered reasonably safe for humans and animals, respectively. However, because humans and animals have been recorded as tolerating somewhat higher concentrations of nitrate with seemingly no ill effects, it is evident that safe limits are difficult to establish due to many variables which affect individual tolerances. The general consensus of the articles reviewed is that more study is needed on the topic of nitrate consumption.

Nitrate Levels in the Seymour Aquifer

Over 70 percent of 820 wells in the Seymour aquifer tested recently exceed the recommended nitrate level for drinking water of 45 mg/l. Most values are between 30 and 90 mg/l.

Nitrate values for wells furnishing municipal needs have the following ranges:

	Number of Wells	Range in Nitrate Content (mg/l)
Aspermont	3	56-57
Benjamin	2	41-51
Goree	3	40-53
Haskell	11	71-148
Knox City	3	75-78
Munday	4	50-60
O'Brien	1	118
Rochester	1	63
Rule	4	40-73
Weinert	2	50-52

Munday, Goree, Haskell, and Knox City will have alternate water supplies available from Millers Creek Reservoir.

Approximately 9 percent or 23 of the domestic and stock wells sampled during this investigation show nitrate contents in excess of 150 mg/l. Present evidence indicates these wells are affected by nearby sources of pollution, mostly septic tanks. Undoubtedly, a number of domestic wells with nitrate concentrations lower than 150 mg/l are affected also by pollution from septic tanks.

To meet current drinking water standards when nitrate levels in a water supply are greater than 45 mg/l requires alternate sources of water or water treatment to remove the offending nitrate. However, as in many areas of the United States, these are not always practicable solutions for the people of Haskell and Knox Counties. At this time, there is no method considered economical by most water users of removing nitrate from ground water, and obtaining alternate sources of water is often cost-prohibitive, also.

In the absence of cost-effective alternatives, use of the present water supply must be continued. Fortunately, the nitrate levels in the Seymour aquifer are not necessarily dangerous to the health of humans and animals if the citizens are alert to the situation and take the proper precautions.

Precautions

It is important for each person to know the nitrate concentration of his water supply. In the case of municipal supplies, this information is provided. If an individual is using water from a private well, a chemical analysis should be made on water from the well.

If large concentrations of nitrate are found, a physician should be consulted as to the concentration's effect on certain individuals. It is important to remember that small children, pregnant women, and dialysis patients are particularly prone to nitrate toxicity. In the case of infants, formulas which are mixed with water should be discontinued as a method of feeding the child in favor of breast-feeding or the use of undiluted pasteurized cow milk. Care should be taken in these areas also as cases of methemoglobinemia have been reported in infants being breast-fed by mothers drinking contaminated water and in infants drinking cow milk from animals using water with increased nitrates (Older, 1969). In some instances, it may be necessary to obtain alternate drinking water supplies depending on the amount of nitrate in the affected water.

Animals have a higher nitrate tolerance than humans, but a veterinarian should be consulted when elevated nitrate concentrations are discovered in a water supply. Animals should be prohibited from rapidly consuming large quantities of highly nitrated water as this is particularly dangerous. Also, the nutritional quality of the animal's feed seems to be important in relation to nitrate-related illnesses. Much of the literature records vitamins C, D, E, and especially A, as having properties capable of decreasing susceptibility to nitrate toxicity and helping to remedy already occurring cases of the disease. As with humans, there is the possibility that high nitrate concentrations in some water supplies may render the water unacceptable for animal use.

Certain precautions against nitrate contamination can be taken in locating a Seymour water well. The well should be located up the hydraulic gradient and in the opposite direction of ground-water flow from pollution sources such as septic tanks, barnyards, and feedlots. Bosch and others (1950) report that 150 feet is a minimum distance at which a well supply should be located from any type of nitrate contamination source. For a Seymour domestic well, this distance, if up the hydraulic gradient, is adequate in most cases to avoid drawing significant amounts of nitrate from a pollution source. However, the distance depends generally on the pumping rate of the well, the characteristics of the formation, and in some instances, partly on the quantity of the nitrate.

In conclusion, it appears the citizens of Haskell and Knox Counties have reason for concern, but not extreme alarm regarding the typical nitrate levels in their water supplies. Nitrate in ground water is a potential health hazard to humans and animals, but at present, the problem probably can be dealt with most economically by closely monitoring nitrate levels and taking appropriate precautionary measures.

BIBLIOGRAPHY OF NITRATE-RELATED TOPICS

Adams, A. W., Emerick, F. J., and Carlson, C. W., 1966, Effects of Nitrate and Nitrite in the Drinking Water on Chicks, Poults, and Laying Hens, Poultry Science Association, *Poultry Science*, Volume 45, Texas A&M University.

Adams, A. W., West, J. L., and Kahrs, A. J., 1969, Some Effects on Turkeys of Nitrate in the Drinking Water, Poultry Science Association, *Poultry Science*, Volume 48, Texas A&M University.

Alam, B., and others, 1971, Synthesis of Nitrosopiperidine from Nitrate and Piperidine in the Gastro-Intestinal Tract of the Rat, *Nature*, Volume 232, Macmillian Journals Ltd., London, England.

Amant, Percy P., and McCarty, Perry L., 1969, Treatment of High Nitrate Waters, *American Water Works Association Journal*, Volume 61, Denver, Colorado.

American Public Health Association Committee, 1950, Nitrate in Potable Waters and Methemoglobinemia, *Yearbook of the American Public Health Association*, Volume 40, Washington, D.C.

Asahina, S., and others, 1971, Acute Synergistic Toxicity and Hepatic Neurosis Following Oral Administration of Sodium Nitrite and Secondary Amines to Mice, *Cancer Research*, Volume 31, American Association for Cancer Research, Williams & Wilkins Publishing Company, Baltimore, Maryland.

Barker, A. V., Peck, N. H., and MacDonald, G. C., 1971, Nitrate Accumulation in Vegetables—Spinach Grown in Upland Soils, *American Society of Agronomy Journal*, Volume 63, Madison, Wisconsin.

Beffort, J. D., 1969, Nitrate Contamination Study Near Ballinger, Runnels County, Texas, Texas Water Development Board, unpublished report C1-6913.

Behroozi, K., and others, 1971, Changes in the Motor Activity of Mice Given Sodium Nitrite Drinking Solution, Proceedings of Symposium on Environmental Physiology, Beersheba, Israel.

Bennet, R. C., Seath, D. M., and Olds, D., 1968, Relationship Between Nitrate Content of Forage and Dairy Herd Fertility, *American Dairy Science Association Journal*, Volume 51, Number 4, Champaign, Illinois.

Bloomfield, R. A., and others, 1961, Effect of Dietary Nitrate on Thyroid Function, *Science*, Volume 134.

Blood, D. C., and Henderson, J. A., 1968, Nitrate and Nitrite Poisoning, *Veterinary Medicine*, Third Edition, Williams & Wilkins Publishing Company, Baltimore, Maryland.

Bluemle, L. W., 1968, Current Status of Chronic Hemodialysis, *American Journal of Medicine*, Volume 44, Dun-Donnelley Publishing Corporation, New York, New York.

Bodansky, O., 1951, Methemoglobinemia and Methemoglobin-Producing Compounds, *Pharmacological Reviews*, Volume 3, American Society for Pharmacology and Experimental Therapeutics, Williams & Wilkins Publishing Company, Baltimore, Maryland.

Borts, I. H., 1949, Water-Borne Diseases, *American Public Health Association Journal*, Volume 39, Washington, D.C.

Bosch, H. M., and others, 1950, Methemoglobinemia and Minnesota Well Supplies, *American Water Works Association Journal*, Volume 42, Denver, Colorado.

Braun, Werner, 1945, Studies of the Carotenoid and Vitamin A Levels in Cattle, Part II—Carotenoids and Vitamin A in the Liver, Their Ratio and Their Relationship to Blood Levels, *Journal of Nutrition*, Volume 29.

Bucklin, R., and Myint, M. K., 1960, Fatal Methemoglobinemia Due to Well Water Nitrates, *Annals of Internal Medicine*, Volume 52, American College of Physicians, Philadelphia, Pennsylvania.

Burden, E. H. W. J., 1961, The Toxicology of Nitrates and Nitrites With Particular Reference to the Potability of Water Supplies, *The Analyst, Proceedings of the Chemical Society, Analytical Division*, Volume 86, Number 1024, Burlington House, London, England.

Campbell, J. B., Davis, A. N., and Myhr, P. J., 1954, Methemoglobinemia of Livestock Caused by High Nitrate Contents of Well Water, *Canadian Journal of Comparative Medicine and Veterinary Science*, Volume 18, Canadian Veterinary Medical Association, Ontario, Canada.

Campbell, W. A. B., 1952, Methemoglobinemia Due to Nitrates in Well Water, *British Medical Association Journal*, Volume 2, London, England.

Carlisle, M. C., M.D., 1950, Well-Water Methemoglobinemia, *Texas State Journal of Medicine*, Volume 46, Texas Medical Association, Austin, Texas.

Carlson, D. J., and Shapiro, F. L., 1970, Methemoglobinemia From Well Water Nitrates: A Complication of Home Dialysis, *Annals of Internal Medicine*, Volume 73, American College of Physicians, Philadelphia, Pennsylvania.

Carver, L. A., and Pfander, W. H., 1973, Urea Utilization by Sheep in the Presence of Potassium Nitrate, *American Society of Animal Science Journal*, Volume 36, Champaign, Illinois.

Case, A. A., 1957, Abortion in Swine Due to Excessive Nitrates, *Journal of the American Veterinary Medical Association*, Volume 131, Schaumburg, Illinois.

——— 1957, Some Aspects of Nitrate Intoxication in Livestock, *Journal of the American Veterinary Medical Association*, Volume 130, Schaumburg, Illinois.

——— 1970, The Health Effects of Nitrate in Water, *Proceedings of the 12th Sanitary Engineering Conference*, University of Illinois, Urbana, Illinois.

Chapen, F. J., 1947, Methemoglobinemia From Nitrates in Well Water, Michigan State Medical Society, *Michigan Medicine*, Volume 46, East Lansing, Michigan.

Chute, W. D., 1950, Cyanosis in an Infant Caused by Nitrates in Well Water, Missouri State Medical Association, *Missouri Medicine*, Volume 47, Jefferson City, Missouri.

Comly, H. H., 1945, Cyanosis in Infants Caused by Nitrates in Well Water, *American Medical Association Journal*, Volume 129, Chicago, Illinois.

Commoner, B., 1968, Threats to the Integrity of the Nitrogen Cycle: Nitrogen Compounds in Soil, Water, Atmosphere, and Precipitation, Presented to the American Association for the Advancement of Science, Dallas, Texas.

Committee on Nutrition, 1970, Infant Methemoglobinemia, the Role of Dietary Nitrate, American Academy of Pediatrics, *Pediatrics*, Volume 46, Evanston, Illinois.

Cornblath, M., and Hartmann, A. F., 1948, Methemoglobinemia in Young Infants, American Academy of Pediatrics, *Pediatrics*, Volume 33, Evanston, Illinois.

Cox, C. R., 1950, Progress Report of the Committee on Water Supply, *Yearbook of the American Public Health Association*, 1949–1950, Washington, D.C.

Crowley, J. W., 1970, Ways to Prevent Possible Nitrate Problems in Cattle, *Hoard's Dairyman*, Fort Atkinson, Wisconsin.

Cunningham, G. N., Wise, M. B., and Barrick, E. R., 1968, Influence of Nitrite and Hydroxylamine on Performance and Vitamin A and Carotene Metabolism of Ruminants, *American Society of Animal Science Journal*, Volume 27, Champaign, Illinois.

Curtin, T. M., and London, W. L., 1966, Nitrate-Nitrite Intoxication in Swine, *Proceedings of the 70th Annual Meeting of the U.S. Livestock Sanitary Association*.

Davison, K. L., and others, 1964, Nitrate Toxicity in Dairy Heifers: Effects on Reproduction, Growth, Lactation, and Vitamin A Nutrition, *American Dairy Science Association Journal*, Volume 47, Champaign, Illinois.

Dollahite, J. W., and Holt, E. C., 1970, Nitrate Poisoning, *S. A. Mediese Tydskrif*, Volume 44.

Donahoe, Will E., 1949, Cyanosis in Infants With Nitrates in Drinking Water as Cause, American Academy of Pediatrics, *Pediatrics*, Volume 3, Evanston, Illinois.

Dugan, F. C., 1948, The Effect of Nitrates in Rural Water Supplies on Infant Health, Kentucky Department of Health, Bulletin 21, Frankfort, Kentucky.

Elliott, L. F., Schuman, G. E., and Viets, F. G., Jr., 1971, Volatilization of Nitrogen-Containing Compounds From Beef Cattle Areas, *Soil Science Society of America Proceedings*, Volume 35, Madison, Wisconsin.

Emerick, R. J., 1974, Consequences of High Nitrate Levels in Feed and Water Supplies, Federation of American Societies for Experimental Biology, *Federation Proceedings*, Volume 33, Number 5, Bethesda, Maryland.

Emerick, R. J., Embry, L. B., and Seerley, R. W., 1965, Rate of Formation and Reduction of Nitrite-Induced Methemoglobin in Vitro and in Vivo as Influenced by Diet of Sheep and Age of Swine, *American Society of Animal Science Journal*, Volume 24, Champaign, Illinois.

Emerick, R. J., and Olson, O. F., 1962, Effect of Nitrate and Nitrite on Vitamin A Storage in the Rat, *American Institute of Nutrition Journal*, Volume 78, Bethesda, Maryland.

BIBLIOGRAPHY—Continued

Ewing, M. C., and Mayon-White, R. M., 1951, Cyanosis in Infancy From Nitrates in Drinking Water, *The Lancet*, Volume 1, London, England.

Farra, P. A., and Satter, L. D., 1971, Manipulation of the Ruminal Fermentation: Effect of Nitrate on Ruminal VFA Production and Milk Composition, *American Dairy Science Association Journal*, Volume 54, Champaign, Illinois.

