Technical Report Documentation Page

1. Report No. FHWA/TX-02/1858-2	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THE VALUE OF PIPELINES TO THE TRANSPORTATION SYSTEM OF TEXAS: YEAR TWO REPORT		5. Report Date September 2001 Revised: February 2002
		6. Performing Organization Code
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9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. Project No. 0-1858
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Research: September 2000 – August 2001
		14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.
Research Project Title: The Value of Pipelines to the Transportation System of Texas

16. Abstract

Pipelines represent a major transporter of petrochemical commodities in Texas. The Texas pipeline system represents as much as 17 percent of the total pipeline mileage in the U.S. and links many segments of the country with energy sources located on the Gulf Coast. This research has been undertaken to provide Texas Department of Transportation (TxDOT) a broad understanding of pipeline operations and their relationship to other modes of transportation. Knowledge of the location and interaction dynamics of pipelines with other forms of transportation (trucks, railroads and ocean) is essential for TxDOT to be able to plan and execute transportation improvements in the 21st century. This research is designed to provide TxDOT with an understanding of the location, function, interconnectivity of the state's pipeline system, and insight into how it or other state agencies may best work with pipelines to optimize the transportation system.

The first year task work was described in Report 1858-1. This report documents the second year of research and builds on information presented in the first year report. Included in this report are a literature review of physical, business, and policy issues related to pipeline, documentation of the Geographic Information System (GIS) database that is submitted with this report, further development of an inventory of pipeline interconnections with other modes, discussion of pipeline industry operational and regulatory issues and pipeline utilization, and recommendations to TxDOT regarding roles in pipeline and commodity transport.

17. Key Words Commodities, Interconnections, Pipelines		18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161	
19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 180	22. Price

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

THE VALUE OF PIPELINES TO THE TRANSPORTATION SYSTEM OF TEXAS: YEAR TWO REPORT

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Report 1858-2
Project Number 0-1858
Research Project Title: The Value of Pipelines to the Transportation System of Texas

Sponsored by the
Texas Department of Transportation
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

September 2001
Revised: February 2002
TEXAS TRANSPORTATION INSTITUTE
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ACKNOWLEDGMENTS

The authors wish to thank Mr. Raul Cantu, the project director, and Mr. Jim Randall of the TP&P for their support in this research effort. The authors also wish to thank the Texas Railroad Commission for assistance with the GIS database. In addition, the authors would like to recognize the contribution of the project monitoring committee in setting a clear direction for this important project.

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CHAPTER 1 – REVIEW OF PREVIOUS RESEARCH AND OVERVIEW OF YEAR TWO RESEARCH

INTRODUCTION AND OVERVIEW

Research into the value of pipelines to the transportation system of Texas has been undertaken to assist TxDOT in its understanding of the scope of the Texas pipeline system, how it interfaces with other transportation modes, and whether the pipeline system can be further integrated in the state's transportation system. Texas Transportation Institute (TTI) and Texas Tech University (TTU) collaborated in this effort, with the assistance of the Texas Railroad Commission (RRC).

The first year's work for this two-year effort was published in Research Report 1858-1, which:

- provided an overview of pipeline system characteristics for natural gas, crude and product pipelines;
- included a literature review, presented a preliminary inventory of the Texas pipeline network in GIS format;
- discussed pipeline interconnectivity with other modes; and
- provided an initial regulatory review.

These tasks continued in year two of this work, with the addition of several other tasks. This report includes additional literature review information, further documentation on pipeline interconnectivity with other modes, an enhanced GIS inventory, a detailed regulatory review, an evaluation of pipeline industry operational issues, recommendations to facilitate greater utilization of pipelines, and discussion of roles or responsibilities that may be pertinent to TxDOT relative to pipelines.

LITERATURE REVIEW, ANNOTATED BIBLIOGRAPHY, AND INDUSTRY CONTACTS

Report 1858-1 provides a comprehensive listing of U.S. national and Texas state agencies, organizations, and commercial entities involved in collecting and cataloging data regarding Texas pipelines. The listing also includes national and state entities having a role in pipeline transportation policymaking and rules in Texas. Commodity flow information and basic pipeline design parameters are also discussed.

Chapter Two of this report provides a detailed investigation of specific physical, business, and policy issues of pipelines. The chapter includes listings of particular issues, an annotated bibliography, and industry contacts for each area.

INVENTORY OF TEXAS PIPELINE SYSTEM

RRC provided the GIS database included with this report in a single comprehensive unit for TxDOT's use in the Austin offices. The database information has also been divided into distinct areas, as delineated by the 25 TxDOT district boundaries. Information about road, rail, and waterway interconnections with pipelines has been added to the database by the researchers. Chapter three describes the GIS database.

INVENTORY OF PIPELINE INTERCONNECTIONS WITH OTHER MODES

Report 1858-1 included descriptions of pipeline connections with other modes, noting that the primary setting for such connections is at storage terminals and processing facilities through road, rail, or marine loading racks. The work to inventory the intermodal interconnections with the pipeline system in Texas has continued in year two of this effort, and a partial inventory of intermodal connections with the pipeline system being purchased from Pennwell Mapping Company.

This information has been combined with other data obtained during year one of this research effort, and 126 pipeline interconnection facilities throughout the state of Texas have been integrated with the GIS database. The level of information is particularly developed for port and waterway facilities in the Houston area. Because some of the information used in the database is proprietary, the database is not available for use by the general public. Chapter Four provides a detailed description of pipeline interconnectivity information.

Evaluation of facility significance criteria and preliminary investigation toward defining an effective radius of operation around pipeline petroleum distribution facilities is also presented. While the discussion is speculative and presented as an example only, the criteria that could be included in the development of an economic radius model are identified.

PIPELINE INDUSTRY OPERATIONAL AND REGULATORY ISSUES

The potential for integration of the pipeline network with other modes in Texas' transportation system is impacted by the technical feasibility of commodity shift to pipelines from other modes and the regulatory restrictions that govern the activities of pipeline companies. As discussed in Report 1858-1, the research into the potential for increased integration of the petroleum, refined and chemical product pipeline systems into the overall state transportation system has assumed that the private pipeline companies' management maximizes their assets income. Chapter Five of this report provides detailed discussion of commodity transfer issues, pipeline regulations, and industry perspectives as they impact the potential for increased pipeline integration with the state's transportation system.

Commodity Transfer to Pipeline from Other Modes

Report 1858-1 discusses that commodity transfer to pipelines from other transportation modes faces operational and infrastructure limitations. While the confidentiality of pipeline throughput data restricts the ability for evaluating potential for commodity transfer, both technical issues and an intensely competitive business environment dictate that pipeline companies are likely utilizing available infrastructure and capacity to the extent that is economically practical. While this leads to the conclusion that the competitive business practices of pipelines results in little excess capacity for commodity shift, there may be some limited potential for commodity transfer in certain aspects of the pipeline industry. This has been identified as a potential area for future study should there be significant changes in pipeline technology or business practices.

State and Federal Pipeline Regulatory Responsibilities

Report 1858-1 provides an initial discussion and overview of pipeline regulations and responsibilities. This work has been expanded in year two of this effort, and this report documents the various state and federal agency ownership authorities with respect to pipeline operations and safety. Also examined are the regulatory requirements for pipeline alignments and the extent to which existing safety regulations govern the upgrading of in-place pipelines.

Pipeline Industry Perspectives

The perspective of the pipeline industry is integral to consideration of transport, potential for integration with other transport modes, and assessing the need for agency roles and/or responsibilities. This perspective, particularly with regard to pipeline safety, operational, and regulatory issues, has been provided through participation of the researchers in the American Institute of Chemical Engineers (AIChE) 2001 Spring National Meeting and PetroExpo, and in separate meetings with individual pipeline industry representatives.

PIPELINE UTILIZATION

An assessment of the potential for commodity transfer, examination of regulatory responsibilities, and consideration of pipeline industry input allows for a general comment on pipeline utilization. Pipeline utilization might be increased by minimizing the restrictions placed on pipeline companies only to the point of ensuring efficient competition. This must be balanced with the assumption that pipeline companies will comply with environmental and public welfare regulations only as necessary. Chapter six of this report provides further discussion of pipeline utilization issues.

POTENTIAL NEW ROLES AND RESPONSIBILITIES FOR TXDOT RELATIVE TO PIPELINE TRANSPORTATION

Based on work performed in this research effort, the research team has evaluated how TxDOT may be able to address issues that result from pipeline transportation. Chapter seven of this report is a discussion of potential roles and responsibilities.

REVIEW OF COMPLETED WORK, RECOMMENDATIONS, AND CONCLUSIONS

The results of the year two research as presented in this report are summarized in Chapter Eight. Summaries are presented for the literature review, inventory of the Texas pipeline system, inventory of pipeline interconnections with other transportation modes, pipeline industry operational and regulatory issues, pipeline utilization, and potential new roles and responsibilities for TxDOT relative to pipeline transportation. Overall conclusions regarding this research effort end the chapter.

CHAPTER 2 – LITERATURE REVIEW, ANNOTATED BIBLIOGRAPHY, AND INDUSTRY CONTACTS

INTRODUCTION

Report 1858-1 provides a comprehensive listing of national and Texas state agencies, organizations and commercial entities involved in collecting and cataloging data regarding Texas pipelines. The listing also includes both national and state entities having a role in pipeline transportation policymaking and rules in Texas. Additionally, the report includes commodity flow information along with certain physical, business, and policy issues.

This report provides a more detailed investigation of specific physical, business, and policy issues of pipelines, including discussion of particular issues, an annotated bibliography, and industry contacts for each area.

PHYSICAL, BUSINESS, AND POLICY ISSUES

The expected increase in U.S. demand for gas and other petroleum products has posed many challenges regarding Texas pipeline infrastructure, business environment, and policy. The increase in demand is caused primarily by electric companies' growing dependency on gas and environmental efforts to reduce greenhouse emissions [(1)]. It is predicted that the demand for gas will increase 36 percent by the year 2010 [(2)]. This section will discuss key physical, business, and policy issues currently faced by Texas pipelines.

Physical Issues

- Need for construction
- Decrease in rights-of-way land
- Public opposition
- Aging infrastructure
- Population encroachment
- Third-party damage
- Need for technology use

The concentrated network of pipelines located in Texas is subject to many issues regarding its infrastructure. According to the Interstate Natural Gas Association of America, the construction of pipeline is needed in order to compensate for the increasing U.S. demand for gas [(2)]. The need for pipeline construction comes at a time of decreasing availability of "rights-of-way" land and increasing public opposition to pipeline expansion in populated communities. Populated and environmentally sensitive areas limit new pipeline alignment locations.

Existing pipelines are aging and need monitoring and replacement as they are subject to cracks and leaks. The public is aware of the dangers of these aging pipelines that were once located in rural areas and are now located in neighborhoods due to population encroachment. Pipelines located in developed and populated areas are also at a higher risk for 3rd party damage. "During the 1996-97 period, 73 percent of fatalities and 57 percent of injuries were caused by third-party damage" [(3)].

There is a need for the improvement of technology for monitoring and maintaining the integrity of pipeline infrastructure. In reviewing pipeline literature, the research team found that there is a lack of emphasis in technology in pipeline industry and more focus on management and regulation with respect to maintaining a safe infrastructure and operation [(4)]. This is not to say that pipeline technology does not exist or is not in development. There are many technologies that are available for monitoring and inspection. Examples of various types of existing pipeline technology include:

- supervisory control and data acquisition (SCADA) systems for remote operation and monitoring of pipelines,
- magnetic flux leakage inspection pigs used to measure and locate cracks in both circumferential and longitudinal directions,
- ultrasonic pigs used in locating, quantifying, and classifying defects. The lightweight composite-bodied hyperbaric pigs are easier, safer, and more cost effective for dive-based operations on offshore pipelines.
- the GPS uses satellite to catalog accurate locations of pipeline, and
- the GIS supplies specialty databases for storing, retrieving, manipulating, analyzing, and displaying geographically referenced data.

The problem with pipeline technology is that when it is scaled for commercial use, high costs, design, and operation flaws prohibit many inspection and monitoring technologies from being available for commercial application. A 1999 report stated that 60 percent of major oil and gas pipelines around the world are over 20 years old and that only 10-20 percent of pipelines are pigged regularly [(5)].

Business Issues

- Increasing demand for energy
- Economic slowdown
- Profit growth
- Interest rates
- Technology
- Open border

Due to the increasing demand for energy, there has been an outstanding growth in the market in the last 10 years [(6)]. New high efficiency, gas-fired technologies entering the market are increasing the use of natural gas as fuel. Natural gas continues to be a fuel of choice because it provides both economic and environmental benefits. This increasing demand for energy corresponds with an increasing demand for future pipeline usage. On the other hand, the pipeline industry must also consider possible effects of the economic slowdown, which could reduce the demand for refined petroleum products, and therefore, reduce the throughput on the pipeline system.

As with most businesses, the number one priority in the pipeline business is profit growth. The nature of the pipeline business is based on trade, which makes it sensitive to interest fluctuation. Therefore, "the future growth depends on controlling costs, rolling over debt into low interest rate long term financing, and fine tuning the pipeline system to maximize cash flow"[6]. Profit growth is also dependent on the utilization of technology and innovation to maintain or reduce costs and to improve operational performance.

Looking into the future, the pipeline business will function in a new environment expanding with the demand for gas across the broader. Natural gas will soon flow across the U.S.-Mexico border through existing pipeline connections located in Texas and California [7]. The main issue concerning this gas trade includes the price of gas maintaining a direct relationship to seasonal U.S. gas prices. Mexican industrial consumers may not be willing to pay more for gas based on the U.S. seasonal prices.

Policy Issues

- Federal Energy Regulatory Commission (FERC) Order No. 637
- Integrity management program
- Qualification of pipeline personnel

FERC is employing a new philosophy, which is to be receptive to new ideas and concepts while making policy. FERC wants to build policy that is flexible and gives companies' incentives for better performance. FERC rate-making policy demands managers to be more efficient [8].

FERC Order No. 637 is a recently formed policy that permits interstate pipeline operators to raise rates for current customers in order to offset discounts given to other customers in competition with interstate pipelines [9]. This policy is supposed to increase the actual physical throughput and spread fixed costs, resulting as a benefit for all customers, not just the customer getting the discount. However, the impact of this policy on the pipeline industry is in question. There are two concerns with this policy. One issue is whether the current customers are unfairly affected by the discount adjustments. The other issue is where the limit should be in recovering costs from discounts.

The final rule for a pipeline integrity management program has been published by the Office of Pipeline Safety (OPS). The requirements affect hazardous liquid operators that have lines located in areas that are populated, unusually sensitive to environmental damage, and navigable waterways [10]. These types of areas are labeled high consequence area (HCAs). The program requires operators to develop a written integrity management program that prevents a negative impact of each pipeline segment to HCA. The operator must then set a priority for assessing each segment by producing a baseline assessment schedule.

Qualification of Pipeline Personnel is a new OPS pipeline rule that maintains a written qualification program for performing covered tasks on pipeline facilities [(11)]. The purpose of the rule is to prevent or reduce the probability of incidents caused by human error by ensuring that the personnel are trained and qualified. The rule sets qualification and training requirements for work force performing covered tasks. The requirements are flexible so to be adapted to the unique conditions and environment of each operator. The American Gas Association believes that this rule will provides natural gas utilities with the flexibility to achieve the standard [(12)].

ANNOTATED BIBLIOGRAPHY

Issues concerning the pipeline industry are continuously changing with time, which often makes decision making difficult for regulators. However, it is fundamental for regulators to be well informed of these changing needs and concerns facing the pipeline industry. The literature is a prime resource for identifying and understanding current and changing pipeline issues. Herein provided is an annotated bibliography identifying literature that will help the regulator identify and understand current pipeline issues. The authors believe this annotated bibliography provides an accurate overview of current pipeline issues.

After reviewing 324 articles in the literature, 20 articles were chosen that represent key issues. The literature review covered various professional journals, books, and websites. Books from Pennwell Publishing and the websites of the American Petroleum Industry (API), the American Gas Association (AGA), and the FERC contain useful pipeline information. Journals containing pipeline articles include but are not limited to:

- *Pipeline & Gas Journal,*
- *Oil and Gas Journal,*
- *Pipe Line & Gas Industry, and*
- *American Gas.*

The 20 articles listed represent current issues based on the published date and contain content that is clear and informative. Researchers categorized each reference into one of the following headings:

- Physical,
- Business, or
- Policy.

The articles under the *Physical* heading represent literature found that discuss current issues concerning pipeline infrastructure. Articles under the *Business* heading represent literature found that discuss current issues concerning the economic side of the pipeline system. Literature listed under the *Policy* heading contains current issues in pipeline policy and regulations. A brief synopsis of each article is included after each reference.

Annotated Bibliography of Physical Issues Related to Pipelines

1. **Bandyopadhyay, Tusar, Dey Prasanta K., and Gupta, Saumitro S. (1997). A cost-effective maintenance program through risk analysis. Aace Transactions, 84-89.**
   This paper discusses a cost-effective maintenance program established for a cross-country petroleum pipeline using risk analysis that is based on experience. The program satisfies a need for establishing a theoretical model to identify stretches of pipeline at risk without physical inspection. Physical inspection would only be needed to determine the type of maintenance that is needed. A multiple-attribute decision-making (MADM) technique known as an analytic hierarchy process (AHP) was used for the risk analysis. The model monitors cross-country petroleum pipeline for maintenance planning.
2. **Corbley, Kevin P. (2000). OPS building national pipeline GIS database. Pipeline & Gas Journal, 227(2), 49-52.**
   OPS is currently building the National Pipeline Mapping System using GIS technology. The system will contain a pipeline data format that will eliminate the redundancy of data collection. Operators will be able to conduct detailed spatial analyses, better deploy inspection resources, and identify pipeline at risk. GIS and mapping technologies will eventually be widely utilized in the petroleum and gas industry.
3. **Keating, Robert (1999). Try plotting this pipeline without GPS technology. Pipeline & Gas Journal, 226(2), 48.**
   This article discusses a pipeline project that uses the latest GPS technology to expedite completion of construction. The project would normally require the use of many people to mark the right-of-way of a pipeline by cutting a line by sight using chain saws. With the use of new technology, this process can now be achieved more accurately and efficiently than ever. Using GPS technology requires no line of sight or control survey.
4. **Kennedy, J. L. (1993). Oil & gas pipeline fundamentals (2nd ed.), Tulsa, OK: PennWell Books.**
   This book provides basic knowledge of the oil and gas pipeline industry and operations. It provides an overview of the pipeline industry and describes the basic physical characteristics of a pipeline, including types of pipe, manufacturing and coating, pipeline design, pumps and compressors, prime movers, and construction practices. Pipeline operations are also discussed, including the following topics: operation and control, metering and storage, maintenance and repair, and inspection and rehabilitation. Pipeline safety is also addressed in the discussion of pipeline regulation, safety and environmental protection, and tomorrow's technology.
5. **McAllister, Ed (1998). Pipeline rules of thumb. Butterworth-Heinemann.**
   This text offers a compilation of general pipeline information. Pipeline construction issues are discussed such as right-of way, ditching, and pipe design. Safety tools used for maintenance and monitoring address leak detection and the importance of coating to prevent corrosion. The engineering of the throughput is explained considering hydraulics, gas compression, pumps, and instrumentation. The text also covers economics of the pipeline industry as well as risk analysis.
6. **Strategies for pipeline safety (2000). Global Energy Business, 2(5), 47.**
   Research has identified causes of pipeline accidents. Major causes of pipeline failure are earth-moving equipment, corrosion-weakened pipe walls, and improperly made welds and weak spots. In order to prevent pipeline failures, the infrastructure needs to be located, monitored, and replaced if necessary. Costs associated with pipeline damage have doubled from the period of 1986-1992 to 1996-1999, as a result of pipelines being located in populated areas. It is suggested that in order to minimize hazards, pipelines should be built in unpopulated areas.

Annotated Bibliography of Physical Issues Related to Pipelines

7. **Webster, Brian, and Kaplan, Helena (1999). Integrating SCADA associated technologies improves performance. Pipeline & Gas Journal, 226(2), 34-35.**
Supervisory control and data acquisition systems are used for remote operation and monitoring of pipelines. Texas Eastern Pipeline and Williams Gas Pipeline are both using SCADA technology. However, both companies want to improve the efficiency of operators, engineers, and daily operations by combining SCADA, transient hydraulic modeling, databases, and user interfaces, known as Operations Synergies. The goal is to integrate business, engineering, and operations into a highly competitive system process. Two common difficulties found in implementing technologies include imposing on users' comfort zones and the importance of senior management's impact. As a result, the Operations Synergies will utilize user-friendly interfaces to eliminate the user's fear and to promote the user's comfort with the technology. In order to address senior management, the project implementation team will design the project under the management's framework in considering benefits, cost, and financial return.

Annotated Bibliography of Business Issues Related to Pipelines

1. **Jacobs, Russell H. (1997). Global energy for the next millennium. Pipeline & Gas Journal, 224, 22-27.**
The article discusses the effects on the industry and the planning that is necessary with the increased demand for natural gas. The availability of more gas-fired power plants, demand changes, regulatory policy, infrastructure development, and technology are due to the increased demand for natural gas. As a result, new gas industries are being developed, and the existing gas industries are restructuring. The increase in growth of the gas industry calls for planning the growth of infrastructure, developing and implementing new technologies, and understanding and managing new regulatory changes.
2. **Marcoux, J. Michael (2000). Gas-on-gas discounting: Still a zero-sum game. Public Utilities Fortnightly, 138(8), 42-49.**
The article discusses the issue of discrimination in pipeline rate discounting. The Federal Energy Regulatory Commission attempts to end discrimination in pipeline rate discounting policy under Order No. 637. Yet, in practice Order No. 637 permits interstate pipelines to raise rates for captive customers to offset discounts given to other customers to compete with interstate pipelines. Pipeline companies justify the rate discounting discrimination by claiming that all customers benefit from an assumed increase in units of service.

3. **Melickian, Gary (2001). Industrial market issue summaries. American Gas Association. 4-10-01, (http://www.aga.org/AdvocacyIssues/IssueSummaries/GasMarkets/947.html).**
Natural gas continues to be the chosen energy source in the industrial sector of the U.S. Industry consumed nearly half of all gas in the U.S. in 1998. The use of natural gas will continue to grow with new, gas-fired industrial technologies. It is projected that the demand for industrial natural gas will grow 1 percent per year for the next 20 years. This includes pipeline, lease, and plant fuel. The American Gas Association believes that the economic and environmental benefits achieved from using natural gas will result in its continued use as a prime source for industrial fuel in the future.

Annotated Bibliography of Business Issues Related to Pipelines

4. **P&GJ (1997). Leading gas executives say consumers will call shots. <u>Pipeline & Gas Journal</u>, 224, 19-20.**
Southern Gas Association Corporate Telelink Network in Dallas, Texas, sponsored a roundtable on the future of expanding energy services. Attendees included the CEOs or presidents of the Williams Companies, El Paso Energy, NGC Corp., ENSERCH Corp., and Bay State Energy Co. The discussion involved the restructuring of the natural gas industry, more specifically the opportunities, products, and services that will be in demand. All the companies are preparing to meet increased demands of the consumers in a deregulated marketplace; yet, the demands in the next five years are unclear. In order to stay competitive, flexible strategies are being adopted. It was said that growth depends on how well companies will tailor their products and services to meet their customers' demands. It was identified that an obstacle in ordering energy services in the future is that all pieces of the industry are regulated unevenly. It was also criticized that there was an excess of government involvement. However, the construction of cross-country pipeline facilities will continue. Yet, in addressing infrastructure, the gas industry needs to catch up in the use of technology, which will be a necessity to do business. The regulatory process does not help in speed and flexibility in recovering costs from implementing new technology.
5. **Richards, Don (1996). Houston area town files complaint on ethane plan. Friendswood opposes conversion of pipeline from crude ethane. <u>Chemical Marketing Reporter</u>, 249, #7.**
This article reveals a city's public concern for safety regarding the use of a pipeline. In the city of Friendswood, Texas, people are opposing an application from Exxon Pipeline to the Railroad Commission of Texas to convert the use of a crude oil pipeline to ethane. Exxon needs an increased supply of ethane. The residents of Friendswood are concerned for their safety for the following reasons: the pipeline is a large 16-inch line; the physical condition of the 30-year old pipeline is in question; and ethane is a highly volatile liquid. In sum, the residents are concerned with leaks and vapor clouds from transporting an extremely hazardous liquid in a very large and aging pipeline that runs through their city.
6. **Share, Jeff (1998). Colonial moves ahead with maintenance and new ventures. <u>Pipeline & Gas Journal</u>, 225(3), 26-28.**
Colonial Pipeline Company is restructuring the way it does business. The company is adopting a systems integrity program in its attempt to take better care of its assets. Colonial wants to build, maintain, and operate a leak-free and spill-free system that transports refined products from Texas to the New York Harbor. It is investing in inline inspection pigs, cathodic protection, and right-of-way maintenance. The company is also expanding into businesses outside of its transportation and distribution system.

Annotated Bibliography of Business Issues Related to Pipelines

7. **Sickles, R.C., and Streitwier, M. L. (1998). An analysis of technology, productivity, and regulatory distortion in the interstate natural gas transmission industry: 1977-1985. Journal of Applied Econometrics, 13(14), 377-395.**
The paper provides an analysis of the interstate pipeline industry's cost structures and production in the movement toward partial price deregulation from 1977–1985. Twenty-four interstate pipeline companies were examined to determine how the regulatory changes during this period affected the pipeline industry. The study addressed the impact of the 1978 Natural Gas Policy Act, technical change, output change, scale economies, and non-optimal productivity growth.
8. **Texas Independent Producers and Royalty Owners Association (TIPRO) (2001). TIPRO Addresses State of the Industry, 2-23-01, (http://www.tipro.org/target/maytarg/stateind.htm).**
Representatives from production, transportation, and the allied petroleum service industry attended an annual meeting in Austin to discuss and voice opinions to key issues regarding the Railroad Commission. The president of TIPRO, Rex H. White states, "there is not absolute competition in the gas services industry today." He also states that discrimination exists along with the existence of monopolies. However, others from the pipeline industry argue that "competition is alive and well in the Texas gathering market." It is clear that there is confusion whether FERC Order 363 was designed to increase or decrease prices. Industry wants electronic access to the Railroad Commission's records in order to fully utilize their resources, which currently requires physical access. TIPRO cautions the commission to carefully review oil pro-rationing and other oil-related rules in its movement to streamline rules.

Annotated Bibliography of Policy Issues Related to Pipelines

1. **Felder, Richard B. (1998). Building experience with risk management. Pipeline & Gas Journal, 225(9), 44-49.**
OPS is trying to change the relationship between the pipeline industry and regulator. OPS believes that it is in the economic interest of industry to design and maintain a safe and reliable pipeline system. Therefore, a movement has been developed at OPS that leads away from the idea that improved safety comes from increasing rules and regulations. The aim of the movement is to create an environment that encourages and supports companies to develop their own cost-effective means to ensure safety to the public and the environment. However, it is necessary that the regulatory structure be flexible to accommodate a variety of innovative safety solutions. The Risk Management Demonstration Program authorized in 1996 to test whether risk management would provide an alternative regulatory approach to pipeline safety. Specific objectives of the program include: understanding of causes of pipeline risks and risk control actions, improve information flow between the operator and regulator, identify and manage risks inadequately managed by compliance, and develop new risk management processes, models, and tools.

2. **Fitzsimmons, Edward L. (1998). Oil pipeline industry rates during regulatory reform. Transportation Journal, 38(1), 29-37.**
This paper addresses the FERC rate-making reforms. As the U.S. oil pipeline industry remains to be the last domestic transportation industry under extensive economic federal regulation, the Energy Policy Act of 1992 mandated guidelines for reform. As a result, FERC proposed reforms of rate-making rules and procedures. Uncertainty about the character of the FERC's regulatory reform of the oil pipeline transportation has been much debated. However, the regulatory reform has influenced a rate reduction for shippers and compares to the performance of other deregulated industries. The future impact of pipeline economic regulatory reform remains to be seen.

3. **Heintz, Frank (1996). Future unsubscribed pipeline capacity. <u>Gas Energy Review</u>, 24(6), 6-8.** This article summarizes an issue paper regarding the future and emerging problems of unsubscribed capacity of interstate natural gas pipelines. It also estimates the scope of the problem and explores the ramifications and implications for distributor-shippers and pipelines. In the next 10 years, long-term contracts between local gas distribution companies (LDCs) and pipelines companies will be renewed. LDCs are likely to choose to reduce subscriptions of firm capacity for the following reasons: shifting patterns of gas purchasing, cost of LDCs with low load factors, shippers maximizing their competitive choices, low-cost options from increasing availability of new pipeline connections, storage facilities and sophisticated capacity management services, and reduction in end-use market from increase appliance efficiency and conservation efforts. A reduction in LDCs contract obligations will cause pipelines to increase rates and reservation charges, to seek cost allocation and rate design changes, as well as reallocate risks and rewards between the pipeline and the customer. The purpose of the paper is to advance understanding of interrelated regulatory and market issues and to help gas industry stakeholders and regulators to successfully address the problem. It is stated that continuing analysis and discussion will be needed within the industry.
4. **O&GJ (1998). Industry groups disagree on FERC policy. <u>Oil & Gas Journal</u>, 96(8), 37-38.** The paper addresses the issues regarding the need for U.S. Federal Energy Regulatory Commission actions to improve the financial health of the U.S. pipeline industry. Gas pipelines, utilities, and producers have offered differing views. The International Natural Gas Association of America (INGA) believes that the pipeline industry needs to act now to meet the future increase in demands for gas with new construction projects. Due to the expanding need for gas in electric power and efforts to reduce greenhouse gas emissions, INGA has predicted an increase of 36 percent in gas demand to 30 tcf/year by 2010. The Independent Petroleum Association of America (AGA) claims that there is no tangible evidence of a financial crisis that would require policy change. The American Gas Association would like FERC to focus on the efficient use of existing pipeline capacity. A study showed that 60 percent of local gas utility respondents plan to reduce their pipeline capacity contract levels over the next five years, and less than 15 percent expect to increase the amount of capacity under contract. The study also showed that the majority of respondents want shorter-term contracts when recontracting for capacity.

5. **Real Estate Research Center, College of Agriculture, Texas A&M University (1984). <u>The appraisal of pipeline and public utilities: a report of February 16-17, 1984, seminar.</u>** The reports discusses a seminar in February 16-17, 1984, sponsored by the Association of Texas Real Estate Economists in cooperation with Texas Real Estate Research Center at Texas A&M University. The seminar discussed a study that showed the relationship between regulatory policy and the modern corporation in the 20th century. Information for the study was taken from the Panhandle Eastern Pipeline Company. The information was analyzed through the perspective of three eras: unregulated, regulated, and deregulated.
6. **Senate toughens pipeline rules. (2000). <u>Engineering New-Record</u>, 245(11), 21.** The article discusses new legislation resulting from recent pipeline accidents. A gasoline pipeline explosion in Washington State killed three people in 1999, and a natural gas pipeline explosion in Carlsbad, New Mexico, killed 12 people in 2000. As a result, legislation has been approved that increases regulatory and testing requirements for operators. The bill would require operators to periodically inspect pipeline integrity using various methods. The legislation also raises penalties for violations. The maximum civil penalty for safety violations would increase from $25,000 per day to $500,000 per day. The bill would authorize over $56 million over three years for federal pipeline safety programs.

7. **United States Bureau of Land Management (1993). <u>Express crude oil pipeline, final environmental impact statement</u>.**
Pipeline accidents have a detrimental effect on the health and safety of the environment. Clean up is expensive and takes a considerable amount of time. Clean up does not undo the damage to plant, wildlife, and water supply. It takes years for the environment to restore itself back to its original state. It is therefore crucial to understand the impact pipeline accidents have on the environment.