Faucett, R. L., and Miller, H. C., 1947, Methemoglobinemia Occurring in Infants Fed Milk Diluted With Well Water of High Nitrate Content, American Academy of Pediatrics, *Pediatrics*, Volume 29, Evanston, Illinois.

Fawns, H., and Aldridge, A., 1954, Methemoglobinemia Due to Nitrates and Nitrites in Drinking Water, *British Medical Association Journal*, Volume 575, London, England. Reprinted in *Water Pollution Abstracts*, 1955, Volume 28, Water Research Centre, Stevenage Laboratory, Elder Way Herts SGI 1TH, England.

Feth, J. H., 1966, Nitrogen Compounds in Natural Water—A Review, American Geophysical Union, *Water Resources Research*, Volume 2, Number 1, Washington, D.C.

Finch, C. A., 1948, Methemoglobinemia and Sulfhemoglobinemia, *New England Journal of Medicine*, Volume 239, Massachusetts Medical Society, Boston, Massachusetts.

Gad, G., and Naumann, K., 1956, Harmful Contents of Nitrate in Water Supply, Gas-U. Wasserfach.

Ganong, W., 1969, The Thyroid Gland, *Review of Medical Physiology*, Fourth Edition, Lange Medical Publishers, Los Altos, California.

Garner, G. B., and others, 1958, Further Studies on the Effects of Nitrate Upon Reproduction and Vitamin A Storage With Rats and Swine, *American Society of Animal Science Journal*, Volume 17, Champaign, Illinois.

Gartner, H., and Staak, H. H., 1960, The Significance and Determination of Nitrate Content of Drinking Water, Gesundheits-Ingenieur, Volume 81, Rosenheimer Str. 145, 8000 Munich 80, West Germany.

Gass, Tyler E., 1978, Ground-Water by Gass: Drinking and Human Health, Part II, *National Water Well Association Journal*, April, Volume 32, Number 4, Worthington, Ohio.

Gelperin, A., 1970, The Health Effects of Nitrate in Water, *Proceedings of the 12th Sanitary Engineering Conference*, University of Illinois, Urbana, Illinois.

——— 1971, Methemoglobinemia in Infants, Presented at the 1971 Meeting of the American Medical Association, Atlantic City, New Jersey.

George, W. O., and Hasting, W. W., 1951, Nitrate in the Ground Water of Texas, *Transactions, American Geophysical Union*, Volume 32, Number 3, Washington, D.C.

Gillham, R. W., and Webber, L. R., 1969, Nitrogen Contamination of Groundwater by Barnyard Leachates, *Water Pollution Control Federation Journal*, Volume 41, Number 10, Washington, D.C.

Goodrich, R. K., Emerick, R. J., and Embry, L. B., 1964, Effect of Sodium Nitrate on the Vitamin A Nutrition of Sheep, *American Society of Animal Science Journal*, Volume 23, Champaign, Illinois.

Greenberg, L. A., Lester, D., and Haggard, H. W., 1943, Reaction of Hemoglobin and Nitrite, *American Society of Biological Chemists Journal*, Volume 151, Bethesda, Maryland.

Greene, I., and Hiatt, E. P., 1954, Behavior of the Nitrate Ion in the Dog, *American Physiological Society Journal*, Volume 176, Bethesda, Maryland.

Gruener, N., and Shuval, H. I., 1970, Health Aspects of Nitrates in Drinking Water, *Developments in Water Quality Research*, Ann Arbor Science Publishers, Ann Arbor, Michigan.

——— 1973, Health Implications of Environmental Exposure to Nitrates, *Harefuah*, Volume 85, Number 1, Israel Medical Association, Tel Aviv, Israel.

Gruener, N., and others, 1972, Methemoglobinemia Induced by Transplacental Passage of Nitrites in Rats, *Proceedings of the Third Scientific Conference of the Israel Ecological Society*, Tel Aviv, Israel.

Haggerty, R. J., 1962, Blue Baby Due to Methemoglobinemia, *New England Journal of Medicine*, Volume 267, Massachusetts Medical Society, Boston, Massachusetts.

Hale, W. H., Hubbert, F., and Taylor, R. E., 1962, Effect of Energy Level and Nitrate on Hepatic Vitamin A and Performance of Fattening Steers, *Society for Experimental Biology and Medicine, Proceedings,* Volume 109, New York, New York.

Hampers, C. L., and Merrill, J. P., 1966, Hemodialysis in the Home: Thirteen Months' Experience, *Annals of Internal Medicine*, Volume 67, American College of Physicians, Philadelphia, Pennsylvania.

Hanway, J. J., and others, 1963, The Nitrate Problem, Iowa State University of Science and Technology, Special Report Number 34, Ames, Iowa.

Harmesan, Robert H., Sollo, F. W., Jr., and Larson, T. E., 1971, The Nitrate Situation in Illinois, *American Water Works Association Journal*, Volume 63, Number 5, Denver, Colorado.

Harris, D. J., and Rhodes, H. A., 1960, Nitrate and Nitrite Poisoning in Cattle in Victoria, *Austrian Veterinary Journal*, Volume 45.

Harper, H.A., 1967, *Review of Physiological Chemistry*, 11th Edition.

Hatfield, E. E., and Smith, G. S., 1963, Nitrate and Urea in Rations of Feeder Animals, *American Society of Animal Science Journal*, Volume 22, Champaign, Illinois.

Hawksworth, G., and Hill, M. J., 1971, The Formation of Nitrosamines by Human Intestinal Bacteria, Volume 122, Colchester, Essex, England.

Heuvelen, W. V., 1948, What About Nitrates in North Dakota Drinking Water?, North Dakota Water and Sewage Works Conference, Official Bulletin 16, Bismark, North Dakota.

Hoar, D. W., Embry, I. B., and Emerick, R. J., 1968, Nitrate and Vitamin A Interrelationships in Sheep, *American Society of Animal Science Journal*, Volume 27, Champaign, Illinois.

Hoar, D. W., and others, 1968, Urea-Nitrate Interrelationships in Sheep Under Feedlot Conditions, *American Society of Animal Science Journal*, Volume 27, Champaign, Illinois.

Holzmacher, Robert G., 1976, Nitrate Removal From a Groundwater Supply, *Water & Sewage Works*, Volume 123, Scranton Publishing Company, Chicago, Illinois.

Hutagalung, R. I., and others, 1968, Effects of Nitrates and Nitrites in Feed on the Utilization of Carotene in Swine, *American Society of Animal Science Journal*, Volume 27, Champaign, Illinois.

Jaffe, E. R., and Heller, P., 1964, Methemoglobinemia in Man, *Progress in Hematology*, (C. V. Moore and E. B. Brown, eds.), Volume IV, Grune and Stratton, New York, New York.

Jablo, N. S. K. A., Ulrych, A., and Frelek-Karska, M., 1974, Methemoglobinemia in Two Infants Caused by Nitrates Contained in Well Water, *Polski Tygodnik Lekarski*, Volume 29, Number 32, Warsaw, Poland. Distributed by Ars Polona-Ruch Krakowskie Przedmiescie 7, Warsaw, Poland.

Jainudeen, M. R., Hansel, W., and Davison, K. L., 1965, Nitrate Toxicity in Dairy Heifers: Endocrine Responses to Nitrate Ingestion During Pregnancy, *American Dairy Science Association Journal*, Volume 48, Champaign, Illinois.

Jensen, C. W., and Anderson, H. D., 1941, Rate of Formation and Disappearance of Methemoglobin Following Oral Administration or Injection of Sodium Nitrite, *South Dakota Academy of Science*, Volume 21, Pierre, South Dakota.

Johns, M. W., and Lawrence, C. R., 1973, Nitrate-Rich Groundwater in Australia: A Possible Cause of Methemoglobinemia in Infants, *Australian Medical Association Journal*, Volume 2, Number 20, Glebe, Australia.

Johnson, G., and others, 1946, Nitrate Level in Water From Rural Iowa Wells, *Iowa Medical Society Journal*, Volume 36, Des Moines, Iowa.

Johnson National Drillers Journal, 1948, Blue Baby Deaths Laid to Water, *Johnson National Drillers Journal*, Volume 20, Universal Oil Products Co., Johnson Division, St. Paul, Minnesota.

Jones, D. C., 1973, An Investigation of the Nitrate Problem in Runnels County, Texas, Environmental Protection Agency, EPA-R2-73-267.

Jones, I. R., and others, 1966, The Effect of High Nitrate Consumption on Lactation and Vitamin A Nutrition of Dairy Cows, *American Dairy Science Association Journal*, Volume 49, Champaign, Illinois.

Jones, J. H., and others, 1973, Grandmother's Poisoned Well: Report of a Case of Methemoglobinemia in an Infant in Oklahoma, *Oklahoma State Medical Association Journal*, Volume 66, Number 2, Oklahoma City, Oklahoma.

Kapanadze, S. K., 1961, Determination of the Maximum Permissible Concentration of Nitrates in Water, *Gigiena i Sanitariya*, Volume 26, Number 9, Ministerstvo Zdravookhraneniya, Moscow, U.S.S.R.

Kearley, E. O., 1964, Nitrate Metabolism in the Ruminant, *Proc. Am. Coll. Vet. Toxicol.*, Volume 6.

Keeney, D. R., 1970, Nitrates in Plants and Waters, *Journal of Milk Food Technology*, Volume 33.

Keeney, D. R., and Walsh, L. M., 1970, The Pollution Problem—Nitrates in Ground-Water, *Hoard's Dairyman*, Atkinson, Wisconsin.

Keleti, I., and Kamenski, P., 1959, Nitrates in Drinking Water in Relation to Toxic Cyanosis in Nursing Children, *Gigiena i Sanitariya*, Volume 24, Ministerstvo Zdravookhraneniya, Moscow, U.S.S.R.

Keller, W. D., and Smith, G. E., 1967, Ground-Water Contamination by Dissolved Nitrate, Geological Society of America, Paper 90, Boulder, Colorado.

Keokane, K. W., 1960, An Investigation of Differing Sensitivity of Juvenile and Adult Erythroctes to Methemoglobinization, *Phys. Med. Bio.*, Volume 5.

Kienholz, E. W., 1968, Sodium Nitrate as a Growth Promoting Stimulant in Market Turkeys, Report to the National Turkey Federation.

Kilgore, L., Almon, L., and Gieger, M., 1959, The Effects of Dietary Nitrate on Rabbits and Rats, *American Institute of Nutrition Journal*, Volume 69, Bethesda, Maryland.

Kittel, G., 1958, The Toxicity of Nitrate in Water Supplies, Zentralblatt Fuer Bakteriologie, Stuttgart, West Germany. Reprinted in *Water Pollution Abstracts*, 1958, Volume 31, Water Research Centre, Stevenage Laboratory, Elder Way, Stevenage, Herts SGI 1TH, England.

Knotek, Z., and Schmidt, P., 1964, Pathogenesis, Incidence and Possibilities of Preventing Alimentary Nitrate Methemoglobinemia in Infants, American Academy of Pediatrics, *Pediatrics*, Volume 34, Evanston, Illinois.

——— 1966, Problems of Nitrate Food Methemoglobinemia of Infants in Czechoslovakia, *Gigiena i Sanitariya*, Volume 2, Ministerstvo Zdravookhraneniya, Moscow, U.S.S.R.

Koch, B. A., Parrish, B. B., and Sukhonthasarnpa, S., 1963, Effects of Dietary NO_2 and NO_3 on Growing Swine, *American Society of Animal Science Journal*, Volume 22, Champaign, Illinois.

Krasovsky, G. N., Korolev, A. A., and Shigan, S. A., 1973, Toxicological and Hygienic Evaluation of Diethylene Glycol Dinitrate in Connection With Its Standardization in Water Reservoirs, *Journal of Hygiene, Epidemiology, Microbiology and Immunology*, Volume 17, Number 1, State Health Publishing House, Prague, Czechoslovakia. Distributor in Western countries: Karger Libri A G, Petersgraben 31, 4011 Basel, Switzerland.

Kravitz, H., and others, 1956, Methemoglobin Values in Prematures, Mature Infants, and Children, *American Journal of Dis. Children*, Volume 91.

Lancet, The, 1968, Nitrites, Nitrosamines, and Cancer, *The Lancet*, London, England.

Lautner, V., 1972, The Influence of Ammonium Nitrite and Nitrate Upon Deposits of Carotenoids, Vitamin A, and α-Tocopherol in Eggs of Layers, *Biol. Chem. Vyz. Zvirat*, Volume 8.

Lewis, D., 1951, The Metabolism of Nitrate and Nitrite in the Sheep: The Reduction of Nitrate in the Rumen of the Sheep, *Biochemical Society Journal*, Volume 48, Colchester, Essex, England.

Lichtenwalner, R. E., 1971, The Effect of Feeding Nitrate to Beef Cattle (Ph.D. Thesis), Virginia Polytech. Institute and State University, Blacksburg, Virginia.

Lijinsky, W., and Epstein, S. S., 1970, Nitrosamines as Environmental Carcinogens, *Nature*, Volume 225.

London, W. T., Henderson, W., and Cross, R. F., 1967, An Attempt to Produce Chronic Nitrite Toxicosis in Swine, *American Veterinary Medical Association Journal*, Volume 150, Schaumburg, Illinois.

Magee, P. N., and Barnes, J. M., 1967, Carcinogenic Nitroso Compounds, *Advanced Cancer Research*, Volume 10.

Marcus, H., and Joffe, J. R., 1949, Nitrate Methemoglobinemia, *New England Journal of Medicine*, Volume 240, Massachusetts Medical Society, Boston, Massachusetts.

Marrett, L. E., and Sunde, M. L., 1968, The Use of Turkey Poults and Chickens as Test Animals for Nitrate and Nitrite Toxicity, Poultry Science Association, *Poultry Science*, Volume 47, Texas A&M University.

Maxcy, Kenneth F., 1950, Report on the Relation of Nitrate Nitrogen Concentrations in Well Waters and the Occurrence of Methemoglobinemia in Infants, *Sanitary Engineering and Environment* (App. D.), National Research Council Bulletin.

Mayo, N. S., 1895, Cattle Poisoning by Nitrate of Potash, Kansas Agricultural Experiment Station, Bulletin 49, Topeka, Kansas.

McDermott, J. H., Kabler, P. W., and Wolf, H. W., 1971, Health Aspects of Toxic Material in Drinking Water, *American Public Health Association Journal*, Volume 61, Washington, D.C.

Medony, Harry, 1950, Methemoglobinemia, *Canadian Medical Association Journal*, Volume 562, Ottawa, Canada.

Metzler, D. F., and Stoltenberg, H. A., 1950, The Public Health Significance of High Nitrate Waters as a Cause of Infant Cyanosis and Methods of Control, *Kansas Academy of Science, Transactions*, Volume 53, Kansas Wesleyan, Salina, Kansas.

Mielke, L. N., and others, 1970, Groundwater Quality and Fluctuation in a Shallow Unconfined Aquifer Under a Level Feedlot, Northern Plains Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, in cooperation with Nebraska Agricultural Experiment Station, Journal Series Paper Number 2690.

Mitchell, G. E., Jr., Little, G. O., and Hayes, B. W., 1963, Pre-Intestinal Destruction of Vitamin A by Ruminants Fed Nitrate, *American Society of Animal Science Journal*, Volume 26, Champaign, Illinois.

Mikosz, R. W., Asowicz, Z., and Wojnarowska, K., 1973, Three Cases of Toxic Methemoglobinemia in Infants, *Wiadomosci Lekarskie*, Volume 26, Number 3, Warsaw, Poland. Distributed by ARS Polona-Ruch, Krakowskie Przedmiescie 7, Warsaw, Poland.

Miller, L. W., 1971, Methemoglobinemia Associated With Well Water, *American Medical Association Journal*, Volume 216, Number 10, Chicago, Illinois.

Murphy, L. S., and Cosch, J. W., 1970, Nitrate Accumulation in Kansas Ground Water, Kansas State University, Kansas Water Resources Institute, Project Completion Report, Manhattan, Kansas.

Murray, L. R., and Siebert, B. D., 1962, Nitrate in Underground Waters of Central Australia, *Australian Journal of Science*, Volume 25, Australian and New Zealand Association for the Advancement of Science, Sydney, Australia.

Muschter, W. Z., 1962, Nitrate Contents in Drinking Water and Two Cases of Methemoglobinemia in Berlin Caused by Well Water, *Ges. Hyg.*, Volume 8.

National Academy of Sciences, 1972, Accumulation of Nitrate, Committee on Nitrate Accumulation, National Academy of Sciences, Washington, D.C.

Nelson, H. G., and Sanders, H. R., 1951, Methemoglobinemia in Infants Due to Ingestion of Nitrates From Well Water, *Oklahoma Medical Association Journal*, Volume 44, Oklahoma City, Oklahoma.

O'Dell, B. I., and others, 1960, Effects of Nitrite-Containing Rations in Producing Vitamin A and Vitamin E Deficiencies in Rats, *American Society of Animal Science Journal*, Volume 19, Champaign, Illinois.

Older, J. Justin, M.D., 1969, Increased Nitrate Concentration in Well Water, Runnels County, Texas Department of Health, inter-office memo.

Olson, J. R., Oehme, F. W., and Carnahan, D. L., 1972, Nitrate Levels in Water and Livestock Feeds, *Veterinary Medicine/Small Animal Clinician*, Volume 67, Number 3, Veterinary Medicine Publishing Company, Bonner Springs, Kansas.

Perlmutter, Nathaniel M., and Koch, Ellis, 1972, Preliminary Hydrogeologic Appraisal of Nitrate in Ground Water and Streams, Southern Nassau County, Long Island, New York, U.S. Geological Survey, Professional Paper 800-B.

Poch, M., 1971, Effect of Increasing Nitrogen Fertilization on the Nitrate Content of Ground-Water, *Zeitschrift Fuer Die Gesamte Hygiene*, Volume 17, Number 8, VEB Verlag Volk and Gesundheit, Neue Gruenstr. 18, 102 Berlin, East Germany.

Pollard, M., Sharon, N., and Chang, C. F., 1972, Synthesis of Hepatoxic Agents in Germ-Free and Conventional Mice Which Had Been Fed $NaNO_2$ and Dimethylamine, *Society for Experimental Biology and Medicine, Proceedings*, Volume 140, New York, New York.

Pugh, D. L., and Garner, G. B., 1963, Reaction of Carotene With Nitrate Solutions, *Agricultural and Food Chemistry Journal*, Volume 11, American Chemical Society, Washington, D.C.

Pugh, D. L., and others, 1962, Carotene-Vitamin A Destruction by Nitrate in Vitro, *American Society of Animal Science Journal*, Volume 21, Champaign, Illinois.

Rapaport, S. I., 1971, *Introduction to Hematology*, Harper and Row, New York, New York.

Ridder, W. E., and Oehme, F. W., 1974, Nitrates as an Environmental, Animal, and Human Hazard, *Clinical Toxicology*, Volume 7, Number 2, Marcel Dekker Journals, New York, New York.

Ridder, W. E., Oehme, F. W., and Kelley, D. C., 1974, Nitrates in Kansas Groundwaters as Related to Animal and Human Health, *Toxicology*, Volume 2, Number 4, Elsevier-North Holland Scientific Publishers Co. Ltd., Limerick, Ireland.

Roberts, W. K., and Sell, J. L., 1963, Vitamin A Destruction by Nitrite in Vitro and Vivo, *Journal of Animal Science*, Volume 22.

Robertson, H. E., and Riddell, W. A., 1949, Cyanosis of Infants Produced by High Nitrate Concentration in Rural Waters of Saskatchewan, *Canadian Journal of Public Health*, Volume 40, Ottawa, Canada.

Robinson, S., and others, 1971, Changes in the Electrical Activity of the Brain of Rats Fed With Sodium Nitrite, Proceedings of Symposium on Environmental Physiology, Beersheba, Israel.

Rosenfield, A. B., and Huston, R., 1950, Infant Methemoglobinemia in Minnesota Due to Nitrates in Well Water, Minnesota State Medical Association, *Minnesota Medicine*, Volume 33, St. Paul, Minnesota. Reprinted in *Water Pollution Abstracts*, 1951, Volume 24, Water Research Centre, Stevenage Laboratory, Elder Way, Stevenage, Herts SGI 1TH, England.

Ross, J. D., and Desforges, J. F., 1959, Reduction of Methemoglobin, American Academy of Pediatrics, *Pediatrics*, Volume 23, Evanston, Illinois.

Sattelmacher, P. G., 1962, [Methemoglobinemia From Nitrates in Drinking Water] *Schriftenreiche des Verein fur Wasser, Boden und Lufthygiene*, Number 21, Wollgrasweg 49, Postfach 720143, 7000 Stuttgart 72, Gustav Fischer Verlag, West Germany.

Schaper, G., 1958, Methemoglobinemia in Infants Caused by Water Containing Nitrate, *Medizinische*, Volume 115, 1958, Volume 168 (449): Zentralblatt Fuer Bakteriologie, 1, Ref., Gustave Fischer Verlag, Wollgrasweg 49, Postfach 720143, 7000 Stuttgart 72, West Germany. Reprinted in Water Pollution Abstracts, 1959, Volume 32: Water Research Centre, Stevenage Laboratory, Elder Way, Stevenage, Herts SGI 1TH, England.

Schmitz, J. T., M.D., 1961, Methemoglobinemia—A Cause of Abortions?, American College of Obstetricians and Gynecologists, *Obstetrics and Gynecology*, Volume 17, Number 4, Chicago, Illinois.

Seerley, R. W., and others, 1965, Effect of Nitrate or Nitrite Administered Continuously in Drinking Water for Swine and Sheep, *American Society of Animal Science Journal*, Volume 24, Champaign, Illinois.

Sell, J. L., and Roberts, W. K., 1963, Effects of Dietary Nitrite on the Chicks: Growth, Liver, Vitamin A Stores and Thyroid Weight, *Nutrition Journal*, Volume 79, American Institute of Nutrition, Bethesda, Maryland.

Shearer, L. A., and others, 1972, Methemoglobin Levels in Infants in an Area With High Nitrate Water Supply, *American Public Health Association Journal*, Volume 62, Number 9, Washington, D.C.

Shuvall, H. I., and Gruener, N., 1972, Epidemiological and Toxicological Aspects of Nitrates and Nitrites in the Environment, *American Public Health Association Journal*, Volume 62, Number 8, Washington, D.C.

Sibbald, I. R., Rowland, J. B., and Berg, R. T., 1956, The Relationship Between the Blood Plasma Vitamin A Levels of Sows and of Their Suckling Pigs, *American Society of Animal Science Journal*, Volume 15, Champaign, Illinois.

Simon, C., and others, 1964, Uber Vorkommen, Pathogenes und Moglichkeiten zur Prophylaxe der Durch Nitrit Verusachten Methamoglobinamie. *Zeitschrift fuer Kinderheilkunde*, Number 91, c/o European Journal of Pediatrics, Springer-Verlag, New York, New York.

Simon, J. J., and others, 1958, Pathological Changes Associated With the Lowland Abortion Syndrome in Wisconsin, *American Veterinary Medical Association Journal*, Volume 132, Schaumburg, Illinois.

Simon, J., Sund, J. M., Douglas, F. D., Wright, M. J., and Kowalczyk, T., 1959, The Effect of Nitrate or Nitrite When Placed in the Rumens of Pregnant Dairy Cattle, *American Veterinary Medical Association Journal*, Volume 135, Schaumburg, Illinois.

Sinha, D. P., and Sleight, S. D., 1971, Pathogenesis of Acute Nitrite Toxicosis in Guinea Pigs, *Toxicology and Applied Pharmacology*, Volume 18, Academy Press, Inc., New York, New York.

Singer, R. H., 1968, Environmental Nitrates and Animal Health, *Southwestern Veterinarian*, Volume 1968, American Veterinary Medical Association, Student Chapter, College of Veterinary Medicine, Texas A&M University.

Sleight, S. D., and others, 1972, Effect of Sodium Nitrite on Reproductive Performance of Pregnant Sows, *Journal of the American Veterinary Medical Association*, Volume 161, Schaumburg, Illinois.

Smith, G. E., 1965, Nitrate Problems in Plants and Water Supplies in Missouri, Missouri Agricultural Experiment Station, Columbia, Missouri.

——— 1967, Contamination of Water by Nitrates, Fertilizer Solutions, *National Fertilizer Solutions Association*, Peoria, Illinois.

Smith, G. S., 1965, Diagnosis and Causes of Nitrate Poisoning, *Journal of the American Veterinary Medical Association*, Volume 147, Schaumburg, Illinois.

Smith, J. E., and Beutler, E., 1966, Reduced Diphosphopyridine Nucleotide-Dependent Diaphorase in Foetal, Newborn, and Adult Cattle, *Nature*, Volume 211, Macmillian Journals Ltd., London, England.

——— 1966, Methemoglobin Formation and Reduction in Man and Various Animal Species, *American Physiological Society Journal*, Volume 210, Bethesda, Maryland.

Sokolowski, J. H., Garrigus, U. S., and Hatfield, E. E., 1960, Some Effects of Varied Levels of Potassium Nitrate Ingestion by Lambs, *American Society of Animal Science Journal*, Volume 19, Champaign, Illinois.

Souchon, F., 1956, Severe Methemoglobinemia in an Infant Caused by Well Water Containing Nitrate, *Deutsche Medizinische Wochenschrift*, Volume 81, G. T. Verlag, Herdweg 63, Postfach 732, 7000 Stuttgart 1, West Germany. Reprinted in Water Polllution Abstracts, 1957, Volume 30, Water Research Centre, Stevenage Laboratory, Elder Way, Stevenage, Herts SGI 1TH, England.

Stewart, B. A., and others, 1967, Nitrate and Other Water Pollutants Under Fields and Feedlots, *Environmental Science and Technology*, Volume 1, Number 9.

Stewart, G. A., and Merilan, C. P., 1958, Effect of Potassium Nitrate Intake on Lactating Dairy Cows, Missouri Research Bulletin Number 650, Jefferson City, Missouri.

Subbotin, F. N., 1958, Some Data on the Hygienic Significance of Nitrates in Drinking Water, [*Hygiene and Sanitation*] Gigiena i Sanitariya, Volume 23, Ministerstvo Zdravookhraneniya, Moscow, U.S.S.R.

Sund, J. M., and others, 1964, Protect Livestock From Nitrate Poisoning, University of Wisconsin, College of Agriculture, Extension Service Bulletin, Circular 627, Madison, Wisconsin.

Sunde, M. L., 1964, The Use of the Turkey Poult as a Test Animal for Nitrite Toxicity, Poultry Science Association, *Poultry Science*, Volume 43, Texas A&M University.

Tarr, L., 1933, Transient Methemoglobinemia Due to Ammonium Nitrate, *Arch. Intern. Med.*, Volume 51, Chicago, Illinois.

Texas Water Quality Board, 1969, Investigation of Suspected Nitrate Intoxication of Livestock in Runnels County From Ground-Water Sources, Texas Water Quality Board, Technical Services Section, unpublished staff report.

Tillman, A. D., Sheriha, G. M., and Sirny, R. J., 1965, Nitrate Reduction Studies With Sheep, *American Society of Animal Science Journal*, Volume 24, Champaign, Illinois.

Tollett, J. T., and others, 1960, Effect of Dietary Nitrate on Growth and Reproductive Performance of Swine, *American Society of Animal Science Journal*, Volume 19, Champaign, Illinois.

University of Wisconsin, 1967, What's New in Farm Science? Vitamin A Prevents Nitrite Poisoning in Poultry, University of Wisconsin, Bulletin 587, Annual Report, Part 2, LaCrosse, Wisconsin.