CONTACTS

It is often time consuming and difficult to find specific or detailed information regarding pipelines through various pieces of literature. This information can easily be obtained from an expert or person working in the field. However, another obstacle is faced when trying to locate a person with expertise in the particular area of interest. Provided is a list of people with various expertise in pipelines. The reference list is intended to assist Texas regulators and others with resources that will provide additional information regarding the pipeline industry.

The reference list is made up of people who researchers identified in literature and professional websites as expressing knowledge and expertise in specific pipeline. The experts were chosen in order to provide a reference list that covers a wide range of pipeline issues. Many of the references chosen were quoted in the literature for their opinions regarding specific issues, and others are authors of various papers on pipeline issues published in professional journals. Some of the references are staff members of pipeline-related organizations or consultants.

The information provided in the reference list is organized for ease of obtaining the proper reference and contact information. Each reference is categorized under the terms *physical*, *business*, and *policy*. The experts listed under the term *physical* have a background that relates to pipeline infrastructure. Those listed under *business* have expertise in pipeline economics and operations. Experts listed under *policy* have interests and knowledge in pipeline regulation and policy. Within each category (physical, business, or policy), the experts are listed providing the following information:

- name of the expert reference,
- company or organization they represent or where they are employed,
- position held at that company or organization,
- specific areas of expertise listed under expertise, and
- contact information.

Given the layout of this reference list, the user can locate an expert to contact by category of pipeline issue (physical, business, or policy), name, company or organization, or specific area of interest.

Table 1. Listing of Contacts for Pipeline Physical Issues.

Name	Company or Organization	Position	Expertise	Contact Information
Mariam Arnaout	American Gas Association	Staff	Pipeline construction	Washington, DC 202-824-7000 marnaout@aga.org
Steve Fischer	Office of Pipeline Safety	GIS Coordinator	National Pipeline Mapping System	Washington, DC 202-366-6267
Roland Goodman	American Petroleum Institute	Transportation and Storage Corrosion Committee	Transportation, storage, and corrosion	Washington, DC 202-682-8571 goodmanr@api.org
John Barrett	Conoco Pipe Line	Transportation Regulatory Management Team	GPS mapping	Ponca City, OK 580-767-3456
Diane J. Hovey	EFA Technologies	Quality Assurance Manager	Pipeline leak detection Pipeline accident report statistics	Sacramento, CA 916-443-8842
Edward J Farmer	EFA Technologies	President of EFA Technologies	Pipeline leak detection Pipeline accident report statistics	Sacramento, CA 916-443-8842
Joseph Caldwell	Pipe Line & Gas Industry	Contributing Editor	Pipeline safety	Houston, TX 713-529-4301
John R. Chechak, Jr.	IDS Engineering	Consultant	Operations technology	Tulsa, OK 918-270-1171 johnc@inddata.com

Table 2. Listing of Contacts for Pipeline Business Issues.

Name	Company or Organization	Position	Expertise	Contact Information
Karen Hill	American Gas Association	Staff	Ratemaking Pipeline capacity issues	Washington, DC 202-824-7000 khill@aga.org
David Shin	American Gas Association	Staff	Pricing/economics	Washington, DC 202-824-7000 dshin@aga.org
John A. Krembs	M&M Protection Consultants	Senior Consultant	Accident losses Hazard control Risk analysis	Chicago, IL 321-627-6000
James M. Connolly	M&M Protection Consultants	Managing Consultant	Accident losses Emerging risk evaluation New hazard control technologies	Chicago, IL 321-627-6000
Nancy Humphrey	Special Projects Division of the Transportation Research Board	Senior staff officer	Pipeline safety planning and practice	Washington, DC 888-624-8373
Paul Gustilo	American Gas Association	Staff	Pipeline operations	Washington, DC 202-824-7000 pgustilo@aga.org
Marty Matheson	American Petroleum Institute	Operations. Technical Committee Cybernetics Subcommittee Training Subcommittee	Technical operations and policy	Washington, DC 202-682-8192 Matheson@api.org
Roland Goodman	American Petroleum Institute	Transportation and Storage Corrosion Committee	Transportation, storage, and corrosion	Washington DC 202-682-8571 goodmanr@api.org

Table 3. Listing of Contacts for Pipeline Policy Issues.

Name	Company or Organization	Position	Expertise	Contact Information
William Mulkey	Olympic Pipeline Co.	Manager of regulatory and environmental affairs		Renton, WA 877-659-7473
George Mosinskis	American Gas Association	Staff	Operator qualification DOT regulations	Washington, DC 202-824-7000 gmosinskis@aga.org
Kyle Rogers	American Gas Association	Staff	Excess flow valves Damage prevention DOT Risk Management One Call Programs	Washington, DC 202-824-7000 krogers@aga.org
Marty Matheson	American Petroleum Institute	Operations Technical Committee Cybernetics Subcommittee Training Subcommittee	Technical operations and policy	Washington, DC Matheson@api.org
Louise Scott	American Petroleum Institute	Public Awareness Committee Committee on Environment, Health and Safety	Environment and public education	Washington, DC 202-682-8000 scottl@api.org
Andrea Johnson	American Petroleum Institute	Staff	Pipeline standard	Washington, DC 202-682-8000 johsona@api.org
Michele F. Joy	Association of Oil Pipe Lines	General Counsel	Regulation of oil pipelines	Washington, DC 202-408-7970
Raymond Paul	Association of Oil Pipe Lines	Director of Public Affairs	Legislation and public relations	Washington, DC 202-408-7970

CHAPTER 3 – INVENTORY OF TEXAS PIPELINE SYSTEM

INTRODUCTION

Pipelines are a major transporter of commodities in the entire United States. According to the 1997 Commodity Flow Survey, over 22,000 tons of commodities were moved via pipeline in the U.S. A modal breakdown indicates that pipelines transport almost a quarter of the commodities moved, second only to trucks with 50 percent. The total pipeline mileage in Texas approaches 270,000 miles, which represents as much as 17 percent of the total pipeline mileage in the U.S. and links many segments of the country with energy sources located on the Gulf Coast. Report 1858-1 discusses commodity movement by pipelines in further detail.

TEXAS PIPELINE SYSTEM

National jurisdiction over pipelines includes over 2.1 million miles of pipeline throughout the U.S. Of that total, natural gas pipelines, including distribution lines, make up over 92 percent of the mileage. Information in Table 4 is taken from the USDOT, Research and Special Programs Administration, Office of Pipeline Safety website and shows the national pipeline system mileage by system type.

Table 4. National Pipeline System Mileage (13).

National Pipeline System	Miles of Pipeline
Natural Gas	
Transmission	301,079
Onshore	295,062
Offshore	6,017
Gathering	31,759
Onshore	25,930
Offshore	5,829
Distribution	1,677,536
Natural Gas Total	2,010,374
Liquid	157,024
Total Pipeline Mileage	*2,167,398*

Texas has one of the greatest concentrations of pipelines within its border compared to the other states with over 275,000 miles. As with the national totals, natural gas represents the most miles of pipeline in Texas, with over 87 percent of the total statewide pipeline mileage. Information in Table 5 is taken from the Railroad Commission of Texas information and shows the estimated pipeline mileage in Texas by system type.

Table 5. Texas Pipeline System Mileage (14).

System Types	Miles of Pipeline
Crude	
Gathering	4,030
Transmission	6,880
Offshore	290
Total	11,200
Natural Gas	
Gathering	46,710
Transmission	117,510
Offshore	1,170
Distribution	71,410
Master Meter	4,660
Total	241,460
Hazardous Liquids	24,040
State Total	276,700

PIPELINE SYSTEM INVENTORY DATA SOURCES

Researchers identified several data sources related to pipeline operation or locations during the course of this project. These sources were identified as potential data available for the pipeline system inventory. Several of these sources include government entities charged with examining the location of pipelines and/or pipeline operations. One entity was a private company extensively involved in the energy industry.

Railroad Commission of Texas

The Railroad Commission of Texas (RRC) has four regulatory divisions that oversee the Texas oil and gas industry, gas utilities, pipeline and rail safety, safety in the liquefied petroleum gas industry, and the surface mining of coal and uranium. As a part of its pipeline safety program, RRC began creating a GIS database of the Texas pipeline system. This ongoing effort includes acquiring digital data from pipeline companies and incorporating data through research, data collection, and data transformation. Information related to RRC activities, including the pipeline GIS database, is found at the RRC website (www.rrc.state.tx.us).

The GIS database developed by RRC has been used in this project to show the pipeline locations and will be provided to TxDOT for the same reason. The GIS database includes liquid and gas transmission, gathering, and flow pipelines under RRC's jurisdiction. An agreement with the U.S. DOT's Office of Pipeline Safety (OPS) to become the State of Texas' pipeline repository will allow RRC to include the estimated 80,000 miles of interstate pipelines. Currently, the database includes approximately 200,000 miles of inter- and intrastate pipelines, with the goal to include the entire estimated 270,000 miles of pipelines in the state. Further development of the pipeline database includes increasing the amount of information included, the degree of accuracy of the initial database, and adding information on the remaining pipeline mileage.

U.S. Department of Transportation – Office of Pipeline Safety

An effort to create a national pipeline GIS is currently being undertaken by the USDOT Office of Pipeline Safety and is titled the *National Pipeline Mapping System* (NPMS). For the NPMS, pipeline operators contribute data voluntarily to either a state repository or the national repository. The purpose of the NPMS is for tracking all natural gas transmission pipelines, hazardous liquid trunklines, and Liquid Natural Gas (LNG) facilities in the United States for use in assessing the risks associated with the Nation's liquid and gas pipeline infrastructure.

The data included in the NPMS have a target positional accuracy of +/- 500 feet; however, the spatial accuracy of the pipeline operators' submissions and other available sources dictate the actual positional accuracy. For the NPMS, positional accuracy is designated in categories ranging from "Excellent" (within 50 feet) to "Poor" (501-1000 feet). NPMS information and data are available at the National Pipeline Mapping System website (www.npms.rspa.dot.gov).

The current NPMS database includes over 28,000 miles of pipelines in Texas, 10 percent of which has a positional accuracy of 50 feet or less and 85 percent of which has a positional accuracy of 500 feet or less. The majority of the entries are for natural gas, crude oil, or product lines.

As the Texas state repository, RRC is required to process data according to specified standards developed for NPMS to ensure consistency. RRC continues to upgrade its pipeline system to NPMS standards, which will allow additional data to be entered into the national repository.

Texas General Land Office

The Texas General Land Office (GLO) is the management agency for state lands and mineral rights properties totaling 20.4 million acres. This includes coastal beaches, bays, "submerged" lands extending 10.3 miles out from the shoreline, and other state lands within Texas. The management activities include leasing state land for oil and gas production and also activities protecting the natural resources found on the properties managed by GLO.

One of the tools used by GLO in the management of the state lands is GIS. Originally used for surveying state lands and for legislative redistricting, the use of GIS has expanded to include supporting lease sales, oil spill response, coastal resource management, land surveying, and other business functions of the land office (GLO website www.glo.state.tx.us. "About Geographic Information Systems at the Texas General Land Office"). Over 100 GIS data layers have been created by GLO for use within the agency and for pubic use.

One of the GIS data layers is pipeline locations on lands and water features handled by GLO. The pipeline data layer, concentrated mostly in the bays and offshore areas off the Texas coast, is part of the surveying efforts by GLO but also can be used in protection of the natural resources. The pipeline data layer, along with many GIS data layers created by GLO, is available to the public. Acquisition directions and information on any of the available GIS data layers is found on the GLO website (www.glo.state.tx.us). It should be noted that pipeline information contained in the GLO database does not directly correspond to information contained in the RRC database.

Pennwell Corporation

PennWell Corporation is a media company providing resources to a diversity of markets, including energy (petroleum exploration, processing, and power generation), electronics, communications, information technology, control technology, water, and fire services. These services include publications, conferences, research, and databases. Services for the energy industry are through PennPoint, a subsidiary of PennWell Corporation. PennPoint's MAPSearch provides database and mapping information for the energy industry including pipeline system information, featuring pipeline and facility interconnections. The information is disseminated through databases, printed maps and atlases, and custom services.

PennWell has developed a GIS pipeline mapping database that contains terminal information and can be purchased for $43,000 or accessed annually for a fee of $15,000 per year. Custom information purchased from PennWell MAPSearch was valuable in completing this research. However, because the purchased information is proprietary, it is only available for use by the State of Texas; the information details are not published in this document but are included in the GIS database provided. Information about PennWell and MAPSearch are found on their websites (www.pennwell.com and www.mapsearch.com).

U.S. Department of Energy – Energy Information Administration, Office of Oil and Gas

In the early 1990s, the Energy Information Administration (EIA), Office of Oil and Gas began the task of creating a GIS system centered on the natural gas industry to aid its analysis of the rapidly changing industry. The EIA Specialized Natural Gas Geographic Information System (EIAGIS-NG) currently contains 126 domestic and 18 Canadian natural gas pipeline systems. The EIAGIS-NG operates in conjunction with the MapInfo GIS software package.

The transportation of natural gas through pipelines does not directly create interconnections with other modes of transportation, but the processing plants and other facilities may do so. These facilities are provided in the EIAGIS-NG, along with other data layers that may produce intermodal connections, including oil tank farms, oil import points, and strategic petroleum reserve sites. However, the research team was unable to incorporate these data because of the customization of the EIAGIS-NG data for use with the MapInfo software package.

Information on EIAGIS-NG is found at the Energy Information Administration's website (www.eia.doe.gov).

GEOGRAPHIC INFORMATION SYSTEM (GIS) DATABASE OF THE TEXAS PIPELINE SYSTEM

The research effort to develop a comprehensive inventory of the state's pipeline system utilizes the RRC GIS pipeline database as the base data layer, with additional fields created by the research team. For TxDOT's use, the research team created a statewide database and divided the data into the 25 TxDOT districts.

The entire database contains over 200,000 miles of liquid and gas transmission, gathering, and flow pipelines in Texas, including offshore pipelines.

Positional Accuracy

Positional accuracy of +/- 500 feet has been attempted by RRC efforts. The spatial accuracy of the pipeline segments in the database will vary greatly by the data acquisition method or source material. Not all pipeline companies use electronic maps to inventory their pipeline systems, and, according to the RRC, very few use GIS.

One area where RRC has made efforts to increase accuracy to a very high level is around rivers and waterways where it has received federal funding to map to a +/- 3 feet level. The hazards associated with dredging, floating debris, construction, or other items or activities creating safety concerns make understanding the locations of pipelines in river and waterway areas especially important. When completed, this information may be particularly useful to TxDOT in its function as the state sponsor for dredging activities and obtaining properties for dredged material storage areas, as applicable.

Pipeline Network Database Attributes

Along with providing the spatial location of the pipelines, the database contains several attributes associated with the pipeline ownership and operations. Several of the major attributes are listed below, with the fields marked with an asterisk indicating the ones included by the research team. Appendix A provides the full description of the database.

- Fluids – Primary commodity categories carried by the pipeline system.
- Pipeline system – Operator-assigned name for a functional grouping of pipelines.
- System Type – Abbreviation for the system type description, e.g. natural gas transmission line.
- Inter/Intrastate designation – Designates a pipeline as either inter- or intrastate.

- *Length – Pipeline segment length.
- County Federal Information Processing Standard (FIPS) – Provides the county FIPS code related to the pipeline segment location.
- *County – Provides the county name of the pipeline segment location.
- *TxDOT district – Indicates the TxDOT district of the pipeline segment location.

GIS DATA ANALYSIS

One highly useful use of GIS is the ability to analyze data visually and analytically. The pipeline database provided the ability to show pipeline concentrations and other geographic characteristics. The following sections will characterize the pipeline system in Texas based on the pipeline GIS database.

The total statewide pipeline mileage in the GIS database is 214,000 miles. This total is greater than the total presented in Report 1858-1 because of two factors. The first relates to the data presented in Report 1858-1. At that point, the pipelines included for analysis included limited erroneous data that required correcting. The most significant errors included misidentification of the system type or improper correlation between the system type and fluid fields. Instead of improperly including the data into a system type, the researchers chose to exclude the erroneous records from the database. Correcting these values allowed for inclusion in the data analysis.