U.S. Public Health Service, 1962, Drinking Water Standards, 1962: Public Health Service Publication 956.

Van Slyke, D. D., and Vollmund, E., 1925, Studies of Methemoglobin Formation, *Journal of Biological Chemistry*, Volume 66.

Vetter, I., 1960, Methemoglobinemia in Infants in the District of Helmstedt With Reference to the Existing Well Water Supply, Akademie fur Staatsmedizin, Homburg, 1959; Zentralblatt Fuer Bakteriologie, 1, Ref., 1960, Volume 177 (153), G. F. Verlag, Wollgrasweg 49, Postfach 720143, 7000 Stuttgart 72, West Germany. Reprinted in *Water Pollution Abstracts*, 1961, Volume 34, Water Research Centre, Stevenage Laboratory, Elder Way, Stevenage, Herts SGI 1TH, England.

Viets, F. G., Jr., and Hageman, R. H., 1971, Factors Affecting the Accumulation of Nitrate in Soil, Water, and Plants, U.S. Department of Agriculture Handbook 413, Washington, D.C.

Vigil, J., Warburton, S., Haynes, W. S., and Kaiser, L. R., 1965, Nitrates in Municipal Water Supply Cause Methemoglobinemia in Infant, *Public Health Report*, Volume 80, Number 12.

Wallace, J. D., Raleigh, R. J., and Weswig, P. H., 1964, Performance and Carotene Conversion in Hereford Heifers Fed Different Levels of Nitrate, *American Society of Animal Science Journal*, Volume 23, Champaign, Illinois.

Walton, G., 1951, Survey of Literature Relating to Infant Methemoglobinemia Due to Nitrate-Contaminated Water, *American Public Health Association Journal*, Volume 41, Washington, D.C.

BIBLIOGRAPHY—Continued

——— 1960, Fatal Methemoglobinemia Due to Well Water Nitrates, *Annals of Internal Medicine*, Volume 52, American College of Physicians, Philadelphia, Pennsylvania.

Waring, F. H., 1949, Significance of Nitrates in Water Supplies, *American Water Works Association Journal*, Volume 41, Denver, Colorado.

——— 1951, Nitrates in Water and Their Relationship to Methemoglobinemia, University of Michigan Inservice Training Course in Water Works Problems, East Lansing, Michigan.

Weart, J. G., 1948, Effect of Nitrates in Rural Water Supplies on Infant Health, Illinois State Medical Society, *Illinois Medical Journal*, Volume 93, Chicago, Illinois.

Wedemeyer, F. W., 1956, Methemoglobinemia of Infants Caused by Well Water Containing Nitrate, *Arch. Kinderheilk*, Volume 152; LitBer. Wass. Abanass. Luft. u. Boden, 1956, Volume 5 (124). Reprinted in *Water Pollution Abstracts*, 1957, Volume 30, Water Research Centre, Stevenage Laboratory, Elder Way, Stevenage, Herts SGI 1TH, England.

Weichenthal, B. A., and others, 1963, Influence of Sodium Nitrate, Vitamin A and Protein Level on Feedlot Performance and Vitamin A Status of Fattening Cattle, *American Society of Animal Science Journal*, Volume 22, Champaign, Illinois.

Welsch, C. R., and others, 1961, Effect of Dietary Nitrate on Thyroid and Adrenal Gland Weight, *American Society of Animal Science Journal*, Volume 20, Champaign, Illinois.

Werner, W., Thal, W., and Wuttke, W. D., 1965, Severe and Fatal Forms of Methemoglobinemia in Young Infants After Drinking Nitrate-Containing Well Water, *Deutsche Medizinische Wochenschrift*, Volume 90, G. T. Verlag, Herdweg 63, Postfach 732, 7000 Stuttgart 1, West Germany.

Whitehead, E. I., and Moxon, A. L., 1952, Nitrate Poisoning, South Dakota Agricultural Experiment Station, Bulletin 424.

Williamson, A. E., and Peterson, N. L., 1951, Nitrates in North Dakota Well Waters, North Dakota Water and Sewage Works Conference Bulletin, Volume 19.

Winks, W. R., Sutherland, A. K., and Salisbury, R. M., 1950, Nitrite Poisoning of Pigs, *Queensland Journal of Agricultural Science*, Volume 7, Department of Primary Industries, Brisbane, Queensland, Australia.

Winter, A. J., 1962, Studies on Nitrate Metabolism in Cattle, *American Journal of Veterinary Research*, Volume 23, American Veterinary Medical Association, Schaumburg, Illinois.

Winter, A. J., and Hokanson, J. F., 1964, Effects of Long-Term Feeding of Nitrate, Nitrite, or Hydroxylamine on Pregnant Dairy Heifers, *American Journal of Veterinary Research*, Volume 25, American Veterinary Medical Association, Schaumburg, Illinois.

Winton, E. F., Tardiff, R. G., and McCabe, L. J., 1971, Nitrate in Drinking Water, *American Water Works Association Journal*, Volume 63, Number 2, Denver, Colorado.

Wolff, I. A., and Wasserman, A. E., 1972, Nitrates, Nitrites, and Nitrosamines, *Science*, Volume 177.

Wood, R. D., and others, 1967, Effect of Adding Nitrate or Nitrite to Drinking Water on the Utilization of Carotene by Growing Swine, *American Society of Animal Science Journal*, Volume 26, Champaign, Illinois.

Wright, A. J., and Davison, K. L., 1964, Nitrate Accumulation in Crops and Nitrate Poisoning in Animals, *Advances in Agronomy*, Volume 16, Academic Press, New York, New York.

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #8

Attachment 8-1
August 2, 2021

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STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, FORT WORTH DISTRICT
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

February 17, 2021

Regulatory Division

SUBJECT: Project Number SWF-2020-00481, City of Haskell Landfill

Janet Moeller
City of Haskell
101 N. Ave. E., Ste. B
P.O. Box 1001
Haskell, Texas 79521
citymanager@haskelltexasusa.com

Dear Ms. Moeller:

This letter is in regard to information received November 03, 2020, and subsequent information dated December 08, 2020, concerning the proposal by the City of Haskell to expand existing landfill located in the City of Haskell, Haskell County, Texas. This project has been assigned Project Number SWF-2020-00481. Please include this number in all future correspondence concerning this project.

Under Section 404 of the Clean Water Act the U.S. Army Corps of Engineers (USACE) regulates the discharge of dredged and fill material into waters of the United States, including wetlands. USACE responsibility under Section 10 of the Rivers and Harbors Act of 1899 is to regulate any work in, or affecting, navigable waters of the United States. Based on your description of the proposed work, and other information available to us, it appears there are no waters of the United States present on the proposed project site. Therefore, no permit is required under Section 404 of the Clean Water Act or Section 10 of the River and Harbors Act of 1899.

The USACE based this decision on an approved jurisdictional determination (JD) that there are no waters of the United States on the project site. The basis of this approved JD is enclosed. This approved JD is valid for a period of no more than five years from the date of this letter unless new information warrants revision of the delineation before the expiration date.

The Applicant may accept or appeal this approved JD or provide new information in accordance with the enclosed Notification of Administration Appeal Options and Process and Request for Appeal (NAAOP-RFA). If the Applicant elects to appeal this approved JD, the Applicant must complete Section II (Request for Appeal or Objections to an Initial Proffered Permit) of the enclosure and return it to the Division Engineer, ATTN: CESWD-PD-O Appeals Review Officer, U.S. Army Corps of Engineers, 1100 Commerce Street Suite 831, Dallas, Texas 75242-0216 within 60 days of the date of this notice. Failure to notify the USACE within 60 days of the date of this notice means you accept the approved JD in its entirety and waive all rights to appeal the approved JD.

Thank you for your interest in our nation's water resources. If you have any questions concerning our regulatory program, please refer to our website at http://www.swf.usace.army.mil/Missions/Regulatory or contact Mr. Brian Bartels at the address above, by telephone (817) 886-1742, or by email Brian.C.Bartels@usace.army.mil, and refer to your assigned project number.

Please help the regulatory program improve its service by completing the survey on the following website: http://corpsmapu.usace.army.mil/cm_apex/f?p=regulatory_survey

Sincerely,

For: Brandon W. Mobley
Chief, Regulatory Division

Enclosures

Copies Furnished by Email:
Mr. David Hudson dhudson@jacobmartin.com

I. ADMINISTRATIVE INFORMATION

Completion Date of Approved Jurisdictional Determination (AJD): 2/17/2021
ORM Number: SWF-2020-00481
Associated JDs: N/A
Review Area Location[1]: State/Territory: Texas City: Haskell County/Parish/Borough: Haskell
Center Coordinates of Review Area: Latitude 33.171391° Longitude -99.645988°

II. FINDINGS

A. Summary: Check all that apply. At least one box from the following list MUST be selected. Complete the corresponding sections/tables and summarize data sources.

☒ The review area is comprised entirely of dry land (i.e., there are no waters or water features, including wetlands, of any kind in the entire review area). Rationale: Project information provided by the consultant and supporting data indicate that the project area is upland (dry land). Aerial imagery indicates that the project area currently is used as row-crop agriculture. The project area is without water features, streams, and/or wetlands. The proposed work will not result in the placement of fill or dredged material within a water feature or waters of the U.S.

☐ There are "navigable waters of the United States" within Rivers and Harbors Act jurisdiction within the review area (complete table in Section II.B).

☐ There are "waters of the United States" within Clean Water Act jurisdiction within the review area (complete appropriate tables in Section II.C).

☐ There are waters or water features excluded from Clean Water Act jurisdiction within the review area (complete table in Section II.D).

B. Rivers and Harbors Act of 1899 Section 10 (§ 10)[2]

§ 10 Name	§ 10 Size		§ 10 Criteria	Rationale for § 10 Determination
N/A.	N/A.	N/A	N/A.	N/A.

C. Clean Water Act Section 404

Territorial Seas and Traditional Navigable Waters ((a)(1) waters):[3]				
(a)(1) Name	(a)(1) Size		(a)(1) Criteria	Rationale for (a)(1) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

Tributaries ((a)(2) waters):				
(a)(2) Name	(a)(2) Size		(a)(2) Criteria	Rationale for (a)(2) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

Lakes and ponds, and impoundments of jurisdictional waters ((a)(3) waters):				
(a)(3) Name	(a)(3) Size		(a)(3) Criteria	Rationale for (a)(3) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

[1] Map(s)/figure(s) are attached to the AJD provided to the requestor.
[2] If the navigable water is not subject to the ebb and flow of the tide or included on the District's list of Rivers and Harbors Act Section 10 navigable waters list, do NOT use this document to make the determination. The District must continue to follow the procedure outlined in 33 CFR part 329.14 to make a Rivers and Harbors Act Section 10 navigability determination.
[3] A stand-alone TNW determination is completed independently of a request for an AJD. A stand-alone TNW determination is conducted for a specific segment of river or stream or other type of waterbody, such as a lake, where upstream or downstream limits or lake borders are established. A stand-alone TNW determination should be completed following applicable guidance and should NOT be documented on the AJD Form.

Adjacent wetlands ((a)(4) waters):				
(a)(4) Name	(a)(4) Size		(a)(4) Criteria	Rationale for (a)(4) Determination
N/A.	N/A.	N/A.	N/A.	N/A.

D. Excluded Waters or Features

Excluded waters ((b)(1) – (b)(12)):[4]				
Exclusion Name	Exclusion Size		Exclusion[5]	Rationale for Exclusion Determination
N/A.	N/A.	N/A.	N/A.	N/A.

III. SUPPORTING INFORMATION

A. Select/enter all resources that were used to aid in this determination and attach data/maps to this document and/or references/citations in the administrative record, as appropriate.

☒ Information submitted by, or on behalf of, the applicant/consultant: Project description, NWI Map, USGS Topographic Map – 2020-11-03, submitted by Jacob Martin Consulting, Inc.
This information is sufficient for purposes of this AJD.
Rationale: N/A

☐ Data sheets prepared by the Corps: N/A

☒ Photographs: Aerial: Imagery from Google Earth and Digital Globe – all available years

☐ Corps site visit(s) conducted on: N/A

☐ Previous Jurisdictional Determinations (AJDs or PJDs): N/A

☐ Antecedent Precipitation Tool: *provide detailed discussion in Section III.B*.

☐ USDA NRCS Soil Survey: N/A

☒ USFWS NWI maps: ESRI managed imagery, SWF Regulatory Viewer, 2021-02-17

☒ USGS topographic maps: Haskell, TX - 1:24,000

Other data sources used to aid in this determination:

Data Source (select)	Name and/or date and other relevant information
USGS Sources	National Hydrography Dataset, SWF Regulatory Viewer, 2021-02-17
USDA Sources	N/A.
NOAA Sources	N/A.
USACE Sources	N/A.
State/Local/Tribal Sources	N/A.
Other Sources	Location and topographic maps provided by the consultant

B. Typical year assessment(s): N/A

C. Additional comments to support AJD: N/A

[4] Some excluded waters, such as (b)(2) and (b)(4), may not be specifically identified on the AJD form unless a requestor specifically asks a Corps district to do so. Corps districts may, in case-by-case instances, choose to identify some or all of these waters within the review area.
[5] Because of the broad nature of the (b)(1) exclusion and in an effort to collect data on specific types of waters that would be covered by the (b)(1) exclusion, four sub-categories of (b)(1) exclusions were administratively created for the purposes of the AJD Form. These four sub-categories are not new exclusions, but are simply administrative distinctions and remain (b)(1) exclusions as defined by the NWPR.

NOTIFICATION OF ADMINISTRATIVE APPEAL OPTIONS AND PROCESS AND REQUEST FOR APPEAL

Applicant: Janet Moeller, City of Haskell	File Number: SWF-2020-00481	Date: February 17, 2021
Attached is:		See Section below:
INITIAL PROFFERED PERMIT (Standard Permit or Letter of permission)		A
PROFFERED PERMIT (Standard Permit or Letter of permission)		B
PERMIT DENIAL		C
APPROVED JURISDICTIONAL DETERMINATION		D
PRELIMINARY JURISDICTIONAL DETERMINATION		E

SECTION I - The following identifies your rights and options regarding an administrative appeal of the above decision. Additional information may be found at http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/appeals.aspx or Corps regulations at 33 CFR Part 331.

A: INITIAL PROFFERED PERMIT: You may accept or object to the permit.

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- OBJECT: If you object to the permit (Standard or LOP) because of certain terms and conditions therein, you may request that the permit be modified accordingly. You must complete Section II of this form and return the form to the district engineer. Your objections must be received by the district engineer within 60 days of the date of this notice, or you will forfeit your right to appeal the permit in the future. Upon receipt of your letter, the district engineer will evaluate your objections and may: (a) modify the permit to address all of your concerns, (b) modify the permit to address some of your objections, or (c) not modify the permit having determined that the permit should be issued as previously written. After evaluating your objections, the district engineer will send you a proffered permit for your reconsideration, as indicated in Section B below.

B: PROFFERED PERMIT: You may accept or appeal the permit

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- APPEAL: If you choose to decline the proffered permit (Standard or LOP) because of certain terms and conditions therein, you may appeal the declined permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

C: PERMIT DENIAL: You may appeal the denial of a permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

D: APPROVED JURISDICTIONAL DETERMINATION: You may accept or appeal the approved JD or provide new information.

- ACCEPT: You do not need to notify the Corps to accept an approved JD. Failure to notify the Corps within 60 days of the date of this notice, means that you accept the approved JD in its entirety, and waive all rights to appeal the approved JD.
- APPEAL: If you disagree with the approved JD, you may appeal the approved JD under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

E: PRELIMINARY JURISDICTIONAL DETERMINATION: You do not need to respond to the Corps regarding the preliminary JD. The Preliminary JD is not appealable. If you wish, you may request an approved JD (which may be appealed), by contacting the Corps district for further instruction. Also you may provide new information for further consideration by the Corps to reevaluate the JD.

SECTION II - REQUEST FOR APPEAL or OBJECTIONS TO AN INITIAL PROFFERED PERMIT

REASONS FOR APPEAL OR OBJECTIONS: (Describe your reasons for appealing the decision or your objections to an initial proffered permit in clear concise statements. You may attach additional information to this form to clarify where your reasons or objections are addressed in the administrative record.)

ADDITIONAL INFORMATION: The appeal is limited to a review of the administrative record, the Corps memorandum for the record of the appeal conference or meeting, and any supplemental information that the review officer has determined is needed to clarify the administrative record. Neither the appellant nor the Corps may add new information or analyses to the record. However, you may provide additional information to clarify the location of information that is already in the administrative record.

POINT OF CONTACT FOR QUESTIONS OR INFORMATION:

If you have questions regarding this decision and/or the appeal process you may contact:	If you only have questions regarding the appeal process you may also contact:
Mr. Brian C. Bartels Regulatory Specialist (CESWF-RDE) U.S. Army Corps of Engineers P.O. Box 17300 819 Taylor Street, Room 3A37 Fort Worth, Texas 76102-0300 817-886-1742	Mr. Elliott Carman Administrative Appeals Review Officer (CESWD-PD-O) U.S. Army Corps of Engineers 1100 Commerce Street, Suite 831 Dallas, Texas 75242-1317 469-487-7061

RIGHT OF ENTRY: Your signature below grants the right of entry to Corps of Engineers personnel, and any government consultants, to conduct investigations of the project site during the course of the appeal process. You will be provided a 15-day notice of any site investigation and will have the opportunity to participate in all site investigations.

Signature of appellant or agent.	Date:	Telephone number:

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #9

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER
8-9-21

Attachment 9-1
August 2, 2021

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Biological Assessment for Haskell Landfill

1.0 Biological Resources

The proposed project area is located in Haskell County, Texas. Haskell County is located in the Rolling Plains ecoregion of Texas. The area is more significantly held within the Southern Rolling Plains of Texas (Griffith, et al.). Several Texas rivers begin in the Rolling Plains, an extensive area dominated by livestock ranching and farming.

1.1.1 Vegetation

Native vegetation varies across the Rolling Plains. The original prairie grasslands included tall and mid-grasses such as bluestems and side-oat gramas. Buffalo grass and other short grasses have increased under heavy grazing and mesquite is a common invader, hence much of the Rolling Plains today can be described as a mesquite-shortgrass savanna. Stream floodplains are dominated by various hardwood species. The western edge of the region ends abruptly with the steep slopes, cliffs, and canyons of the Caprock Escarpment. Crop and livestock production are the major agricultural industries in this region. Elevations vary from 800 to 3,000 feet above sea level. Average annual rainfall is 20 inches, with peaks in May and September; summers are typically hot with high evaporation rates. Soils vary from coarse sands to tight clays and shales.

Shrubs found in this eco-region include species of wild cherry and plum, as well as sages. The Rolling Plains region contains many of the typical plains grasses: Buffalo grass, hairy, blue, and sideoats grama, big bluestem, Indiangrass, Canada wildrye and Texas Bluegrass. In particular, the proposed location is gently rolling to flat scrubland with mesquite and shin oak.

1.1.2 Wildlife Communities

Representative wildlife which can be found in the proposed project area may include the opossum (*Didephis virginiana*), armadillo (*Dasypus novemcinctus*), eastern cottontail (*Canis latrans*), coyote (*Canis latrans*), western spotted skunk (*Spilogale gracilis*), western hognose skunk (*Conepatus leuconotus*), striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), white-tailed deer (*Odocoileus viginianus*), common raccoon (*Procyon lotor*), fox squirrel (*Sciurus niger,*) and wild turkey (*Meleagris gallopavo*).

During migration periods, various species of waterfowl may inhabit the area due to the proximity to the Red Creek River and utilize local lakes and stock ponds. The area is a mosaic of mesquite, shin oak and short grasses, not usually associate with migratory stop overs and summer breeding ground for song birds.

There are no state or national parks, forests, wildlife refuges, wild or scenic rivers, or natural areas located within or adjacent to the proposed project area

1.1.3 Threatened and Endangered Species

A review of the known threatened and endangered species listed in Haskell County revealed a total of 11 species of birds, reptiles, mussels, plants and mammals (TPWD 2020)(USFWS 2020). A list of these specific species in addition to other commonly discussed species can be found in Table 1.

The Texas Horned Lizard (*Phrynosoma cornutm*) is known to occur throughout western Texas including potentially near and on the proposed project near the Haskell area. Texas Horned Lizards were not observed during the field visit, but local habitat within the proposed project was observed for the species.

Table 1

	COMMON NAME	SCIENTIFIC NAME	FED STATUS	STATE STATUS
MAMMALS	x	*x*		
BIRDS	Bald Eagle	*Haliaeetus leucocephalus*	DL	T
	Black-capped Vireo	*Vireo atricapilla*	--	*
	Black Rail	*Laterallus jamaicensis*	PT	--
	Golden Cheek Warbler	*Setophaga chrysoparia*	LE	E
	Interior Least Tern	*Sternula antillarum athalassos*	LE	E
	Piping Plover	*Charadrius melodus*	LT	T
	White Faced Ibis	*legadis chihi*	--	T
	Whooping Crane	*Grus americana*	LE	E
	Red Knot	*Calidris canutus rufa*		T
REPTILES	Texas Horned Lizard	*Phrynosoma cornutum*	--	T
	Brazos Water Snake	*Nerodia harteri*	T	--
FISH	Small Eye Shiner	*Notropis buccula*	LE	--
	Sharpnose Shiner	*Notropis oxyrhynchus*	LE	--
	Chub Shiner	*Notropis potteri*	--	T
MOLLUSKS	Texas Fawnfoot	*Truncilla macrodon*	C	T
PLANTS	x	*x*		

LE- Listed Endangered **T- Threatened** **E- Endangered** **C- Candidate** **DL- De-listed**

Bald Eagle – formerly State Threatened – (Federally protected under Bald and Golden Eagle Protection Act) – This species is found near lakes and rivers, and prefers to nest in tall trees and cliffs near water. The proposed project is located within a Shin oak pastureland . The lack of sustainable water and food nearby neglect potential habitat needs of the species. No raptor nests were observed during biological ground surveys in the area. Due to the limited lack of habitat associated with the proposed project, this species will not be affected.
Interior Least Tern – Federal and State Endangered - Sand beaches, flats, bays, inlets, lagoons, islands. Subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc.); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony. This species only needs to be considered under Wind Energy Projects. There are no critical habitats within the project area. The species will not be affected by the proposed project.

Piping Plover – Federal and State Threatened - Beaches, sandflats, and dunes along Gulf Coast beaches and adjacent offshore islands. Also spoil islands in the Intracoastal Waterway. Based on the November 30, 1992 Section 6 Job No. 9.1, Piping Plover and Snowy Plover Winter Habitat Status Survey, algal flats appear to be the highest quality habitat. Some of the most important aspects of algal flats are their relative inaccessibility and their continuous availability throughout all tidal conditions. Sand flats often appear to be preferred over algal flats when both are available, but large portions of sand flats along the Texas coast are available only during low-very low tides and are often completely unavailable during extreme high tides or strong north winds. Beaches appear to serve as a secondary habitat to the flats associated with the primary bays, lagoons, and inter-island passes. Beaches are rarely used on the southern Texas coast, where bayside habitat is always available, and are abandoned as bayside habitats become available on the central and northern coast. However, beaches are probably a vital habitat along the central and northern coast (i.e. north of Padre Island) during periods of extreme high tides that cover the flats. Optimal site characteristics appear to be large in area, sparsely vegetated, continuously available or in close proximity to secondary habitat, and with limited human disturbance. This species only needs to be considered under Wind Energy Projects. There are no critical habitats within the project area. The species will not be affected by the proposed project.

Black Rail – Federal Potential Threatened - Salt, brackish, and freshwater marshes, pond borders, wet meadows, and grassy swamps; nests in or along edge of marsh, sometimes on damp ground, but usually on mat of previous years dead grasses; nest usually hidden in marsh grass or at base of Salicornia. The species will not be affected by the proposed project.

White Faced Ibis – State Threatened - Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats. The species will not be affected by the proposed project.

Red Knot – Federal Threatened State Threatened - Prefers tidal flats, in migration and winters habitat is coastal mudflats and tidal zones, sometimes open sandy beaches. Long migrating bird traveling from Argentina to Canada. Roosts in densely packed flocks, standing shoulder to shoulder. This species only needs to be considered under the Wind Energy Projects. There are no critical habitats within the project area. The species will not be affected by the proposed project.

Gray Wolf – Formerly found throughout North America, the gray wolf can be found in wilderness that is not subject to human population pressures. The wolf is considered extirpated from most of the contiguous U.S. due to human-caused direct mortality. This species will not be affected.

Red Wolf – The species, if it still exists in un-hybridized form, is considered extinct in the wild since the early 1980's. Historically, it was believed that the species occurred from central Texas eastward to the coasts of Florida and Georgia and north to Carolina. The last remnant population along Texas/Louisiana coast was rendered functionally extinct due to hybridization with coyote. The species will not be affected by the proposed project.

Whooping Crane – Federal and State Endangered – This species is included in the IPaC report but would only be found in the area as a migrant. The species inhabits large wetland areas as stopover points during migration. The Aransas National Wildlife Refuge near Corpus Christi, Texas is approximately 385 air miles inland from the project. There are no critical habitats within the project area. The Whooping Crane will not be affected due to the minimal construction associated with this project and due to restrictive nature of this species.

Texas Horned Lizard – State Threatened – Habitat consists of arid to semi-arid environments with sparse vegetation and sandy to rocky soil. This species usually can be found near harvester ant mounds where they forage. Texas Horned Lizard habitat was possible across much of the proposed project; however, the potential for the species to in the project but no observations have been recorded. Upland range areas outside of the City of Haskell also contain areas of potential habitat for the horned-lizard. Due to the restricted nature of the proposed construction and the noted mitigation, this species will not be affected.

Brazos Water Snake -- Habitat includes rocky stream beds and banks of the Brazos River; this species is not found along the sandy stretches of this river system. The proposed project is not directly connected to the Brazos River. No instances of the Brazos River Water Snake have been reported in the project area. The species will not be affected by the proposed project.

Small eye Shiner /Sharpnose Shiner -- the USFWS has designated approximately 623 miles of the Upper Brazos River Basin and the upland areas extending beyond the river channel by 98 feet on each side as critical habitat for the two fish in the Texas counties of Baylor, Crosby, Fisher, Garza, Haskell, Kent, King, Knox, Stonewall, Throckmorton and Young. Project is on the Double Mountain Fork of the Brazos River. Due to the use of directional boring, the species will not be affected by the proposed project.

Chub Shiner - Flowing water with silt or sand substrate makes up the designated habitat. This project is on the Double Mountain Fork of the Brazos River or on any flowing water. Due to the use of directional boring, the species will not be affected by the proposed project.

There are no state or national parks, forests, wildlife refuges, wild or scenic rivers, or natural areas located within or adjacent to the proposed project area

1.1.4 Direct Effects

TPWD online was contacted for its review of the project. Their response dated 05/17/2021 is included in this report. The IPaC Information for Planning and Consultation date is May 14, 2021.

TPWD recommendations are to follow best management practices for MBTA, Parks and Wildlife Code chapter 64, Texas Horned Lizard and to contact TPWD for any occurrence of a rare species.

Direct effects to biological resources is not likely to occur as a result of this project.

1.1.5 Indirect Effects

This project does not anticipate indirectly creating residential or corporate growth near the proposed area; therefore, no indirect impacts to biological resources is likely to occur.

1.1.6 Mitigation

Several mitigation measures as standard practice for the TPWD recommendations will be adhered to during construction and afterword during maintenance. Ground disturbance in the site will be done in conjunction with a storm water pollution prevention plan to protect these areas from pollution.