The second factor affecting the database mileage values relates to the presentation of the data. GIS software packages use complex mathematical models to represent the curved surface of the earth onto a flat, two-dimensional map. This process unavoidably distorts the properties of the objects on the map, including shape, area, length, direction, and more. The projection used in the year two data analysis was changed from the projection used for the year one analysis in order to be compliant with TxDOT GIS standards. By using a different map projection in year two, the lengths calculated have changed from the lengths presented in year one.

System Characteristics

The main system types observed for the analysis include carbon dioxide pipelines, crude pipelines, natural gas pipelines, and refined product pipelines. The other system types included in the database were not significant enough to warrant separate considerations but were included in the total pipeline mileage calculations.

Statewide Distribution

The following sections describe the characteristics of the pipeline system types in Texas. Report 1858-1 initially provided maps for each type of characteristic. The database has not been significantly modified in this research effort with respect to the information shown on the state distribution maps.

Carbon Dioxide Pipelines

There are approximately 750 miles of carbon dioxide pipelines in Texas, most of which are located in West Texas, around Lubbock and Odessa. Used primarily for enhanced oil extraction techniques for reduced production crude wells, the total mileage of the carbon dioxide line did not exceed 1 percent of the total pipeline mileage in Texas.

Crude Pipelines

Crude pipelines represent approximately 17 percent of the total pipeline mileage in Texas. Of the 37,000 miles of crude pipelines, over 60 percent are crude transmission lines. The other 40 percent are transmission lines.

There are two major concentration areas in Texas for crude pipelines. Crude lines are located along the entire Texas Gulf Coast, with particular concentrations between Beaumont, Houston, and Corpus Christi. These lines are most likely used by the many petroleum refineries located along the coast with the needed crude oil for production.

The other major concentration of crude lines exists between North Texas around Wichita Falls, through the Abilene area, and West Texas around the Odessa area. The Odessa region is populated with large concentrations of crude-gathering lines. The gathered crude oil is then shipped through a large concentration of transmission lines over to the Wichita Falls area in North Texas.

Natural Gas Pipelines

Natural gas pipelines are the most prevalent pipelines in Texas, with over 65 percent of the total mileage. Over 139,000 miles of natural gas pipelines stretch to all reaches of the state. The gathering and transmission lines are distributed relatively equally according to mileage.

Several large pockets of natural gas gathering lines exist throughout the state, including areas in the Texas Panhandle, the Odessa region, between Fort Worth and Abilene in North Texas, in East Texas region, and in Central Texas. The major concentration of transmission lines consists along the Texas Gulf Coast.

Refined Products Pipelines

Approximately 33,000 miles of refined products pipelines exist in Texas, representing around 15 percent of the total pipeline mileage. The majority of the refined products pipelines transport highly-volatile-liquids (HVL), while the remaining transport non-HVL product. The HVL pipelines represent over 60 percent of the refined products pipelines.

The refined products pipelines typically transport product over a long distance. With the high concentration of refineries located along the Texas Gulf Coast, the majority of the refined products lines stretch either along the coast or from the coast toward the Dallas-Fort Worth or Odessa areas.

TxDOT District Pipeline Distribution

The pipeline system in Texas is extensive, with the vast majority of the state containing large quantities of pipelines. The previous section discussed where the different system types are concentrated around the state and their coverage. This section will divide the state pipeline system into the 25 TxDOT districts. Table 6 provides the pipeline mileage in each TxDOT district, along with the percentage of the total statewide pipeline system. The following discussion will examine the data, and Appendix B contains detailed breakdowns for the state and for each TxDOT district.

As shown in Table 6, the TxDOT districts with the greatest quantities of pipelines are Odessa and Houston, each with approximately 9 percent of the total statewide pipeline mileage. Following with 8 percent is Corpus Christi and with 7 percent is Beaumont.

Table 6. Pipeline Mileage by TxDOT District.

TxDOT District	System Type				District Total	District Total as a % of State Total
	Natural Gas	Crude Oil	Refined Products	Other		
Abilene	5,860	2,980	1,810	160	10,810	5
Amarillo	10,440	1,940	2,220	130	14,730	7
Atlanta	4,630	330	180	510	5,650	3
Austin	2,110	330	910	10	3,360	2
Beaumont	5,090	3,390	5,480	630	14,590	7
Brownwood	7,390	950	760	280	9,380	4
Bryan	5,830	1,100	1,130	130	8,190	4
Childress	2,420	460	90	0	2,970	1
Corpus Christi	9,620	3,770	2,190	830	16,410	8
Dallas	1,920	450	620	0	2,990	1
El Paso	1,170	580	340	10	2,100	1
Fort Worth	9,440	990	1,290	30	11,750	5
Houston	9,000	3,000	6,600	290	18,890	9
Laredo	4,370	640	100	20	5,130	2
Lubbock	5,410	900	960	940	8,210	4
Lufkin	2,480	330	960	40	3,810	2
Odessa	12,380	5,250	1,880	220	19,730	9
Paris	1,680	190	240	10	2,120	1
Pharr	6,520	430	260	370	7,580	4
San Angelo	8,190	2,110	1,330	20	11,650	5
San Antonio	2,330	590	590	0	3,510	2
Tyler	5,110	1,230	840	60	7,240	3
Waco	1,610	620	670	110	3,010	1
Wichita Falls	2,730	3,070	280	0	6,080	3
Yoakum	9,310	980	1,310	380	11,980	6
Offshore Districts	1,750	440	10	30	2,230	1
*State Total**	*138,790*	*37,050*	*33,050*	*5,210*	*214,100*	*100*

*Note: Rounding errors created slightly different values than those presented in Appendix B.

As stated previously, the carbon dioxide pipelines are generally located in West Texas. In fact, 95 percent of the total carbon dioxide pipelines are located in either the Lubbock District (67 percent) or the Odessa District (28 percent). The remaining carbon dioxide pipelines are in the Abilene District (1 percent), San Angelo District (3 percent), or Tyler District (1 percent).

The crude oil pipeline system has concentrations along the coast and in West Texas. The TxDOT districts with the most crude oil pipelines by percentage are Odessa (14 percent), Corpus Christi (10 percent), Beaumont (9 percent), Abilene (8 percent), Wichita Falls (8 percent) and Houston (8 percent). Odessa's crude oil pipeline system exceeds 5,000 miles.

The entire state has heavy concentrations of natural gas pipelines. The TxDOT districts with the highest levels include Odessa, Amarillo, Corpus Christi, Fort Worth, and Yoakum Districts. Odessa's natural gas pipeline system includes over 12,000 miles, representing 9 percent of the state's natural gas pipelines.

The refined products pipelines have the greatest concentration along the Texas Gulf Coast. The Houston District contains 20 percent, and the Beaumont District contains 17 percent of the total refined products pipeline mileage in Texas. Other than the Gulf Coast region, the Amarillo District in the Texas Panhandle contains 7 percent of the total refined products pipelines in Texas.

CHAPTER 4 – PIPELINE INTERCONNECTIVITY WITH OTHER MODES

INTRODUCTION

Report 1858-1 included descriptions of pipeline connections with other modes, noting that the primary setting for such connections is at storage terminals and processing facilities through road, rail, or marine loading racks. Such connections are not directly between modes but are facilitated by tankage, refining, and purifying equipment. The work to inventory the intermodal interconnections of the pipeline system in Texas has continued in year two of this effort, with a partial inventory of intermodal connections with the pipeline system being purchased from Pennwell Mapping Company.

Pipeline Connectivity

While gas pipelines represent over 92 percent of national pipeline mileage and 87 percent of Texas' pipeline mileage, based on quantities presented in Tables 4 and 5 of this report, there is relatively little interconnectivity between gas pipelines and other modes of transportation, as shown in the diagram for the gas pipeline systems (Figure 1). Report 1858-1 and this report have focused on the interconnectivity of crude and refined petroleum product pipelines with other modes of transportation. Figure 2 shows a diagram for the petroleum pipeline system.

Data Sources

This research effort has worked to synthesize pipeline interconnectivity information found in year one and additional sources of information found in year two. The year one sources are principally the U.S. Army Corps of Engineers (USACE) *Port Series* reports and the Houston-Galveston Area Council (HGAC) *Intermodal Facilities* database. A petroleum storage tank database obtained from the Texas Natural Resource Conservation Commission (TNRCC) was also evaluated for pipeline facility information and has resulted limited additional information.

The *Port Series* reports are developed by the USACE and identify port facilities for waterways over which USACE has jurisdiction. Reports are available for all of Texas' Gulf coastline and its larger waterways. However, the accuracy of the information contained in the reports released prior to the mid 1990s is limited, particularly for multimodal information such as railroad and truck access facilities. The most recently updated reports are *Port Series No. 24* for the Port of Houston (1999) and *Port Series No. 23* for the Ports of Galveston and Texas City (1996). It is anticipated that an updated *Port Series No. 22* for the Ports of Port Arthur, Beaumont, and Orange, Texas, will be released sometime in 2001 or 2002.

Report 1858-1 also discussed the applicability of the *Intermodal Facilities* report and that additional regional planning and development groups would be contacted for similar information for year two. All organizations listed on the Texas Metropolitan Planning Organization (MPO) website were contacted in year two regarding such information. Unfortunately, no MPO representatives were aware of such information for their jurisdictions.

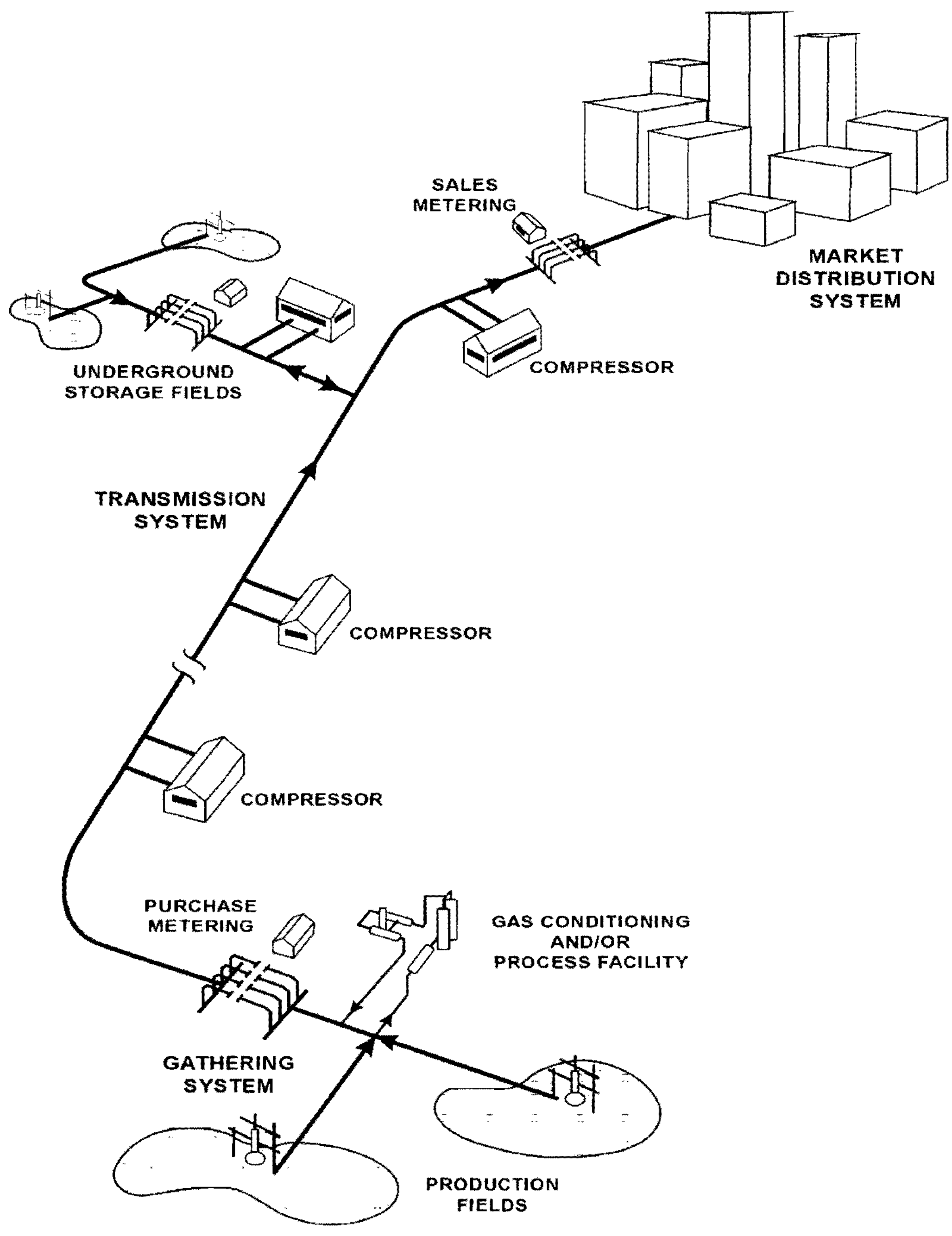


Figure 1. Gas Pipeline Gathering and Distribution Network (15).

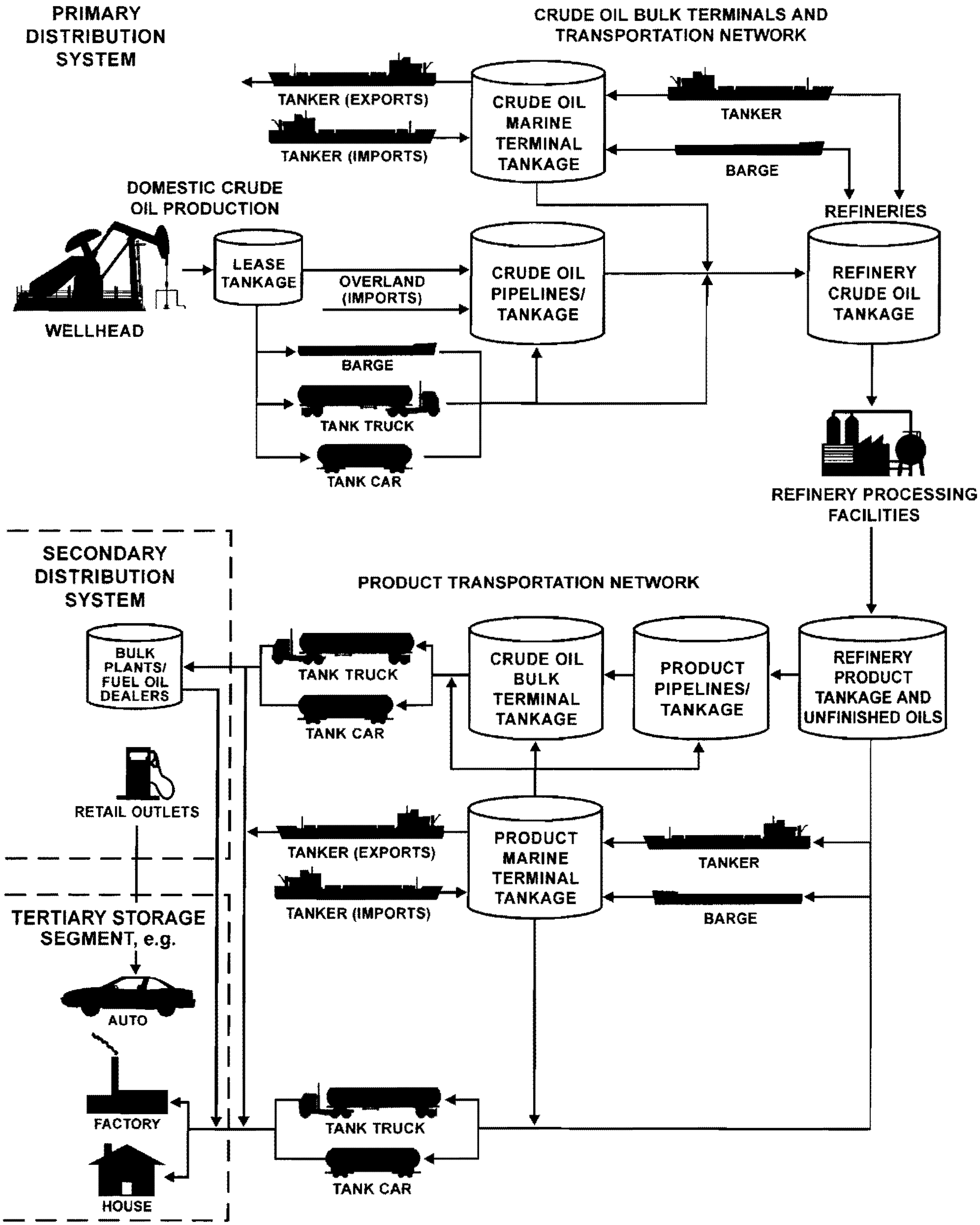


Figure 2. Petroleum Pipeline Gathering, Refining, and Distribution Network (16).