Federal Laws

Migratory Bird Treaty Act (MBTA)

The Migratory Bird Treaty Act (MTBA) prohibits direct and affirmative purposeful actions that reduce migratory birds, their eggs, or their nests, by killing or capturing, to human control, except when specifically authorized by the Department of the Interior. This protection applies to most native bird species, including ground nesting species.

Recommendation: TPWD recommends excluding vegetation clearing activities during the general bird nesting season, March 15 through September 15, to avoid adverse impacts to birds. If clearing vegetation during the migratory bird nesting season is unavoidable, TPWD recommends surveying the area proposed for disturbance for active nests (nests with eggs or young). Any vegetation (trees, shrubs, and grasses) or bare ground where occupied nests are located should not be disturbed until the eggs have hatched and the young have fledged.

TPW Code Section 64.002, regarding protection of nongame birds, provides that no person may catch, kill, injure, pursue, or possess a bird that is not a game bird. TPW Code Section 64.003, regarding destroying nests or eggs, provides that, no person may destroy or take the nests, eggs, or young and any wild game bird, wild bird, or wild fowl. TPW Code Chapter 64 does not allow for incidental take and therefore is more restrictive than the MBTA.

Recommendation: Please review the Federal Law. Migratory Bird Treaty Act section above for recommendations as they are also applicable for Chapter 64 of the Parks and Wildlife Code compliance.

Parks and Wildlife Code, Section 68.015

Section 68.015 of the TPW Code regulates state-listed species. Please note that there is no provision for the capture, bap, take, or kill (incidental or otherwise) of state-listed species. A copy of TPWD Guidelines for Protection of State-Listed Species, which includes a list of penalties for take of species, can be found on the TPWD website. State-listed species may only be handled by persons with appropriate authorization from the TPWD Wildlife Permits Office. For more information, please contact the Wildlife Permits Office at (512) 389-4647.

Texas horned lizard (Phrynosoma cornutum—) State-listed Threatened

The Texas horned lizard can be found in open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees. If present in the project area, the Texas horned lizard could be impacted by ground disturbing construction activities. Homed lizards may hibernate on-site in the loose soils a few inches below ground during the cool months from September/October to March/April. Construction in these areas could harm hibernating lizards. Horned lizards are active above ground when temperatures exceed 75 degrees Fahrenheit. If homed lizards (nesting, gravid females, newborn young, lethargic from cool temperatures or hibernation) cannot move away from noise and approaching construction equipment in time, they could be affected by construction activities. Based on a review of aerial imagery and Ecological Mapping Systems of Texas data, suitable habitat for the Texas homed lizard may occur in the proposed project area.

Recommendation: TPWD recommends avoiding disturbance of the Texas horned lizard, its burrows, and colonies of its primary food source, the harvester ant (Pogonomyrmez sp.), during clearing and construction. TPWD recommends a permitted biological monitor be present during construction to relocate Texas horned lizards, if found. If the presence of a biological monitor during construction is not feasible, Texas horned lizards observed during construction should be allowed to safety leave the site.

A mixture of cover, food sources, and open ground is important to the Texas horned lizard and harvester ant. Disturbed areas within suitable habitat for the Texas horned lizard should be re-vegetated with site-specific native, patchy vegetation rather than sod-forming grasses.

Rare Species

In addition to state and federally-protected species, TPWD tracks special features, natural communities, and rare species that are not listed as threatened or endangered. TPWD actively promotes their conservation and considers it important to evaluate and, if necessary, minimize impacts to rare species and their habitat to reduce the likelihood of endangerment and preclude the need to list. These species and communities are tracked in the Texas Natural Diversity Database (TXNDD). The most current and accurate TXNDD data can be requested from the TXNDD website.

No records of rare, threatened, or endangered species have been documented within 1.5 miles of the project area in the TXNDD. Please note that the absence of TXNDD information in an area does not imply that a species is absent from that area. Given the small proportion of public versus private land in Texas, the TXNDD does not include a representative inventory of rare resources in the state. Although it is based on the best data available to TPWD regarding rare species, the data from the TXNDD do not provide a definitive statement as to the presence, absence or condition of special species, natural communities, or other significant features within your project area. These data are not inclusive and cannot be used as presence/absence data. This information cannot be substituted for on-the- ground surveys.

Recommendation: Please review the TPWD county list for Haskell County, as rare species could be present, depending upon habitat availability. These lists are available on the Rare, Threatened, and Endangered Species of Texas website. If during construction, the project area is found to contain rare species, natural plant communities, or special features, TPWD recommends that precautions be taken to avoid impacts to them. The USFWS should be contacted for species occurrence data, guidance, permitting, survey protocols, and mitigation for federally-listed species. For USFWS threatened and endangered species lists, please see the USFWS Information for Planning and Consultation website.

Determining the actual presence of a species in a given area depends on many variables including daily and seasonal activity cycles, environmental activity cues, preferred habitat, transiency and population density (both wildlife and human). The absence of a species can be demonstrated only with great difficulty and then only with repeated negative observations, taking into account all the variable factors contributing to the lack of detectable presence. If encountered during construction, measures should be taken to avoid impacting wildlife.

Texas horned lizard (Phrynosoma cornutum) Best Management Practices (BMPs)

TPWD recommends implementing the following BMPs to assist in minimizing potential impacts to the Texas horned lizard. TPWD notes that implementing the following BMPs could also help minimize impacts to a variety of native wildlife species that may inhabit the project area:

Texas Horned Lizard Surveys — TPWD recommends having a qualified biologist survey the proposed project site for any Texas horned lizards that may be in the area that is proposed for disturbance. As previously mentioned, a useful indication that the Texas horned lizard may occupy the site is the presence of harvester ant mounds. The survey should be performed during the warm months of the year when the horned lizards are active.

Contractor Training for Protected Species - TPWD generally recommends providing training for project contractors prior to the construction of the proposed project. Wildlife training should consist of identification of Texas horned lizards and their primary food source (harvester ants), and the proper protocol to avoid impact if a Texas horned lizard or other rare or protected species is encountered. TPWD recommends instructing contractors to avoid impacts to harvester ant mounds where feasible. TPWD understands that ant mounds in the direct path of construction would be difficult to avoid, but contractors should be mindful of these areas when deciding where to place project specific locations and other disturbances associated with construction.

Biological Monitor — TPWD recommends that a permitted biologist be onsite during construction activities, especially during site clearing and trenching, to look for protected species, advise the construction crews on appropriate action if horned lizards are observed, and relocate any protected individuals that are in imminent harm. Biologists must be authorized to handle horned lizards and other state-listed species. If a biological monitor cannot be on-site during construction, site personnel should be trained for encounters with protected species and a qualified biologist should be notified of the siting and consulted on appropriate action.

Horned Lizard Encounters - If Texas horned lizards are encountered, they should be avoided and allowed to leave the project area on their own. If a horned lizard must be relocated, TPWD recommends relocating them off-site to an area that is close-by and contains similar habitat. TPWD recommends that any translocations of reptiles be the minimum distance possible, no greater than one mile, preferably within 100 to 200 yards from the initial encounter location. After horned lizard removal, the area that will be disturbed during active construction and project specific locations should be fenced off to exclude horned lizards and other reptiles.

The exclusion fence should be constructed and maintained as follows:

- The exclusion fence should be constructed with metal flashing or drift fence material. Rolled erosion control mesh material should not be used.
- The exclusion fence should be buried at least 6 inches deep and be at least 24 inches high.
- The exclusion fence should be maintained for the life of the project and only removed after the construction is completed and the disturbed site has been revegetated with site-specific native species.

Work During Cold Weather - If construction activities take place during cold weather, it is recommended that construction personnel stay observant of activities that may harm the Texas horned lizard, such as disruption of burrows. In cold weather, this species will use burrows or pallets near the base of vegetation for shelter. Their slow metabolism in cold weather can reduce movements, restricting their ability to flee from danger.

Trenches - To avoid direct harm to state-listed species and other wildlife that may occur in the project area, TPWD recommends that any open trenches or excavation areas be covered overnight and/or inspected every morning to ensure no Texas horned lizards or other wildlife have been trapped. For open trenches and excavated pits, install escape ramps at an angle of less than 45 degrees (1 : 1) in areas left uncovered. Also, inspect excavation areas for trapped wildlife prior to refilling. As previously mentioned, if state-listed species are trapped in trenches, they should be removed by personnel permitted by TPWD to handle state-listed species.

Construction personnel will be instructed to avoid killing Texas Horned Lizards found during construction. Trenches remaining open overnight or for more than 2 hours during the day will be inspected prior to backfilling for the presence of Texas Horned Lizards. Texas Horned Lizards in the trench will be carefully removed and relocated safely away from the construction area by personnel possessing a TPWD scientific collection permit. Such relocations will be reported to Jacob & Martin, LLC, USDA State Environmental Coordinator, and the TPWD.

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #10

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER
8-9-21

Attachment 10-1
August 2, 2021

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HASKELL MSW TRANSFER STATION

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Appendix #10

THE STATE OF TEXAS,
COUNTY OF Haskell

Know All Men By These Presents:

2822 VOL 416 PAGE 781

That we, A.C. BREWER and wife, FREDDIE JEWEL BREWER of the County of Ector, State of Texas, VENICE MARIE ELMORE and husband, E.L. ELMORE of the County of Haskell, State of Texas, J.P. BREWER and wife, BERNICE BREWER of the County of Kaufman, State of Texas, and BRENDA RAY SUMMERS, a single, woman, of the County of Dallas, , State of Texas for and in consideration of the sum of NINETY-SIX THOUSAND and NO/100--($96,000.00)-------------DOLLARS,

to us, cash in hand paid by the City of Haskell, Texas, a municipal corporation, the receipt of which is hereby acknowledged and confessed,

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Attachment 10
Page 3
August2, 2021

have Granted, Sold and Conveyed, and by these presents do Grant, Sell and Convey unto the said City of Haskell, whose mailing address is: P.O. Box 783, Haskell, Texas 79521

of the County of Haskell , State of Texas all that certain lot, tract or parcel of land, lying and being situated in Haskell County, Texas and described as follows, to-wit:

All that certain tract of land lying and being situated in Haskell County, Texas, being the Surface Only of a tract of land of 160 acres out of a survey of one-third league of land patented to James M. Morris, Assignee of Leaper Willoughby, by Pat. No. 475, Vol. 11, Abst. No. 408, Cert. No. 69, described as follows:

BEGINNING at a point 40 vrs. West from the NE corner of said Leaper Willoughby Survey;
THENCE West 969 vrs. with the NBL of said Willioughby Survey to a stake in same for the NW corner of this tract;
THENCE South 0 Deg. 18' West 934 vrs. to a stake in road for the SW corner of this tract;
THENCE East 967 vrs. to a stake in road for the SE corner of this tract;
THENCE North 0 Deg. 18' East 934 vrs. to the place of beginning, and being the same land described in a deed from A.M. Brownfield and wife, Lottie Brownfield, to J.R. Jacobs and Edmon C. Hargraves, dated January 30, 1946, duly recorded in the Haskell County Deed Records, Vol. 166, Page 448, to which deed and the record thereof, reference is here made for all legal purposes. It is understood and agreed that the Surface Estate Only is hereby conveyed, all the minerals in said land having been heretofore reserved by prior grantors. Said property being the same described in a deed from J. R. Jacobs, et al, to Raymond Brewer, dated December 12, 1949, and recorded in Vol. 198, Page 263, Deed Records of Haskell County, Texas, to which reference is hereby made.

CERTIFIED COPY Pg. 1 of 3
ATTEST 10/21 20 20
Belia Abila
Haskell County Clerk
Haskell County, Texas
By Jm Deputy

TO HAVE AND TO HOLD the above described premises, together with all and singular, the rights and appurtenances thereto in anywise belonging unto the said City of Haskell, Haskell, Texas, its successors ~~XXXX~~ and assigns forever; and we, do hereby bind ourselves, our heirs, executors and administrators, to Warrant and Forever Defend all and singular the said premises unto the said City of Haskell, Haskell, Texas, its successors ~~XXXXX~~ and assigns against every person whomsoever lawfully claiming, or to claim the same, or any part thereof.

Witness our hands ~~XX~~ this 26th day of September, A.D. 1984

~~XWitnesses at Request of Grantor~~

J.P. Brewer	A.C. Brewer
Bernice Brewer	Freddie Jewel Brewer
Brenda Ray Summers	Venice Marie Elmore
	E.L. Elmore

THE STATE OF TEXAS, X

COUNTY OF Ector X

This instrument was acknowledged before me on the 10 day of Oct., A.D., 198_ by A. C. Brewer and wife, Freddie Jewell Brewer.

NOTARY PUBLIC STATE OF TEXAS
JUNE FINN
Notary Public, State of Texas
My Commission Expires March 10, 19 85

Notary Public in and for
the State of Texas
My commission expires:

Part I/II
Attachment 10
Page 3 August 2, 2021

A CERTIFIED COPY Pg. 2 of 2
ATTEST 10-21 20 20
Bella Abila
Haskell County Clerk
Haskell County, Texas
By ______ Deputy

HASKELL MSW TRANSFER STATION

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Appendix #11

KEN MARTIN
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Property owner affidavit for the Haskell Transfer Station

I, Alberto Alvarez Jr. , as Mayor of the City of Haskell, Texas,

As authorized signatory for the City of Haskell, Texas,

acknowledge that the State of Texas may hold the City of Haskell either jointly or severally responsible for the operation, maintenance, and closure and post-closure care of the facility;

and acknowledge that the City of Haskell and the State of Texas shall have access to the property during the active life and post-closure care period, if required, after closure for the purpose of inspection and maintenance.