Additional pipeline facility data were sought in year two, with the principal source of information obtained being a custom Texas facility database purchased from Pennwell Maps. The database contains information on over 200 Texas pipeline facilities, most of which have interconnections with other modes. It should be noted that this purchased data was incomplete because information available from Pennwell for Texas was limited at the time of the request. Pennwell believes that facility data will become available for more than 400 additional pipeline facilities in the near future, but it is unknown how many of those facilities have connections with other modes.

For this report, information on facilities was consolidated as available, resulting in relatively complete information for a limited set of pipeline facility intermodal connections, and varying completeness of information for the remainder of those included in this report. Table 7 shows what information is available from those data sources most pertinent to this effort in a matrix format. This information includes facility name and location (address and latitude/longitude), contacts, commodities handled, facility infrastructure and capacity, commodity transfer facilities and loading racks, and pipelines.

Table 7. Information Source Data Matrix.

Title / Information	**USACE *Port Series***	**HGAC *Intermodal Facility Inventory***	**TNRCC Storage Tank Database**	**Pennwell Mapping Company Custom Pipeline Facility Database**
Facility Name	X	X	X	X
Facility Location	X	X	X	X
Facility Contact	X	X	X	X
Commodities Handled		X		X
Pipeline Names				X
Facility Infrastructure Description	X			X
Capacities	X	X		X
Transport Modes	X	X		X
Transfer Facilities	X		X	X

Data Synthesis

Information regarding pipeline connections with other modes has been particularly developed in this research effort for port and waterway facilities in the Houston-Galveston area. Appendix D contains data sheets for 23 facilities in the Houston-Galveston area. The data sheets represent a compilation of available information from the USACE *Port Series*; and the HGAC *Intermodal Facilities* report. This information includes facility identification information, commodity throughput volumes and mode percentages, and commodity transfer infrastructure descriptions.

Because the Pennwell database information is proprietary, information from the database is not available for use by the general public and has not been included for these facilities.

Select information for 126 pipeline facilities throughout the state of Texas will be provided to TxDOT separate from this report. The information includes facility name, location (lat/long), connection modes, and commodities handled. The information regarding modal connections and location for these facilities has been integrated with the GIS database. TxDOT personnel can use this type of information in determining the location of facilities relative to pipeline, roadway, and rail routes, as well as their proximity to residential areas and civic facilities. Because the information for these facilities is based primarily on the Pennwell data set (but also includes additional facilities that were not in the data set but were listed in other sources), this information is not available for use by the general public but only for use by TxDOT.

It should again be noted that this data set for pipeline facilities with multimodal connections is incomplete. Pennwell believes that facility data will become available for more than 400 additional pipeline facilities in the near future, but it is unknown how many of those facilities have connections with other modes. These data have not been synthesized with other data sources, such as the *Port Series* reports.

It is believed that limited research efforts in the near future will be particularly valuable toward developing a more complete, comprehensive inventory of multimodal connections with pipeline facilities in Texas. Development of this inventory will be greatly enhanced by the completion of the Pennwell facility data set for Texas and updated *Port Series* reports. As was done for facilities included in this report, the information regarding modal connections and locations for these facilities could be integrated with the GIS database to assist local planners and TxDOT personnel in determining the location of facilities relative to pipeline, roadway, rail and marine transport routes, as well as their proximity to residential areas and civic facilities.

Facility Significance

The Federal Highway Administration (FHWA) has established guidelines for determining the regional significance of intermodal facilities with respect to their impacts on the national highway system. Under the guidelines, pipeline facilities with truck connections that have traffic levels of 100 trucks per day are considered significant. Significance levels are also provided for truck-water ports and truck-rail facilities, but specifically for pipeline-water and pipeline-rail facilities. However, a water port with 500,000 tons per year is considered regionally significant.

U.S. DOT has specified different designs for highway cargo tanks in the Motor Carrier (MC) series. The current size specifications for petroleum product highway tanks are between 2,000 and 9,500 gallons of product, although older specifications may have permitted larger tanks [(17)]. Railroad tank cars have the capacity to carry between 4,000 and 45,000 gallons of product, although the maximum for new hazardous commodity tank cars is 34,500 gallons [(17)]. Conventional tankers with a draft of less than 40 feet have cargo capacities less than 100,000 dead weight tons (DWT) [(18)]. While barge capacities may vary, many of the tanker barges operating along the Gulf Coast have capacities up to 30,000 barrels [(19)].

A comparative level of traffic may be made for pipeline interfaces with other modes based on FHWA criteria for truck-pipeline facilities. For example, a traffic volume of 100 trucks per day approximately corresponds to 20-30 railroad tank cars per day, 1-2 tank barges per day, and one 50,000 DWT marine tanker every 3-4 weeks.

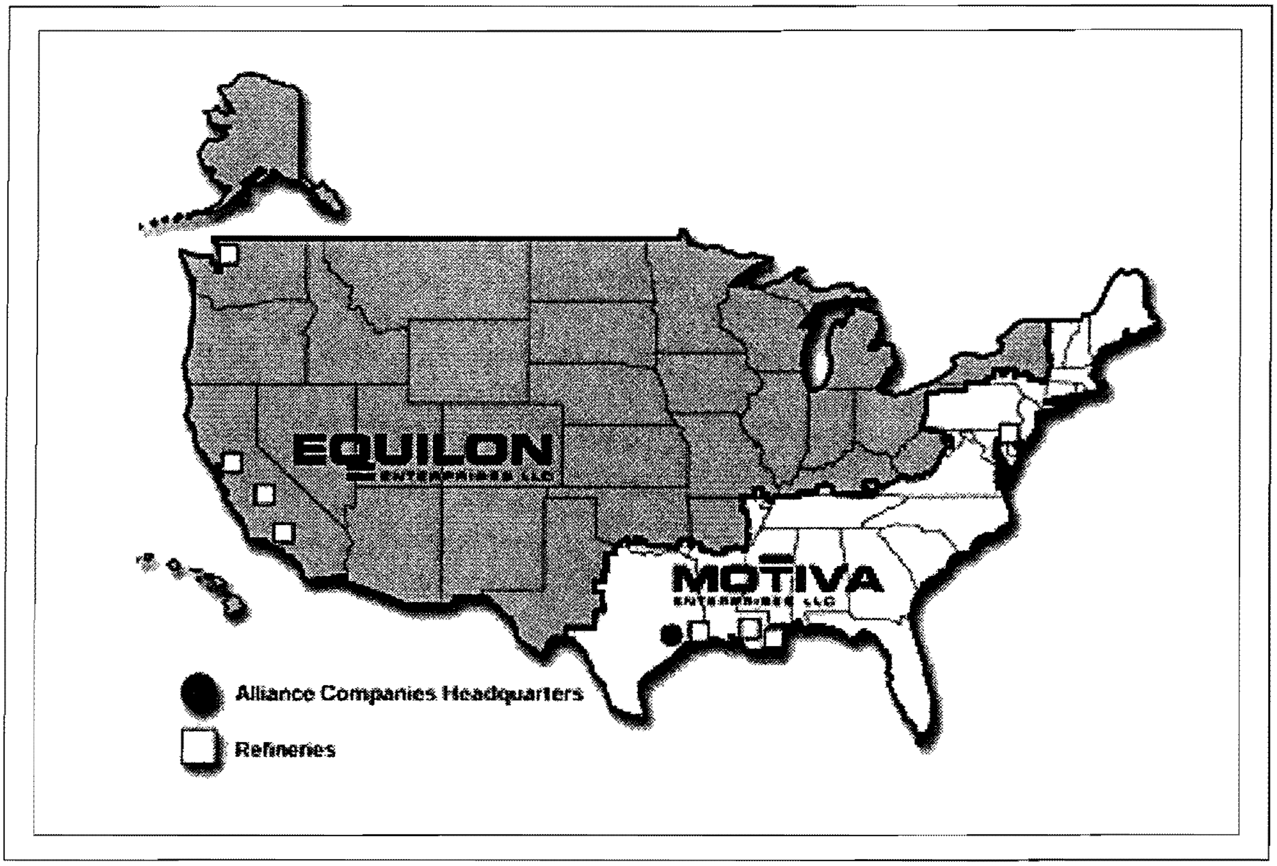
Facility significance was not considered in the criteria for selection of facilities included in the GIS database because throughput information is missing for most facilities listed in data sources. Rather, all pipeline facilities listed in the data sources as having connections with truck, rail, or marine modes were included in the GIS database. Future efforts to identify regionally significant facilities throughout the state of Texas (similar to the work done by HGAC) will require an analysis of throughput information.

Economic Operating Radius

Report 1858-1 described pipeline terminals as an integral part of the linkage between petroleum pipelines and other transportation modes. The report also described plans for year two research to include "investigation toward defining an effective economic radius of operation for petroleum terminals located on pipelines in an effort to determine the maximum distance between storage tank systems and road systems that are impacted…." Based on the year two investigation, it has been determined that economic operating radius around a terminal might be based on several factors, examples of which include terminal price, demographic density, or company contracts. The research suggests that these factors vary in relevance and importance and differ from region to region within the state.

Marketing representatives from several petroleum companies, including Texaco's new marketing representative Equilon, Inc., were contacted to discuss their terminal and trucking logistics operations. Equilon's Transportation Distribution group operates approximately 65 proprietary terminals located throughout the mid-continent and western states, while a sister company Motiva's Commercial Marketing and Distribution organization, covers the northeast, southeast and Gulf Coast states with approximately 50 terminals. These terminals, along with another 320 contracted locations where product is stored on behalf of the distribution groups' customers, provide a source of gasoline products to several transportation modes including tanker trucks, pipelines, railcars, and marine vessels [(20)]. Figure 3 shows the marketing territories for Equilon and Motiva.

Initial contact and information gathering efforts appeared to be promising; however, as the research team contact inquiry got closer to the source of the terminal transportation logistics personnel, availability of company representatives decreased. Information believed to be available within the companies on truck transportation operations and how terminal operations integrate with truck and pipeline networks was not shared with the research team, and demographics surrounding the location of terminals and frequency of truck visits to the terminals were not provided by the pipelines or oil companies contacted.



The Equilon and Motiva market territories
for Texaco, Shell and Aramco retail products

Figure 3. Equilon and Motiva Market Territories (20).

Ultimately, no specific information was obtained from these contact efforts about terminal or petroleum transportation logistics. As a result, all the information presented is from company Internet websites and data gathered from truck drivers and terminal employees interviewed during research team visits to pipeline-truck terminals in Hearne, Texas. The location of Equilon and Motiva distribution terminals is not available on their web page for use to estimate distances between terminals.

Motiva – Equilon Terminal Interviews

The research team visited the Motiva Terminal in Hearne, Texas, to interview the facility management and independent marketing company truck drivers who regularly use the terminal. At this terminal, the interviewees included the terminal records clerk, two truck drivers, and the terminal manager. A synopsis of each interview follows in the order conducted.

Motiva Terminal Interview 1

The first individual who was interviewed at the Motiva Terminal was the terminal records clerk. This interviewee indicated only cursory knowledge regarding the travel range and service area of trucks that load product at the terminal. The clerk was very informative about what motivated terminal selection by the different companies and independent distributors using the terminals.

The principal element affecting which terminal is used to load product is the terminal price. The clerk stated that at least two independent fuel distributors she could think of immediately came from as far away as Wichita Falls, Texas, and Ardmore, Oklahoma, to purchase heating oil from the Motiva terminal because of price differential alone. The clerk did state that these long distance visits were not common, yet they do occur often enough to be an element of consideration for the terminal. Further, the clerk stated that it was not unusual for independent distributors from Dallas, Texas, to load product from the Hearne terminal for distribution in the Dallas area. Again, price at the terminal was cited for dictating the length of haul an independent distributor was willing to travel for product.

Motiva Terminal Interview 2

The second individual who was interviewed at the Motiva Terminal was an independent convenience store truck driver. The driver was very helpful with his responses to questions and indicated the radius of operation for his company on his truck was approximately 50 miles from his home in Cameron, Texas. The only product he delivers is gasoline. He described his farthest typical delivery points as follows: the edge of Waco to the northwest, Buffalo to the northeast, Madisonville to the east, and Bryan to the southeast. The driver also stated that sometimes he might be told to drive to a Dallas terminal to pick-up his fuel load for delivery. This situation had not occurred for some time, but he said the change in terminal use was always based on terminal rack price for the fuel.

Additionally, the driver said that he knew another truck driver for an independent fuel distributor that was based in Brownwood, Texas, who occasionally used the Hearne terminal. He stated that the reason the Brownwood driver came to Hearne was the rack price of fuel. The terminal record clerk agreed with the driver and then added the comments provided in the discussion above pertaining to the very long distance some trucks come to pickup a load in Hearne.

Motiva Terminal Interview 3

The third individual who was interviewed at the Motiva Terminal was a truck driver for H&M Wholesale of Bryan, Texas. This driver stated that his regular radius of operation (deliveries to customers) was within 40 miles of the company headquarters at Bryan. The extent of the driver's deliveries were provided as: Bremond in the northwest, Madisonville in the northeast, Hempstead to the southeast, and Thorndale to the west.

This driver volunteered that his alternate terminal for picking up fuel loads was in Waco at the Koch terminal. He stated that use of this terminal was dictated to the wholesale distribution company he worked for by its contract with the supplier. This statement was further pursued by the researchers to determine what the supply constraints differences were between the convenience store driver and the distributor driver. The distributor driver could not provide additional information regarding this aspect of his company's operation. However, the driver did state that just because the rack price was lower across the road in Hearne at the Exxon terminal, H&M Wholesale could not take advantage of the price.

Motiva Terminal Interview 4

The fourth individual who was interviewed at the Motiva Terminal was the terminal manager, who was asked, "What is the economic radius of operation for trucks filling at a pipeline terminal distribution facility?" The terminal manager said that the question was impossible to answer. The manager also said the operating radius is reflected by the terminal availability and the product's rack price. The manager had nothing else to add to the information provided by the truck drivers and the record clerk.

Exxon Terminal Interviews

The research team also visited the Exxon Terminal distribution facilities in Hearne, Texas to interview the facility management and independent marketing company truck drivers who regularly use the terminal. The Exxon Terminal facility is across the road (Texas State Highway 6) from the Motiva terminal discussed previously. The office clerk was the only individual who was interviewed at the Exxon Terminal. No trucks were at the Exxon Terminal during the time spent there; therefore no driver interviews took place at the facility.

The Exxon Terminal office clerk at the facility stated that she did not know what distance the truck drivers who loaded product at the terminal drove to deliver the product. The clerk stated that one of their customers was from Bryan, but she was uncertain the extent of the driver's delivery area. Further, the customer generally picked-up a load of fuel daily (M-F).

Discussion

Further discussions with the drivers at the Motiva Terminal and the terminal personnel regarding the Hearne Motiva terminal's low rack price, and the distance traveled by drivers to load product led to speculation that Houston terminal prices must be lower than the Hearne price because pipeline transportation would be lower due to proximity to refining centers. However, all of the interviewees expressed that the Houston rack price was always significantly higher than the Hearne price. The outcome of the speculation and discussion was that the pipeline company capital costs or transportation prices to the shipper are not necessarily indicative of the rack price for products at terminals.