Signed By: Date:

X [signature] X 7-14-21

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #12

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REGISTERED
PROFESSIONAL ENGINEER

8-9-21

From: noreply@thc.state.tx.us
Sent: Tuesday, July 6, 2021 9:17 AM
To: David Hudson; reviews@thc.state.tx.us
Subject: Section 106 Submission

TEXAS HISTORICAL COMMISSION
real places telling real stories

Re: Project Review under the Antiquities Code of Texas
THC Tracking #202111586
Date: 07/06/2021
City of Haskell Landfill expansion
5412 Hwy 380 E.
Haskell,TX 79521

Description: The City of Haskell will be adding a transfer station building on the existing landfill property rather than adding an expansion.

Dear David Hudson:
Thank you for your submittal regarding the above-referenced project. This response represents the comments of the Executive Director of the Texas Historical Commission (THC), pursuant to review under the Antiquities Code of Texas.

The review staff, led by Caitlin Brashear, Drew Sitters, has completed its review and has made the following determinations based on the information submitted for review:

Above-Ground Resources

- No historic properties are present or affected by the project as proposed. However, if historic properties are discovered or unanticipated effects on historic properties are found, work should cease in the immediate area; work can continue where no historic properties are present. Please contact the THC's History Programs Division at 512-463-5853 to consult on further actions that may be necessary to protect historic properties.

Archeology Comments

- No effect on identified archeological sites or other cultural resources. However, if cultural materials are encountered during project activities, work should cease in the immediate area; work can continue where no cultural materials are present. Please contact the THC's Archeology Division at 512-463-6096 to consult on further actions that may be necessary to protect the cultural remains.

We look forward to further consultation with your office and hope to maintain a partnership that will foster effective historic preservation. Thank you for your cooperation in this review process, and for your efforts to preserve the irreplaceable heritage of Texas. If the project changes, or if new historic properties are found, please contact the review staff. If you have any questions concerning our review or if we can be of further assistance, please email the following reviewers: caitlin.brashear@thc.texas.gov, drew.sitters@thc.texas.gov.

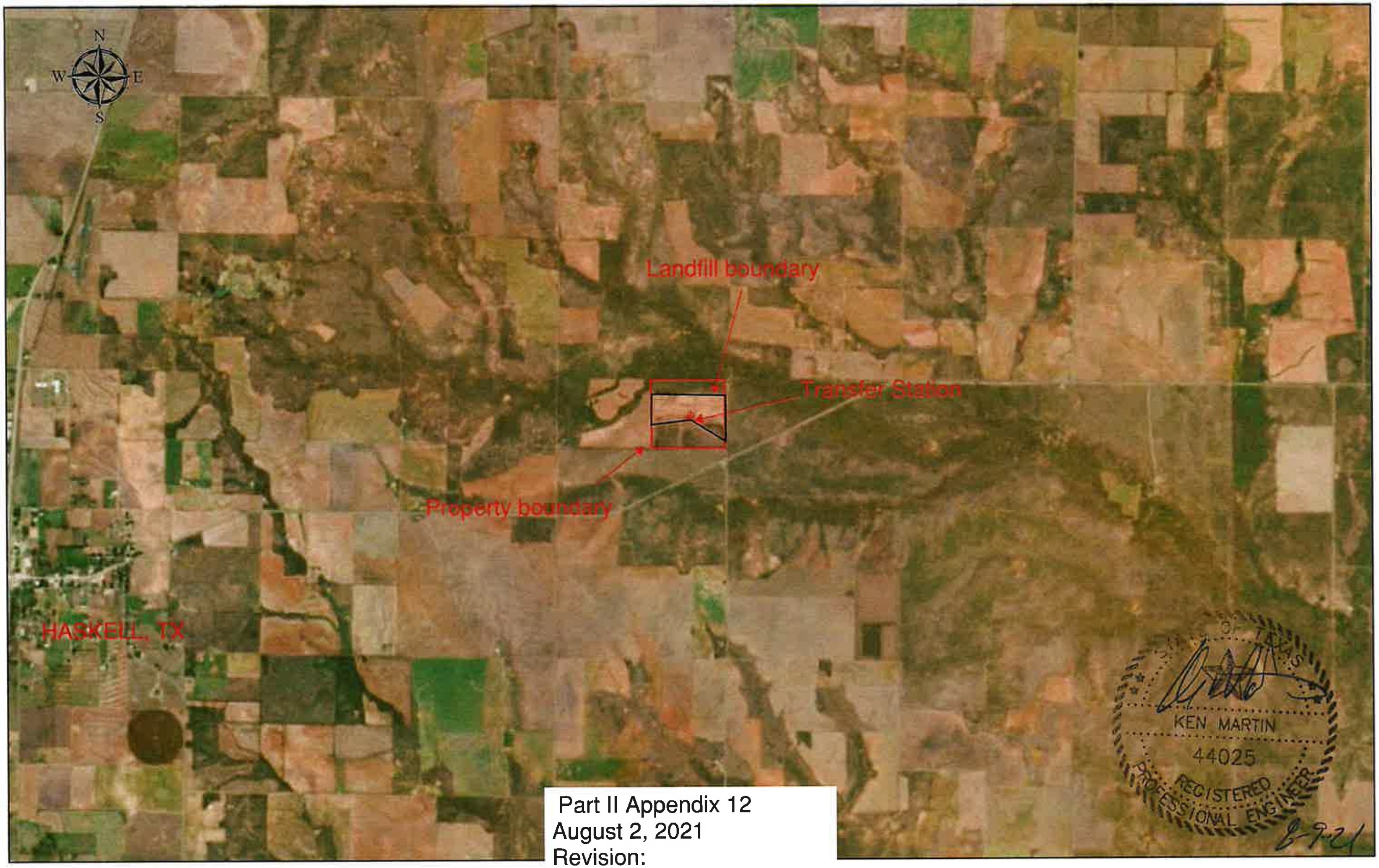
This response has been sent through the electronic THC review and compliance system (eTRAC). Submitting your project via eTRAC eliminates mailing delays and allows you to check the status of the review, receive an electronic response, and generate reports on your submissions. For more information, visit http://thc.texas.gov/etrac-system.

Sincerely,

for Mark Wolfe, State Historic Preservation Officer
Executive Director, Texas Historical Commission

Please do not respond to this email.

No historical, archeological or aesthetic sites adjacent to landfill



Part II Appendix 12
August 2, 2021
Revision:
Page 12-4
Benchmark
Latitude:33.1734445°
Longitude:99.6451909°
Benchmark: 1479.13'

January 21, 2021

1:72,224

0 0.5 1 2 mi

0 0.75 1.5 3 km

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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From: P.J. Sumner <psumner@westcentraltexas.org>
Sent: Monday, June 28, 2021 10:30 AM
To: David Hudson
Subject: City of Haskell, TX - TCEQ Municipal Solid Waste Landfill Type 1AE

The West Central Texas Council of Governments is in support of the City of Haskell obtaining a registration for a transfer station at the current landfill. If you have any questions, please feel free to call our office at 325.672.8544.

Thank you,

PJ Sumner
Environmental Program Coordinator
325.672.8544

HASKELL MSW TRANSFER STATION

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map US Topo

HASKELL QUADRANGLE
TEXAS - HASKELL COUNTY
7.5-MINUTE SERIES

Produced by the United States Geological Survey

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

ROAD CLASSIFICATION

HASKELL, TX
2019

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From: Richard Hanson <Richard.Hanson@tpwd.texas.gov>
Sent: Thursday, June 17, 2021 9:49 AM
To: David Hudson
Subject: RE: City of Haskell, TX —TCEQ Municipal Solid Waste Landfill Type 1AE Expansion (TPWD #45868)

I have no concerns.

Rick Hanson
Wildlife Habitat Assessment Program
Texas Parks and Wildlife Department
1702 Landmark Lane, Suite 3
Lubbock, TX 79415
Office: (806) 761-4936
Richard.Hanson@tpwd.texas.gov

From: David Hudson <dhudson@jacobmartin.com>
Sent: Thursday, June 17, 2021 9:31 AM
To: Richard Hanson <Richard.Hanson@tpwd.texas.gov>
Subject: RE: City of Haskell, TX —TCEQ Municipal Solid Waste Landfill Type 1AE Expansion (TPWD #45868)

Due to an increase in rainfall, the City of Haskell can no longer meet the TCEQ Type 1AE designation and will not be expanding the landfill. They will be applying to TCEQ for a registration of a Type V transfer station on the landfill property. Are there any concerns with this change?

From: Richard Hanson <Richard.Hanson@tpwd.texas.gov>
Sent: Thursday, February 11, 2021 9:14 AM
To: David Hudson <dhudson@jacobmartin.com>
Subject: City of Haskell, TX —TCEQ Municipal Solid Waste Landfill Type 1AE Expansion (TPWD #45868)

Hi David,

Thank you for submitting the proposed City of Haskell landfill expansion project for review. Based on review of the documentation and description provided, the Wildlife Habitat Assessment Program does not anticipate significant adverse impacts to rare, threatened, or endangered species, or other fish and wildlife resources. However, please note it is the responsibility of the project proponent to comply with all federal, state, and local laws that protect fish and wildlife. Provided the project plans do not change, TPWD considers coordination to be complete.

Rick Hanson

Wildlife Habitat Assessment Program
Texas Parks and Wildlife Department
1702 Landmark Lane, Suite 3
Lubbock, TX 79415
Office: (806) 761-4936
Richard.Hanson@tpwd.texas.gov

June 17, 2021

Judge Kenny Thompson
Haskell County
County Courthouse 1 Avenue D
Haskell, TX 79521

RE: City of Haskell, TX – TCEQ Municipal Solid Waste Landfill Type 1AE information and proposed transfer station

Dear Sir:

The City of Haskell is working to obtain a registration for a transfer station at the current landfill with the Texas Commission on Environmental Quality (TCEQ). The proposed project would add a conventional single building transfer station with a ramp and loading alley. The landfill is expected to close when as the currently used final cell is filled. The rainfall data did not support a Type 1AE designation.

Acting on behalf of the City of Haskell, JACOB | MARTIN is in the process of preparing an application pursuant to the rules in 30 TAC § 330.

A project description is hereby submitted to your office along with project maps. Further information is available upon request.

We are requesting that your office review the proposed project and issue comments regarding potential impacts to the environment and other interests that pertain to or are potential conflicts with projects being implemented by your agency.

To aid in a timely and accurate application for the permit amendment we are requesting a response within 30 days. Thank you for your assistance on this project. Should you need additional information or have any questions, please contact me at (325)-695-1070 or through email at dhudson@jacobmartin.com. Please address all correspondence to our Abilene office location.

Sincerely,

JACOB | MARTIN

David Hudson

JACOB MARTIN

INTEGRITY

EXCELLENCE

TRUST

June 17, 2021

West Central Texas Council of Governments
3702 Loop 322
Abilene, TX 79602

RE: City of Haskell, TX – TCEQ Municipal Solid Waste Landfill Type 1AE information and Proposed Transfer Station

Dear Sir or Madam:

The City of Haskell is working to obtain a registration for a transfer station at the current landfill with the Texas Commission on Environmental Quality (TCEQ). The proposed project would add a conventional single building transfer station with a ramp and loading alley. The landfill is expected to close when as the currently used final cell is filled. The rainfall data did not support a Type 1AE designation.

Acting on behalf of the City of Haskell, JACOB | MARTIN is in the process of preparing an application pursuant to the rules in 30 TAC § 330.

A project description is hereby submitted to your office along with project maps. Further information is available upon request.

We are requesting that your office review the proposed project and issue comments regarding potential impacts to the environment and other interests that pertain to or are potential conflicts with projects being implemented by your agency.

To aid in a timely and accurate application for the permit amendment we are requesting a response within 30 days. Thank you for your assistance on this project. Should you need additional information or have any questions, please contact me at (325)-695-1070 or through email at dhudson@jacobmartin.com. Please address all correspondence to our Abilene office location.

Sincerely,

JACOB | MARTIN

David Hudson

JACOB
MARTIN

INTEGRITY
EXCELLENCE
TRUST

Glenn Allbritton, P.E.
Abilene District
Texas Department of Transportation
4250 N. Clack
Abilene, TX 79601

June 24, 2021

RE: City of Haskell, TX – TCEQ Municipal Solid Waste Transfer Station

Dear Sir:

The City of Haskell is working to obtain a registration for a transfer station at the current landfill with the Texas Commission on Environmental Quality (TCEQ). The proposed project would replace the existing landfill as it nears closure.

Acting on behalf of the City of Haskell, JACOB | MARTIN is in the process of preparing an application pursuant to the rules in 30 TAC § 330.

A project description is hereby submitted to your office along with project maps. Further information is available upon request.

We are requesting that your office review the proposed project and issue comments regarding potential impacts to the environment and other interests that pertain to or are potential conflicts with projects being implemented by your agency.

While we understand the volume of request that the agency receives, we are requesting a response within 30 days. Thank you for your assistance on this project. Should you need additional information or have any questions, please contact me at (325)-695-1070 or through email at dhudson@jacobmartin.com. Please address all correspondence to our Abilene office location.

Sincerely,

JACOB | MARTIN

David Hudson

325.695.1070
817.594.9880

info@jacobmartin.com
www.jacobmartin.com

3465 Curry Lane
Abilene, TX 76906

1508 Santa Fe, Suite 203
Weatherford, TX 76086

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #16

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

Attachment 16-1
August 2, 2021

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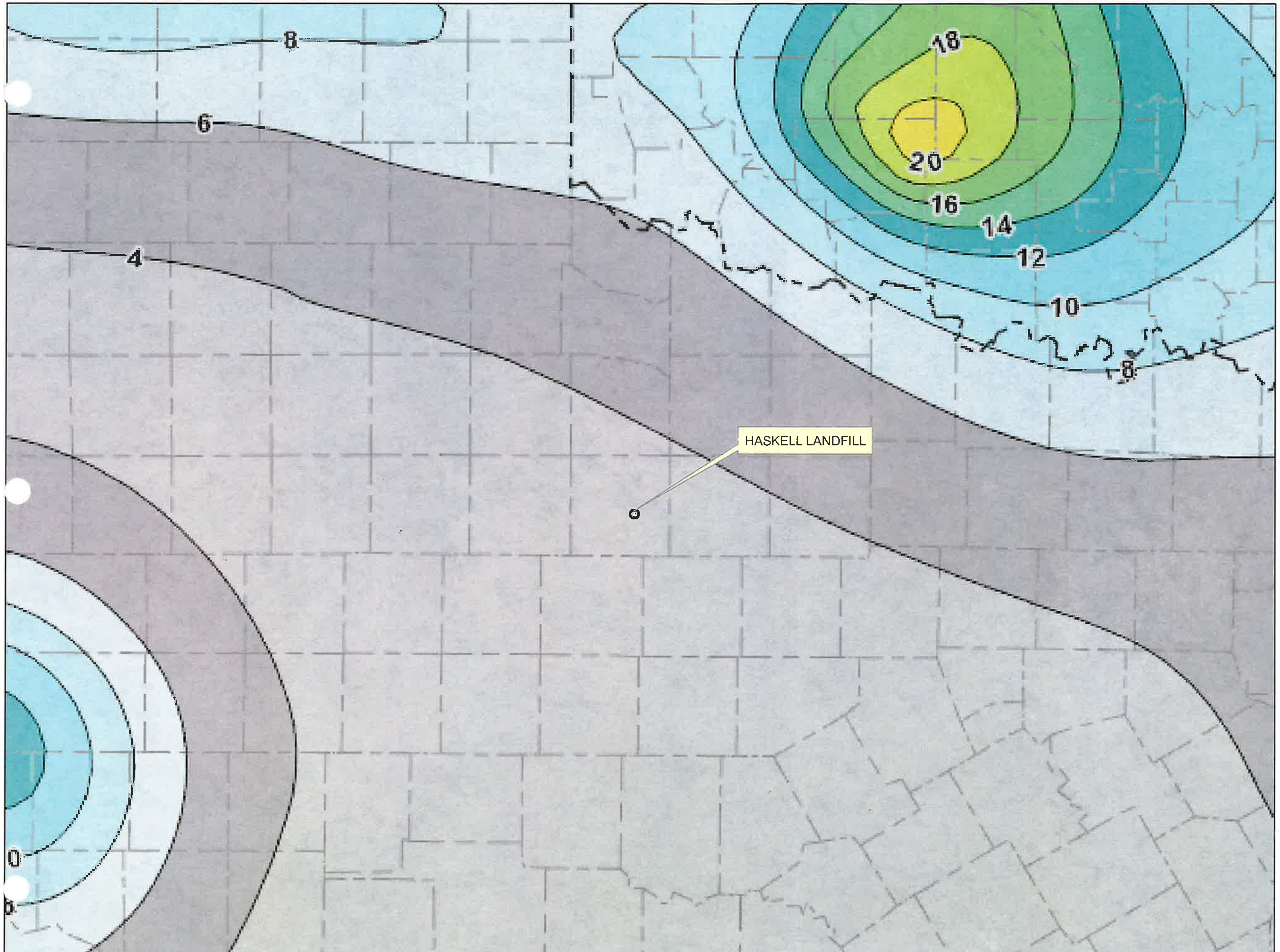
STATE OF TEXAS
KEN MARTIN
44025
REGISTERED
PROFESSIONAL ENGINEER

8-9-21



N
W E
S

0 12.5 25 50 Miles

LEGEND

PERMIT BOUNDARY

ONE MILE BOUNDARY

HASKELL COUNTY
TEXAS

NOTES:

SOURCE: USGS INTERACTIVE NATIONAL SEISMIC HAZARD MAPS

PEAK GROUND ACCELERATION (%g) WITH 2% PROBABILITY OF EXCEEDANCE IN 50 YEARS

Proposed Lateral Expansion
Part II Appendix 16 Page 16-3
June 28 2021
Revision:
Latitude:33.1734445°
Longitude:-99.6451909°
Benchmark: 1479.13'

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21

SEISMIC IMPACT ZONE

Haskell Transfer Station

JACOB MARTIN
FIRM# - F2448
3465 Curry Ln
Abilene Tx, 79606
(325)695-1070

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #17

STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER

8-9-21

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PROFESSIONAL ENGINEER

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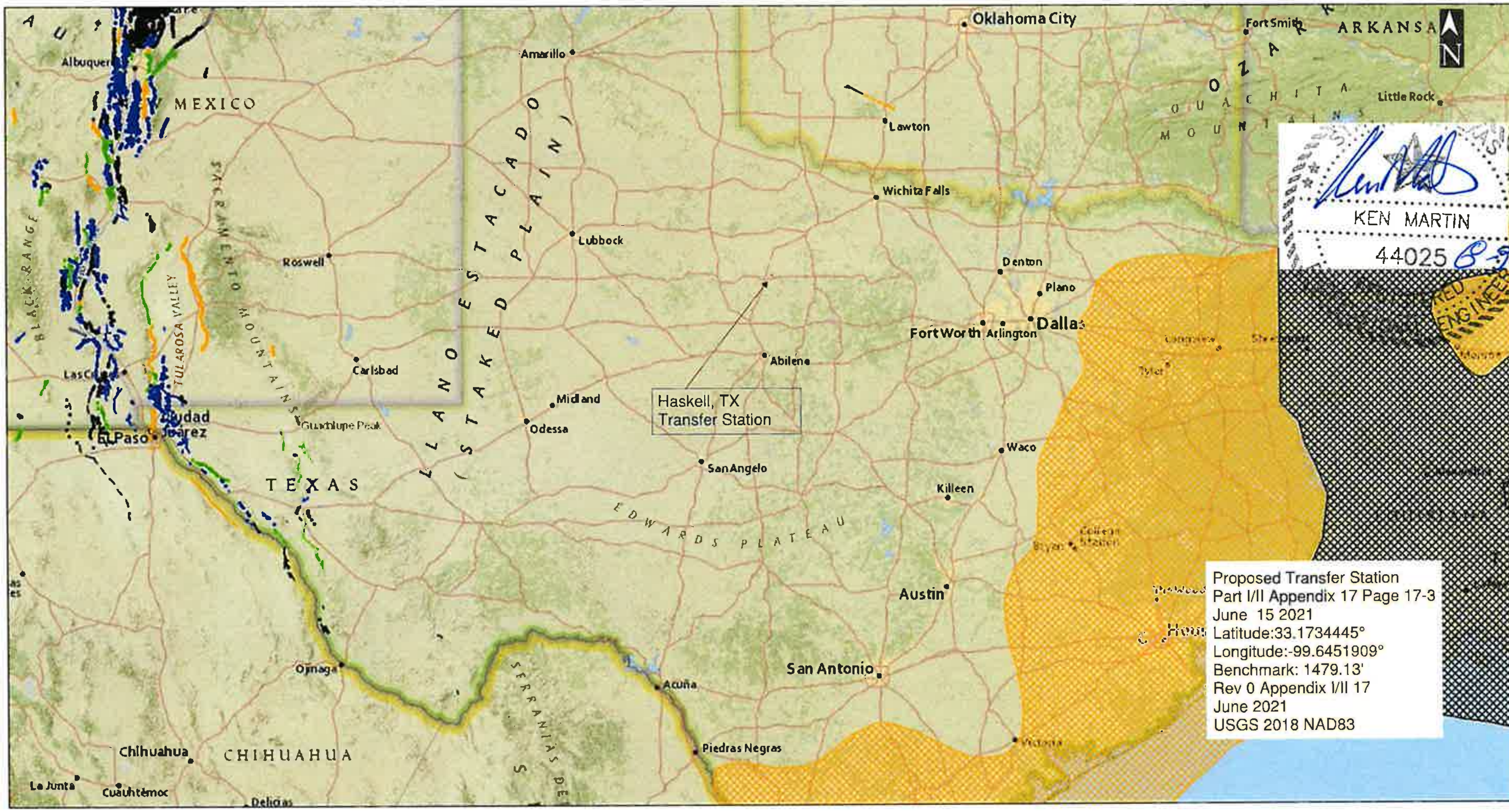
U.S. Geological Survey Quaternary Faults



9/1/2020, 10:53:52 AM

1:4,622,324

0 50 100 200 mi

0 75 150 300 km

Fault Areas

- Historic (< 150 years)
- Latest Quaternary (< 15,000 years)
- Late Quaternary (< 130,000 years)
- Middle and Late Quaternary (< 750,000 years)
- Undifferentiated Quaternary (< 1.6 million years)

Quaternary Faults Database

- Historic (< 150 years), well constrained location
- Historic (< 150 years), moderately constrained location
- Historic (< 150 years), inferred location
- Latest Quaternary (<15,000 years), well constrained location
- Latest Quaternary (<15,000 years), moderately constrained location
- Latest Quaternary (<15,000 years), inferred location
- Late Quaternary (< 130,000 years), well constrained location
- Late Quaternary (< 130,000 years), moderately contrained location
- Late Quaternary (< 130,000 years), inferred location
- Middle and late Quaternary (< 750,000 years), well constrained location
- Middle and late Quaternary (< 750,000 years), moderately constrained location
- Middle and late Quaternary (< 750,000 years), inferred location

USGS, National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

USGS
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. | USGS |

HASKELL MSW TRANSFER STATION

Part I/II Appendices

Appendix #18

Attachment 17-1
August 2, 2021

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KEN MARTIN
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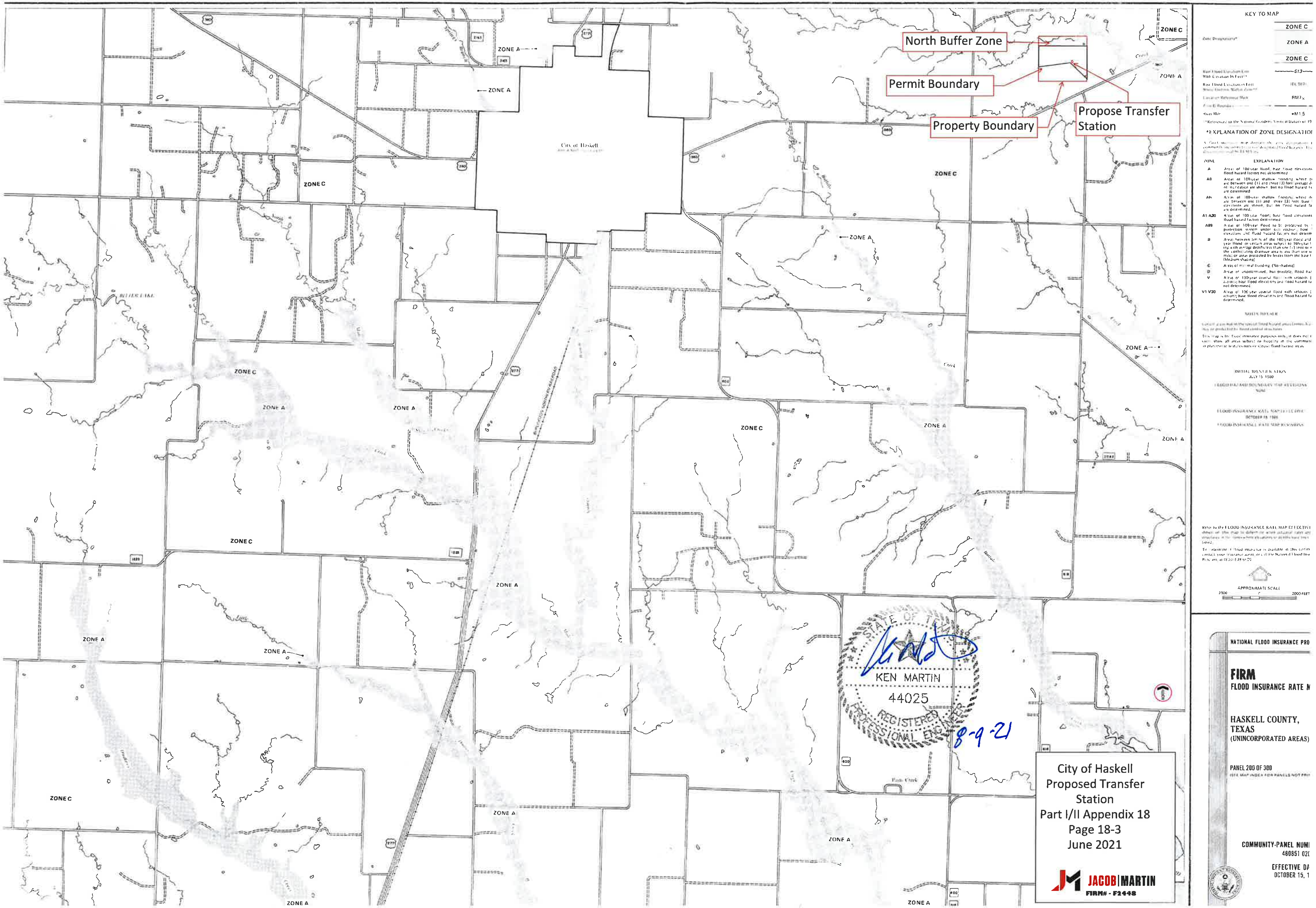
8-9-21


North Buffer Zone
Permit Boundary
Property Boundary
Propose Transfer Station
City of Haskell
ZONE A
ZONE C
KEY TO MAP
EXPLANATION OF ZONE DESIGNATIONS
NATIONAL FLOOD INSURANCE PRO
FIRM
FLOOD INSURANCE RATE M
HASKELL COUNTY, TEXAS
(UNINCORPORATED AREAS)
PANEL 200 OF 300
COMMUNITY-PANEL NUMB
480851 020
EFFECTIVE DA
OCTOBER 15, 1
STATE OF TEXAS
KEN MARTIN
44025
REGISTERED PROFESSIONAL ENGINEER
8-9-21
City of Haskell
Proposed Transfer Station
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June 2021
JACOB | MARTIN
FIRM# - F2448