In special cases, such as when product is sold locally where refining takes place, the company (refiner) does an economic balancing model where quantity moved to local area terminals is priced higher to compensate for the lower prices needed to attract distributor use at wide-area or near-region terminals. Additionally, such a strategy would potentially keep local refinery terminal distributors from moving into markets of the wide-area distributors, such as the Hearne terminal. The near-region terminals, closer to Houston, may be an operating requirement for the oil companies to maintain a proper product mix and availability volume in the area. Without this presence, distribution companies would incur high truck transportation costs in order to maintain the desired availability in the area. Subsequently, an apparent anomaly in cost–availability relationship seems to exist in that lower terminal price does not necessarily dictate business.

The information obtained from the compiled Motiva terminal interviews is the basis for a limited and highly speculative representation (Figure 4) of a potential economic radius of operation that may be a function of a number of widely different factors such as rack price, demographic density, and/or company contracts. It should be noted that not only is the radius speculative for the Hearne region, but should a radius exist, it may also vary in diameter for other regions.

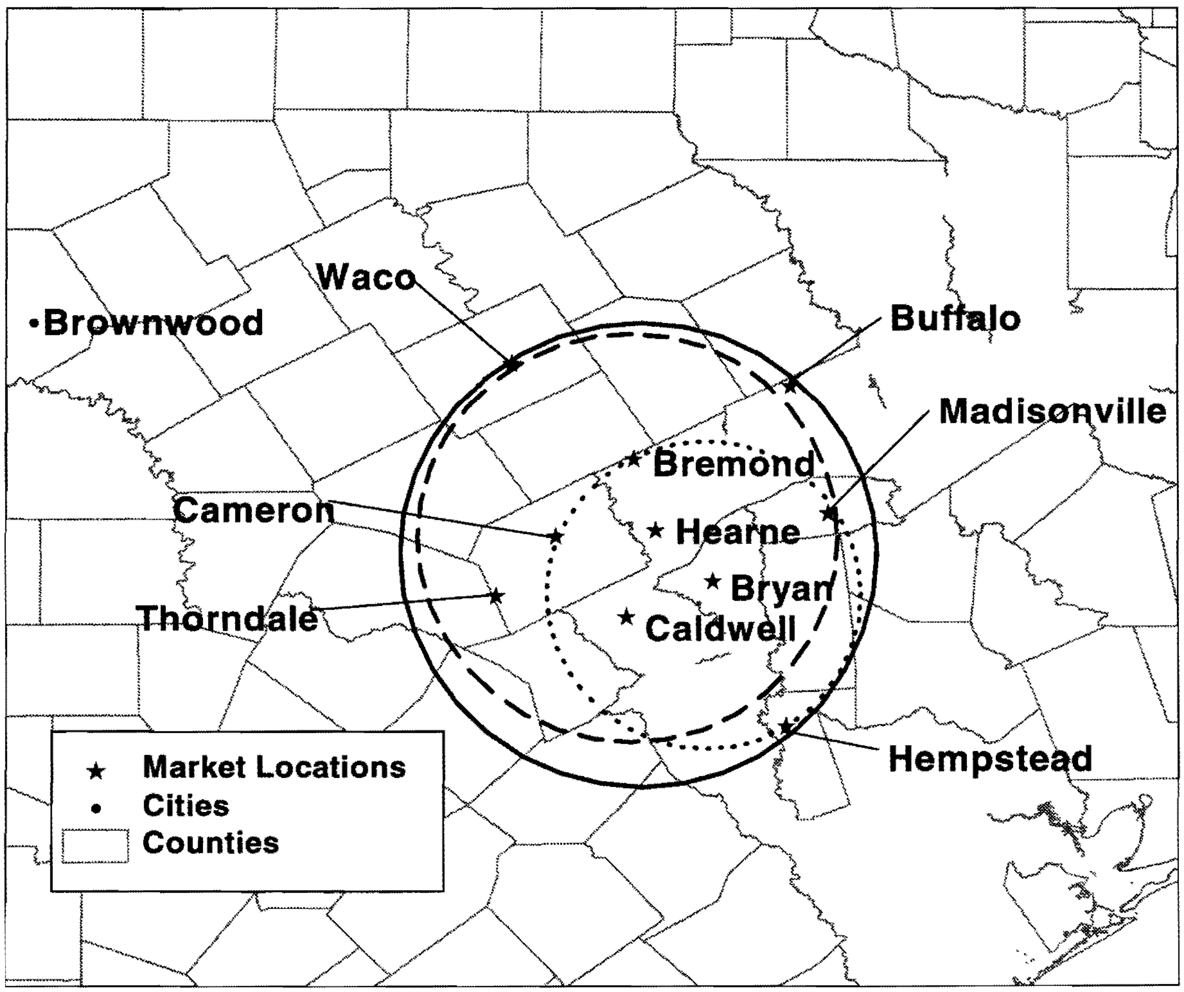


Figure 4. Speculative Economic Radius of Petroleum Distribution.

Multiple factors are believed to influence the pattern of terminal usage by independent distributors. Some of the factors may be the traffic patterns of the local population and growth changes, the introduction of new convenience stores, the acquisition cost of product, and the elimination of competitive terminals through oil company mergers. Pipeline product distribution terminals are generally not widely dispersed along pipelines. Subsequently, changes in economic factors related to petroleum distribution may have significant implications for use of Texas roadways and highways by petroleum product transport trucks.

The speculative operating radii identified in Figure 4 are based on information obtained from terminal employee and truck driver interviews and evaluation of petroleum pipeline distribution terminal operational characteristics. The centers of the market areas, near Hearne and Bryan, are centers of distribution areas for truck drivers interviewed as described under Motiva Terminal Interview 2 and Motiva Terminal Interview 3.

The dashed radius area of operation is based on the interview with the second truck driver at the Motiva Terminal (Motiva Terminal Interview 2). While he indicated that his radius of operation was Cameron, Texas, an evaluation of three of the four typical farthest delivery points, Waco, Buffalo, and Madisonville, shows that they are on the outer edge of a radius that is actually centered at some point *between* Cameron and Hearne. The dotted radius area of operation is based on the interview with the third truck driver at the Motiva Terminal (Motiva Terminal Interview 3). The farthest delivery points of this driver, Madisonville, Bremond, Cameron, and Hempstead, are on the outer edge of a radius that is very nearly centered on Bryan, and is smaller than the dashed radius.

The solid-line large radius area is extended to connect the farthest outliers of both the dashed and dotted-line areas such that both the dashed and dotted-line areas are contained within it. This solid-line radius area is very nearly centered on Hearne, which interestingly happens to be the location of the terminal used by the truck drivers even though they individually indicated alternate market centers. *It is very likely that the large radius area shown is not an actual radius of operation around Hearne, should one exist; it is only an example.*

The large area of operation is based on a very small, statistically insignificant, sample of drivers (who operate in close proximity to the terminal), and as indicated in the interviews, drivers from as far away from Hearne as Brownwood, Wichita Falls, and Dallas in Texas and Ardmore, Oklahoma, will use the terminal based on rack price or contract requirements. A statistically significant information sample may identify a probable radius of operation, somewhat larger or smaller than the solid-line radius area, depending on the particular factors identified and usage weighting.

Because of the nature of the factors potentially involved, the distribution of terminals and population centers, and the level of sampling that may be necessary, it appears unlikely that a simple, straight-forward, general-case model can be *easily* developed to establish an economic operating radius distance around distribution terminals, and it is uncertain whether such a model could be developed at all. This is believed to be especially true for Texas because of the disparity between the east and west resource, refining and pipeline bases, the size of the respective consumer bases, and the distances between population concentrations.

Some combination of variables and factors might be developed to account for differences between regions in the state to allow a single model to reliably predict an economic radius of operation for petroleum distributors from pipeline distribution centers (tank farms). However, development of such a model is beyond resources of this research effort.

The development of such a model would provide a basis for TxDOT to predict changing roadway usage patterns of heavy petroleum product transport trucks around pipeline distribution terminals. It is recommended that a continuation study be conducted to identify whether development of such a model is possible, and the resources and level of effort necessary to accomplish model development. The model should be able to predict the economic radius for distributors on a regional basis.

CHAPTER 5 - PIPELINE INDUSTRY OPERATIONAL AND REGULATORY ISSUES

INTRODUCTION

Pipelines have the potential to affect the transportation systems by transport of commodities that would otherwise travel over the surface, and through the interface of pipelines with other transportation modes. The year two research into the potential for increased integration of the petroleum, refined and chemical product pipeline systems into the overall state transportation system assumes the private pipeline companies' management maximizes their assets income. Using this premise, the research team has considered technical parameters associated with pipeline commodity transport, as discussed in Report 1858-1, and has conducted research into the regulatory issues of what restrictions exist on the pipeline's ability to alter its business focus.

Commodity Transfer to Pipeline from Other Modes and Pipeline Directionality

Report 1858-1 discusses that commodity transfer to pipelines from other transportation modes faces operational and infrastructure limitations. First, the confidentiality of pipeline throughput data restricts the ability for evaluating potential for commodity transfer. Second, the operational nature of pipelines and commodity storage terminals requires that what might be considered as excess capacity at first glance is actually necessary to maintain pipeline and terminal operations.

Many pipelines are limited to the type of commodities that they can carry, and transport of multiple commodities would result in contamination of both product and pipelines. Technically, commodity reversal from one direction to another through pipelines requires significant infrastructure modifications, making this option generally impractical. A pipeline network is designed to move a class of commodities in one direction from point A to point B. By introducing differential pressure in the pipeline, compressor stations serve to propel the commodity through the line to a predetermined destination.

Multiple compressor stations may be used to boost the pressure, and transmission over transcontinental distances are possible as a result. The technology enabling pipelines to operate efficiently also has the effect of defining the direction in which the pipeline can move the material within. The alteration of a line's direction requires significant retooling of the line. This may include changes in compressors and valves as well as in the operation of the affected terminals. Due to the unidirectional nature of most pipelines, flexibility in flow destination is limited. The resulting system is not generally amenable to short-term market needs that would require flow in the opposite direction.

In addition, the private nature of pipeline companies and an intensely competitive business environment dictate that pipeline companies are likely utilizing available infrastructure and capacity to the extent that is economically practical. While this leads to the conclusion that the competitive business practices of pipelines result in little excess capacity for commodity shift, there may be some limited potential for commodity transfer in certain aspects of the pipeline industry. This has been identified as a potential area for future study.

STATE AND FEDERAL PIPELINE REGULATIONS

A general analysis of pipeline regulations at the state and federal levels Report 1858-1 presented. This analysis was expanded for this report, particularly with respect to pipeline operations and safety, which are the subjects of the majority of pipeline regulations. These are discussed in the following sections, and their impact on TxDOT is also discussed.

Regulatory authority over pipelines exists at a both a federal level and state level. At the federal, level regulatory authority is divided into two general areas. Federal regulation of the first general area, the safety of physical aspects of pipelines, is enforced by the Office of Pipeline Safety and promulgated by the United States Department of Transportation. The Federal Energy Regulatory Commission within the Department of Energy (DOE) regulates the second general area, rate setting. At the State of Texas level, the Texas Railroad Commission carries out almost all aspects of pipeline regulation.

Federal Regulation of Pipeline Safety

Overview

The main bodies of federal safety regulations for physical aspects of pipeline systems are given in Title 49 of the *Code of Federal Regulations* (CFR). From a safety regulation standpoint, gas pipelines are distinguished from liquid pipelines because these two system types involve different handling processes, facilities, and risks. Specifically, depending on whether it is a liquid or gas system, a pipeline may be subject to one of the following two CFR parts:

- 49 CFR 192: *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*
- 49 CFR 195: *Transportation of Hazardous Liquids by Pipeline*

Part 192 covers gas pipeline systems, where gas is defined to mean natural gas, flammable gas, or gas that is toxic or corrosive (192.3). Part 195 covers hazardous liquid or carbon dioxide pipeline systems. Hazardous liquid refers to petroleum, petroleum products, or anhydrous ammonia; and carbon dioxide is defined as fluids that consist of more that 90% carbon dioxide molecules compressed to a critical state (195.2).

The regulations described above are implemented by USDOT, which has regulatory authority over the safety characteristics of the physical asset of a pipeline. This authority is embodied in the OPS, and has been variously promoted within OPS at some times and been referred to state authorities at others. Some of the details of this promotion will be described in the material that follows. OPS has not generally been responsible for promulgating regulation, rather, it enforces regulations upon the pipeline industry. USDOT is generally viewed as the promulgator of these regulations, which are found in the CFR parts described above.

The Environmental Protection Agency (EPA) has regulatory authority over all aspects of all pipelines, interstate and intrastate, with regard to environmental permitting for both installation of physical assets and for the actual operations of those assets. Most regulatory authorities are strictly limited in their authority; however, EPA's powers appear to be relatively broad in scope. This broad authority is in contrast to any other regulatory body discovered to date by this study. EPA regulatory statutes are found in CFR Title 40. While environmental protection is not always synonymous with safety, because EPA's regulations impact the physical aspects of pipeline construction and operation, they must be considered relevant to pipeline safety.

In addition to OPS-implemented safety regulations, pipelines must be designed and operated to meet the regulations of the Department of Labor's (DL) Occupational Safety and Health Administration (OSHA). OSHA is authorized by DL to promulgate regulation concerning safe design and design implementation of the pipeline physical asset. OSHA generally carries out promulgation through the adoption of recognized standards set forth by professional societies, such as American Society of Mechanical Engineers, American Society of Testing and Materials, etc. This function has little to do with the transportation mix of pipelines or their location and operation. OSHA regulatory statutes are found in CFR Title 29, Subsection 1920 inclusive.

Federal Safety Regulation of Gas Pipelines

Part 192 prescribes minimum safety requirements for pipeline facilities and the transportation of gas, including facilities and gas transportation within the limits of the outer continental shelf. These regulations do not apply in some cases. Generally, Part 192 applies to all gas pipelines except those used in rural gas gathering systems or those involved in the transportation of gas to a very limited customer base. Explicitly, Part 192 does not apply to:

- Offshore pipelines upstream from the outlet flange of each facility where hydrocarbons are produced or where produced hydrocarbons are first separated, dehydrated, or otherwise processed, whichever facility is further downstream.
- Onshore gathering of gas outside of the following areas:
  1. An area within the limits of any incorporated or unincorporated city, town, or village.
  2. Any designated residential or commercial area such as a subdivision, business, or shopping center, or community development.
  3. Onshore gathering of gas within inlets of the Gulf of Mexico except as provided by 49 CFR 192.612.
- Any pipeline system that transports only petroleum gas or petroleum gas/air mixture to:
  1. Fewer than 10 customers, if no portion of the system is located in a public place.
  2. A single customer, if the system is located entirely on the customer's premises (no matter if a portion of the system is located in a public place).

- On the Outer Continental Shelf upstream of the point at which operating responsibility transfers from a producing operator to a transporting operator.

A gas pipeline is considered by Part 192 to include all physical facilities, new or old, through which gas moves in transportation (192.3). Gas pipelines are categorized in terms of location. This categorization is based on an assessment of the level of human occupancy or public assembly that occurs within a "class location unit." A class location unit is an onshore area that extends 220 yards on either side of continuous 1-mile segments of pipeline. Class location unit categories range from Class 1, in which the class location unit is either offshore or contains fewer than 10 buildings that are intended for human occupancy, to Class 4, in which buildings with four or more stories above ground are prevalent (192.5). No federal regulatory distinction is made between interstate and intrastate gas pipelines, meaning that even intrastate pipelines may be subject to federal safety regulation.

The federal standard does not seem to explicitly guide gas pipeline construction away from inhabited areas or prevent gas pipelines from being built in close proximity to areas where large numbers of people gather, as it does in the case of liquid pipelines. Indeed, gas pipelines must be present in inhabited areas and will often connect with structures in which people gather because these pipelines often serve to distribute natural gas for domestic and commercial consumption. The use of the class location unit attempts to ensure that pipelines in populated areas will be designed to meet higher standards. The design and construction of a new segment of pipeline must conform to the minimum standards described in 49 CFR 192.

The Subparts of Part 192 prescribe minimum requirements that must be met by the components and processes involved in pipeline construction and operation:

Subpart A:	Selection and Qualification of Pipe and Components for use in Pipelines
Subpart B:	Design of Pipe
Subpart C:	Design and Installation of Pipeline Components and Facilities and Protection against Accidental Over pressuring
Subpart D:	Welding Steel Materials in Pipelines
Subpart E:	Techniques Other than Welding Used for Joining Materials in Pipelines
Subpart F:	Construction of Transmission Lines and Mains
Subpart G:	Installation of Customer Meters, Service Regulators, Service Lines, Service Line Valves, and Service Line Connections to Mains
Subpart H:	Protection of Metallic Pipelines from External, Internal, and Atmospheric Corrosion
Subpart J:	Leak-Testing and Strength-Testing
Subpart K:	Increasing Maximum Allowable Operating Pressures
Subpart L:	Operation of Pipeline Facilities
Subpart M:	Maintenance of Pipeline Facilities
Subpart N:	Operator Qualification of Individual Performing Covered Tasks

Two situations may prompt the need for existing pipelines to be reassessed under Part 192. First, the population density through which a given pipeline segment passes may increase, prompting a change in the class location the pipeline must satisfy. Second, a pipeline segment not previously subject to regulation by Part 192 may be brought into compliance with Part 192 so that it may be used for purposes that are regulated by Part 195.

When an increase in population density warrants a change in class location for a pipeline segment, the operator must often immediately examine the pipeline segment. This rule applies to segments that operate with hoop stresses above 40 percent of the specified minimum yield strength or have hoop stress levels that are not appropriate in the new level of class location. The operator must assess the class location, the physical condition and history of the segment, the stresses present in the segment, and the area affected by the population density increase. A comparison of existing pipeline conditions and operating procedures to those required in the upgraded class location must be performed. Section 192.611 describes how to revise the maximum operating pressure if the established operating pressure of the segment is not commensurate with the present class location.

A pipeline must also be reassessed if Part 192 has not previously applied to the pipeline. Examples include gas pipelines that were exempt from Part 192 being converted for use in service that renders them subject to Part 192 and liquid pipelines that are converted for use as gas pipelines. To convert a pipeline to service subject to Part 192, the operator must prepare and carry out a written procedure that meets requirements outlined in Section 192.14. This procedure must include a review of the design, construction, operation, and maintenance history of the pipeline. Where information on these areas is unavailable, appropriate testing must be performed to obtain the necessary information. Inspection for defects and dangerous operating conditions must be carried out and these defects must be repaired. Finally, the pipeline must be tested in a manner that is in accordance with Subpart J of Part 192. The records of these investigations, tests, repairs, replacements, and alterations must be kept for the life of the pipeline.

Federal Safety Regulation of Liquid Pipelines

49 CFR Part 195 prescribes safety standards and reporting requirements for pipeline facilities that are used in the transportation of hazardous liquids or carbon dioxide (195.0). Unlike the gas pipeline regulations of Part 192, Part 195 makes a regulatory distinction between intrastate and interstate liquid pipelines. The details of this distinction will be discussed shortly. Part 195 applies to facilities "in or affecting interstate or foreign commerce, including pipeline facilities on the Outer Continental Shelf" (195.1).

A number of exceptions to Part 195 exist. Many of these exceptions are for systems that either don't use high pressures to move product or aren't pipeline based transportation systems. Other exceptions are granted to limited length pipelines used in terminal or intermodal facilities. In addition, certain rural and offshore gathering pipelines and carbon dioxide pipelines involved in oil-recovery or well injection operations are exempt. The exceptions, as given in Section 195.1, are listed below:

- Hazardous liquids are transported in a gaseous state.
- Hazardous liquids are transported by gravity.

- Transportation occurs through the following low-stress pipelines:
  1. An onshore pipeline or segment that meets all of the following criteria:
     a. does not transport HVL;
     b. is located in a rural area; or
     c. is located outside a waterway currently used for commercial navigation.
  2. A pipeline subject to the safety regulations of the U.S. Coast Guard.
  3. A pipeline that serves refining, manufacturing, or truck, rail or vessel terminal facilities, if the pipeline is less than 1 mile long (measured outside facility grounds) and does not cross an offshore area or a waterway currently used for commercial navigation.
- Transportation of petroleum in onshore gathering lines in rural areas except gathering lines in the inlets of the Gulf of Mexico subject to Section 195.413.
- Transportation of hazardous liquid or carbon dioxide in offshore pipelines that are located upstream from the outlet flange of each facility where hydrocarbons or carbon dioxide are produced or where produced hydrocarbons or carbon dioxide are first separated, dehydrated, or otherwise processed, whichever facility is farther downstream.
- Transportation of hazardous liquid or carbon dioxide through onshore production (including flow lines), refining, or manufacturing facilities or storage or in-plant piping systems associated with such facilities.
- Transportation of a hazardous liquid or carbon dioxide:
  1. by vessel, aircraft, tank truck, tank car, or other non-pipeline mode of transportation.
  2. through facilities located on the grounds of a materials transportation terminal that are used to transfer hazardous liquid or carbon dioxide between non-pipeline modes of transportation or between a non-pipeline mode and a pipeline, not including any device and associated piping that are necessary to control pressure in the pipeline under Section 195.406(b).
- Transportation of carbon dioxide downstream from the following point, as applicable:
  1. The inlet of a compressor used in the injection of carbon dioxide for oil recovery operations, or the point where recycled carbon dioxide enters the injection system, whichever is further upstream.
  2. The connection of the first branch pipeline in the production field that transports carbon dioxide to injection wells or to headers or manifolds from which pipelines branch to injection wells to headers or manifolds from which pipelines branch to injection wells.

Although 49 CFR 195.1 indicates its regulatory application is limited to "facilities in or affecting interstate or foreign commerce," further interpretation of this limitation is given in Appendix A of Part 195. The Hazardous Liquids Pipeline Safety Act of 1979, 49 U.S.C. 2001 *et seq.* (HLPSA) establishes federal authority. HLPSA distinguishes between interstate and intrastate pipeline facilities, leaving interstate pipeline facilities to exclusive federal regulation and enforcement. HLPSA defines an interstate pipeline based on the end points of the transportation involved.

In administering HLPSA, the Department of Transportation has chosen to base the interstate-intrastate delineation on the approach taken by the Natural Gas Pipeline Safety Act of 1968, 49 U.S.C. 1671 *et seq.* (NGPSA) in identifying interstate pipeline facilities. NGPSA identifies these facilities as those that fall under the jurisdiction of the Federal Energy Regulatory Commission. Some question exists as to whether or not this approach correctly identifies all interstate liquid pipeline facilities.

For liquid pipelines, FERC jurisdiction is determined through a reactive process that is spawned by complaints made to FERC. As a result, it is likely that not all interstate pipeline facilities have been recognized by FERC. DOT bases its intrastate/interstate delineation on the FERC jurisdiction determination anyway because it is believed that an approximately correct determination of jurisdiction is achieved that avoids the need to develop a new, separate federal scheme to determine jurisdiction over liquid pipelines.

For pipeline facilities that are deemed to be intrastate pipeline facilities, "the HLPSA provides that the same Federal regulation and enforcement will apply unless a State certifies that it will assume those responsibilities" (Part 195, Appendix A). As a result, it only becomes necessary to distinguish between interstate and intrastate facilities in a given state when that state becomes certified to participate in the hazardous liquid pipeline safety program. Certified states must adopt the same minimum standards but are free to adopt additional, more stringent standards so long as these state standards are compatible with federal standards. Texas is a certified state, whose certified agency is the Railroad Commission of Texas.

The Subparts of 49 CFR Part 195 prescribe minimum requirements that must be met by the components and processes involved in pipeline construction and operation that fall under its jurisdiction:

Subpart B:	Reporting Accidents and Safety-Related Conditions
Subpart C:	Design Requirements
Subpart D:	Construction
Subpart E:	Pressure Testing
Subpart F:	Operation and Maintenance

New liquid pipelines must be built to comply with all pertinent regulations. For instance, construction regulations detail requirements that must be met by pipeline materials, welding processes, and depths of cover. Two rules exist regarding the location of new pipelines (195.210). First, pipeline right-of-way "must be selected to avoid, as far as practicable, areas containing private dwellings, industrial buildings, and places of public assembly." Second, a pipeline cannot be located within 50 feet of private dwellings, industrial buildings or other places where people "work, congregate, or assemble" unless 12 inches of cover, in addition to that cover already prescribed by the regulations, are provided.

In order to operate, a pipeline must have passed pressure tests, prescribed in Subpart E of the regulation, without leakage. Exceptions to this requirement do exist. Certain older pipelines are exempt from pressure testing, as are certain low-pressure pipelines and rural gathering lines. An alternative "risk based alternative to pressure testing" may be required in lieu of pressure testing in certain cases.

If an operator wishes to upgrade an existing liquid petroleum pipeline that is already subject to regulation by Part 195, then the upgrade must meet all the requirements of Part 195. A pipeline may be converted from some other form of service not subject to regulation by Part 195 to service that is subject to Part 195. One example is converting an intrastate, non-federally regulated hazardous liquid pipeline to an interstate, federally regulated hazardous liquid petroleum pipeline. Another example is converting a pipeline designed to handle natural gas into one that will handle hazardous liquids.

To carry out a conversion, the operator must develop and follow a written procedure that describes the steps required to ensure the converted pipeline is safe. This procedure must include plans to review the design and current strength of the existing pipeline, to conduct appropriate pressure tests, to inspect certain segments of the pipeline for defects, and to repair known defects and unsafe conditions in a way that is in accordance with Part 195. The records of the results obtained from following this procedure must be kept for the life of the pipeline.

Federal Regulation of Pipeline Operations

Just as they do for pipeline facility and procedural safety requirements, Federal pipeline operational regulations distinguish between gas and liquid pipelines. The distinction between gas and liquid lines is made because the issues and economics involved with the two systems differ significantly. These operational regulations generally address issues of rate setting, contractual agreements, and customer and supplier complaints.

Currently, FERC is the federal body charged with implementing federal operational regulations for both gas and liquid pipelines. The regulatory authority of FERC was first enacted in the early 1900's. The legislation required both rate and service regulation to ensure that pipelines earned an adequate, i.e., "just and reasonable," rate of return on their capital investment and recovery of operating costs while providing nondiscriminatory access to shippers. FERC regulatory statutes are found in the Code of Federal Regulations (CFR) Title 18.

In addition to FERC, the regulatory authority of two other federal agencies may play a role in pipeline operations. As described previously, both the EPA and OSHA have some authority over certain aspects of pipeline permitting and operations. Before a specific discussion of pipeline operations requirements, a brief explanation is provided regarding "common carrier" and "private carrier" status.

Common Carrier and Private Carrier Status

With respect to pipelines, common carrier status generally means that a pipeline operator is required to ship compatible commodities for anyone at a "published" rate that is available to all shippers. Private carrier status means that the pipeline's operations are solely private – the operator transports only its own commodities through the pipeline and is not required to ship anyone else's commodities.

Historically, common carriers status was considered only for petroleum pipelines. As a result of the initial breakup of the Standard Oil Company, all "for-hire" petroleum pipelines were designated with common carrier status; they were required to publish non-discriminatory tariff rates available to all shippers and file those rates with the U.S. government. Anyone could ship compatible liquid products through the oil pipelines on a first-come-first-served basis.

All liquid petroleum/product lines that offer themselves for hire under any condition become for-hire companies. For example, a company such as Exxon can ship its own products through its own lines and is not forced to carry another company's products. However, should they hire out to transfer product to any another company, then their transport operations are no longer exclusive, and they are required to handle anyone's products, not just those of certain companies.

Prior to 1986, when FERC promulgated 436, natural gas interstate pipelines were solely private; companies contracted to own quantities of natural gas and they selectively sold their owned natural gas along the routes of their pipelines, generally running south to north. There were two notable exceptions to the direction of pipeline transport. El Paso Natural Gas, Inc. pipeline ran from Texas to California, and the Trailblazer Pipeline ran from Colorado and Wyoming to Chicago, Illinois.

With Order 436 (now Order 636), FERC initiated the common carrier characteristic of the oil lines into the natural gas interstate pipeline industry, meaning that interstate pipeline companies no longer could require their customers to purchase service from origin to destination but were only allowed to charge gas transportation service at "postage stamp" (published) rates filed annually with FERC. The pipeline companies *can* provide the full package of origin-destination services, but they can no longer *require* users or transporters to participate in any pipeline company services other than transportation. Generally, intrastate pipeline companies, notably Valero in Texas, maintain private carrier characteristics, but they may be competitively forced into the common carrier market as a result of industry deregulation.

While there are certain common carrier requirements, such as posted transport rates and first-come-first-served shipping, there are methods that pipeline companies and natural gas and petroleum product brokers can and do use to influence the market. For example, a pipeline company can sell "capacity" to shippers and reserve that space. If all the capacity is sold but is not being utilized, the companies can sell the actual transport services for the unused capacity at an alternate rate, "best-effort" basis. Thus, a gas supplier could contract with a company to purchase pipeline capacity and force its competitors to purchase the gas at an inflated "best-effort" rate. This is only one example of how suppliers could, subject to the limitations of the Sherman Antitrust Act, influence the market by purchasing capacity rather than delivered product.

Natural Gas Pipeline Operational Regulation

Three pieces of the U.S. Code are central to federal regulation of natural gas pipelines:

- Natural Gas Act (NGA), 15 U.S.C. §717
- Natural Gas Policy Act of 1978 (NGPA), 15 U.S.C. §3301-3432
- Public Utilities Regulatory Policies Act of 1978, 16 U.S.C §2601 *et seq.*

Federal regulation of the operations of natural gas pipelines started in 1938 with the Natural Gas Policy Act. NGA declared that the "business of transporting and selling natural gas" to the public is a public interest and should, therefore, be subject to regulation when such transportation is interstate in nature. NGA established a Commission, currently the FERC, an independent regulatory agency within the Department of Energy, to regulate operational aspects of natural gas transportation.

According to NGA, all natural gas that is subject to interstate transportation laws is regulated by FERC. The provisions of NGA may not apply to persons who are authorized to engage in interstate natural gas commerce but who sell in a given state all the gas they receive in that state. Such intrastate operators are exempt from FERC regulations if a state commission regulates their rates and services. All that is required to establish the existence of such a State commission is a certification from the state commission to the FERC that the State commission has jurisdiction over such intrastate matters. In Texas, the Railroad Commission of Texas has this jurisdiction. RRC rules are found in the Texas Administrative Code (TAC), Title 16, Part 1. The role of RRC will be discussed shortly.

NGA states that all rates and charges involved in natural gas commerce, which fall under FERC jurisdiction, must be just and reasonable. Rates must not give undue preference to certain customers and must not be unreasonable. Rates must be filed with FERC and be open for public inspection; and all rate changes must be preceded by 30 days notice, unless FERC waives the need for this notice.

In order to keep rates and services "just and reasonable," FERC may enter into a hearing concerning the lawfulness of a rate or service. Such a hearing may be instigated by FERC's own volition or upon the complaint of any state, municipality, state commission, or gas distribution company. FERC may take corrective action based upon the results of this hearing. Such action may include a rate change, although no rate change can actually increase the rate in question.

The Natural Gas Policy Act of 1978 updated and clarified the Natural Gas Act of 1938. In addition to providing a framework through which the federal government deals with a national natural gas emergency, NGPA expands the regulatory role of FERC with regard to natural gas transportation operations, such as rate setting. First, NGPA allows FERC to authorize interstate pipelines to handle gas on behalf of intrastate pipelines and vice-versa. This authorization of handling may also be made on behalf of a distribution company that is served by interstate pipelines. Such authority allows FERC more flexibility to solve problems with rates and services by increasing the number of facilities that it may involve in solutions.

Second, NGPA prohibits natural gas contracts from effectively circumventing the regulatory authority of FERC. In particular, gas contracts may not prohibit commingling of gas that falls under FERC jurisdiction or prohibit gas subject to the contract to be sold to anyone who falls under FERC jurisdiction. This clause prevents gas contracts from discriminating against persons regulated by FERC, and prevents FERC's regulatory effectiveness from being mitigated by existing or future contracts. It may also extend FERC's jurisdiction indirectly by forcing the possibility of FERC regulation on all persons involved in gas transport by forcing them to confront the possibility that they may have to accept FERC-regulated gas at some point in time.

The Public Utilities Regulatory Policies Act of 1978 (PURPA) also impacts gas pipeline operations. In particular, PURPA requires that the appropriate state commission must also implement FERC rules issued in accordance with PURPA. As a result, FERC jurisdiction is effectively extended to include intrastate pipelines, since FERC rules are implemented indirectly through state commissions in intrastate cases.

Liquid Pipeline Operational Regulation

Two sections of U.S. Code and one segment of the Code of Federal Regulations relate to federal regulation of liquid petroleum pipelines:

- Interstate Commerce Act (ICA), 49 U.S.C. Subtitle IV, Part C
- Energy Policy Act (EPAct) of 1992
- Regulations Corresponding to ICA, 18 CFR 340-348

In the Interstate Commerce Act, the federal government makes it a policy to oversee modes of transportation. Among the purposes of this federal oversight are efforts to "recognize and preserve the inherent advantage of each mode" and to establish and maintain reasonable transportation rates that are also nondiscriminatory and don't involve destructive business practices (49 U.S.C §15101). According to ICA, the federal government has jurisdiction over interstate and international pipeline transportation. ICA explicitly states that the federal government does not have jurisdiction over intrastate transportation.

Furthermore, ICA gives power to a state to make rules to ensure that carriers that are already subject to ICA provide "reasonable intrastate transportation." This state regulatory capacity is only prohibited if the state rules are inconsistent with ICA (49 U.S.C §15301). In Texas, the Texas Railroad Commission is the state regulatory agency with authority over intrastate pipeline transportation. The Federal Energy Regulatory Commission is responsible for regulating the operational aspects of interstate pipelines. The Energy Policy Act of 1992 (also contributes to FERC's ability to promote fair industry competition.

Parts 340 to 348 of Title 18 of the Code of Federal Regulations detail the procedures by which FERC can regulate liquid pipeline operations. In particular, carriers must publish rates, which may be rejected, corrected, or modified by FERC.

State of Texas Regulation of Pipelines

As noted previously, the federal government does not regulate all aspects of either pipeline safety or pipeline operations. In many cases, intrastate pipelines are subject only to state regulation. Other sorts of special case pipelines, particularly pipelines involved in gathering operations, are also not subject to all federal regulations. As a result, pipeline regulation clearly must occur at the state level.

Texas Railroad Commission

The Railroad Commission of Texas is the state's primary pipeline regulatory agency. However, other authorities within Texas government are specifically empowered to carry out limited regulation of pipelines within their area of expertise, and there may be a general enabling of regulatory authority at TxDOT in their mandate to coordinate the overall transportation system within the state.

The Cox Act and the Texas Natural Resources Code authorize RRC's existing pipeline safety program. This program regulates the safety of intrastate natural gas and hazardous liquid pipelines. In cases where federal regulations do apply to intrastate pipelines but allow a certified state agency to enforce the regulations, RRC is the certified state entity in Texas. Precedence for RRC's involvement with pipeline safety extends back to 1937 when RRC issued its first pipeline safety order, requiring the odorization of natural gas intended for domestic use.

RRC also appears to be the primary State of Texas regulatory entity when it comes to operational regulation. In the case of natural gas, it has been discussed that intrastate pipeline operations (rates, fees, etc.) are exempt from federal regulation if a state commission regulates them, provided that the State commission certifies to FERC that it has jurisdiction over these state matters. In Texas, RRC is currently the agency certified with FERC to regulate natural gas pipeline operations. As previously noted, PURPA-related FERC rules must also be implemented by the certified state commission. As a result, PURPA related FERC rules are effectively imposed on pipelines normally subject only to state jurisdiction.

In the State of Texas, regulatory control of liquid pipeline operations appears to rest with RRC, which gets its jurisdiction over these matters from Part 1 of Title 16 of the Texas Administrative Code. Chapter 3 of this title covers economic regulation of the Oil and Gas Division of RRC. Crude oil pipeline tariffs are regulated by §3.66. Regulations regarding the connection of unconnected persons to common carrier crude oil pipelines are found in §3.67 and §3.68.

RRC does not appear to be as active in regulating liquid pipeline transportation as it is with natural gas pipeline transportation, especially with regards to rate regulation. This lower level of regulation is probably due, in large part, to three factors. First, the safety concerns that are inherent in gas pipelines are not as severe in liquid pipelines. Second, the economic impact of gas pipeline operations on the energy industry is much more critical to the well being of the citizens of Texas than that of liquid pipeline operations. Finally, RRC is committed to preventing wasteful, inefficient pipeline operations. By avoiding over-regulation of either pipeline safety or operations, RRC probably seeks to allow the market economy itself to regulate efficiency wherever possible.

The construction of new pipelines is also partly regulated in Texas by RRC. Rule §3.65 of Chapter 3 or Part 1 of Title 16 of the Texas Administrative Code requires that all pipelines transporting oil, gas, or geothermal resources from any tract of land in Texas must have a permit that is granted by RRC. This permit is granted when RRC is satisfied that the pipeline in question, whether existing or proposed, will minimize the possibility of waste and will be operated in accordance with appropriate conservation laws, rules, and regulations. Pipelines over which RRC does not have jurisdiction include offshore interstate lines, onshore interstate lines, and flow-lines from wells and unmingled gathering lines, with the exception of sour gas lines.

Chapter 7 of Title 16, Part 1 of the Texas Administrative Code also contains RRC rules. These rules cover the Gas Utilities Division and include regulation for gas distribution including such items as safety, transportation, rates charged for gas in Texas, accounting, record keeping, and leaks.

Texas General Land Office

The Texas General Land Office also plays a role in pipeline operations on state lands. GLO has the authority to grant easements for pipeline placement on state lands. While GLO is not required to grant easement, it will almost always grant easements if the appropriate provisions are met. This authority is given for all upland state properties, approximately 90 percent of which are west of the Pecos River, and for most coastal and tidal properties for up to nine nautical miles from shore, with exceptions of navigation districts and other areas as specifically designated by statute.

Requirements for maintaining a lease granted by GLO can be found in 31 TAC Part 1 Chapter 9, Rule §9.32, and include the requirements for conducting operations and compliance with "...all valid, applicable federal and state laws, regulations and rules" for designing, constructing, treating, testing, maintaining and repairing pipelines." The requirements for easement applications are contained in 31 TAC Part 1 Chapter 13, Rule §13.12 for granting of right-of-way over public lands. The requirements include provisions for submerged and upland pipelines, including:

- For pipeline easements on state-owned submerged land, there are burial criteria including "...at a depth not less than 24 inches or place on a structure of sufficient height to insure reasonable safety from sustaining flood damage," and requirements for pipeline materials, testing, environmental protection, and safety.
- For pipeline easements on state-owned upland, there are burial criteria including "...at least 24 inches below the surface and construct the same so as not to interfere with the use of the land for the grazing of livestock or for farming in the usual manner," requirements for brush clearing and wildlife cover placement, and "...to

minimize clearing so as to leave a screen of natural vegetation where the right-of-way crosses a highway."

31 TAC Part 1 Chapter 16 for Coastal Protection covers water dependent facilities, including "...offshore pipelines...below mean high water." 31 TAC Part 1 Chapter 19 includes Oil Spill Prevention and Response Program requirements. Facilities defined in §19.2 include pipelines used for handing oil and combinations of pipelines, gathering lines and flow lines under common ownership. Spill response requirements are provided in §19.33, including the requirement that "In the event a discharge appears to be from a facility for the exploration, development, or production of oil or gas or from an oil or gas pipeline, a Railroad Commission designee shall act as the state on-scene coordinator for spills of 240 barrels or less. When the spill exceeds 240 barrels, it is the responsibility of the GLO to provide the state on-scene coordinator."

The language of 31 TAC Part 1 Chapter 9, Rule §9.32 regarding compliance with "...all valid, applicable federal and state laws, regulations and rules" is particularly noted. With regards to its activities, the GLO does not enforce the requirements of other agencies and authorities; it only grants easement over state properties. Thus pipelines that are located on GLO easements are subject to requirements of RRC and other state and federal agencies, as applicable. Other rules applicable to GLO, including those covering pipelines and pipeline facilities, may be found in 31 TAC Part 1.

Other State of Texas Agencies

Certain aspects of new pipeline construction, existing pipeline operation, or pipeline upgrade and change-of-use plans may be regulated by agencies such as the Texas Natural Resource Conservation Commission. For example, when a proposed pipeline facility will serve as a source of air contaminants, it must receive authorization from TNRCC. TNRCC regulates emissions to the air, water, and ground. TNRCC regulations are contained in Title 30 of the Texas Administrative Code.

Other Texas agencies may be designated with authority over pipelines by various statues and regulations. For example, the Texas Health and Safety Code Chapter 753 – Flammable Liquids requires that pipelines connecting service stations with bulk plants have safety valves. TNRCC is responsible for inspection of this provision, while the State Fire Marshal is responsible for its enforcement.

Pipeline Safety and the Underground Facility Damage Prevention and Safety Act

Major pipeline accidents have resulted in significant publicity at the national level regarding pipeline safety and operations. Recently, the *Wall Street Journal* published an article that discussed the August 2000 explosion of the El Paso Corp. natural gas pipeline, which killed 12 people in Carlsbad, New Mexico, and a June 1999 gasoline pipeline leak in Bellingham, Washington, that resulted in an explosion and the death of three people. The *Journal* cites both the energy industry and pipeline regulators with blame for pipeline accidents:

> "...a corroded 30-inch-wide steel pipe is as much the symptom as the cause. The U.S. agency that inspects pipelines, federal officials say, lacks trained manpower, reliable data on accidents and the will to crack down on unsafe practices before deadly blasts occur. The pipeline industry has resisted calls from the National Transportation Safety Board and others for mandatory periodic inspections of pipelines and national employee training standards. Meanwhile, the nation's pipelines continue to age, many of them now more than 50 years old and too narrow to accommodate the probes sent through pipes to inspect them internally for defects." (21)

In general, modern-day pipeline construction technologies and methods are far superior to those of a few decades ago. However, the infrastructure of aging pipeline networks is extensive, resulting in continually increasing public risks as pipelines corrode and populations expand. Pipeline safety problems are exacerbated by accidental third party damage that degrades the integrity of pipeline structures and can greatly increase the rate of pipeline failure.

The Underground Facility Damage Prevention and Safety Act, found in Chapter 251 of the Texas Utilities Code, has established requirements for excavators and operators for underground facilities, including "Class A" underground facilities that include those "...used to produce, store, convey, transmit or distribute" natural or synthetic gas and petroleum or petroleum products. The Act also established the "One-Call" program, managed by a notification center that is to coordinate the exchange of information between excavators and operators regarding location of underground facilities.

Participation of excavators is required by Section 9 of the Act, § 251.151: "...a person who intends to excavate shall notify a notification center not earlier than the 14th day before the date the excavation is to begin or later than the 48th hour before the time the excavation is to begin," with certain exceptions for weekends and holidays. The notification center then coordinates information exchange as described by § 251.153(c): "Not later than two hours after the time the notification center receives a notice of intent to excavate from an excavator or from a different notification center, the notification center shall notify each member operator that may have an underground facility in the vicinity of the proposed excavation operation."

Participation of facility operators is covered in Section 7 of the Act, § 251.107:

(a) Each operator of a Class A underground facility, including a political subdivision of this state, shall participate in a notification center as a condition of doing business in this state.

(b) Each operator of a Class A underground facility shall provide to the notification center:

  (1) maps or grid locations or other identifiers determined by the operator indicating the location of the operator's underground facilities;

  (2) the name and telephone number of a contact person or persons; and

  (3) at least quarterly but, if possible, as those changes occur, information relating to each change in the operator's maps or grid locations or other identifiers or in the person or persons designated as the operator's contact person or persons.

(c) The notification center may not require an operator to conduct a survey of the operator's underground facilities or alter the operator's existing signage.

(d) A notification center may not disseminate, make available, or otherwise distribute maps or information provided by an operator unless that action is necessary to perform the notification center's specific obligations under this chapter.

As defined in § 251.157 "...each Class A underground facility operator contacted by the notification system shall mark the approximate location of its underground facilities at or near the site of the proposed excavation if the operator believes that marking the location is necessary." Complicating this issue is the fact that the precise location of known pipeline systems is uncertain. The available GIS location data for many areas in the state of Texas is at best +/- 50 feet, and for most of the state is probably closer to +/- 500 feet. In addition, the locations of some of the oldest pipelines, most of which are inoperational, may have been lost from both private and public record.

Improvements to location discrepancies are not facilitated by § 251.107(c), which states: "The notification center may not require an operator to conduct a survey of the operator's underground facilities or alter the operator's existing signage." The ability to accurately document and locate Texas' aging pipeline infrastructure is likely to be problematic as degradation of these pipelines continues and populations continue to expand into previously rural areas.

Section 3 of the Act defines exemptions to One-Call requirements. Notably, the Texas Department of Transportation is exempted from certain One-Call requirements, defined as follows:

(c) The provisions of this Act are inapplicable to contractors working in the public right-of-way pursuant to a contract with the Texas Department of Transportation.

(d) Excavation by an employee of the Texas Department of Transportation on a segment of the state highway system is not subject to this Act, provided that such excavation is:

(1) less than 24 inches in depth; and

(2) no more than 10 feet from the right-of-way line.

Texas Department of Transportation

Currently, the Texas Department of Transportation does not play a significant role in the state's regulation of petroleum and gas pipeline safety or operations. Although TxDOT's mission statement refers to the desire to provide safe, effective, and efficient movement of people and goods in general, the precedent for pipeline regulation in Texas lies with RRC. This precedent is extensive, and RRC has an established pipeline regulatory program. Currently, RRC carries out the bulk of state-level regulation of pipeline safety and operations. Some environmental and health-related regulation is performed by other state agencies, such as TNRCC.

There is certainly a potential for currently unregulated aspects of pipeline safety or operations to be regulated by TxDOT given TxDOT's mission statement. For instance, intermodal truck-pipeline facilities and operations might be regulated more than they currently are. In fact, regulation of all aspects of pipeline safety and operations could certainly be expanded. However, it is not clear whether broad changes in regulation, such as TxDOT assuming a lead role in pipeline regulation, are appropriate.

While some aspects of pipeline safety and operations are currently unregulated in Texas, this under-regulation is probably not due to a lack of a well-evolved, relatively complete regulatory scheme. In fact, even as broad areas of pipeline safety and operations are unregulated, certain seemingly unimportant details are heavily regulated by RRC. Although it could be argued that aspects of existing regulations have problems and need revision, over-regulation can interfere with efficiency and even harm the public well being. Also, regulation by multiple agencies can unduly complicate matters.

TxDOT does have authority over where pipelines are located in department right-of-way. 43 TAC Part 1 Chapter 21 contains requirements for utility accommodation, including public and private systems. Pipeline locations in highway right-of-way are subject to approval by local district engineers. Public utilities and agencies, including common carrier pipelines, are authorized to locate lines "...along and/or across highway right-of-way," while private lines "...should normally be allowed to cross, but not be permitted longitudinally on highway right-of-way." With respect to right-of-way, there are additional rules for location, general design criteria, aesthetics, safety, general rules for pipelines, specific rules for high-pressure gas and liquid petroleum lines, and specific rules for low-pressure gas lines.

With these considerations in mind, the fact remains that TxDOT infrastructure is impacted (to an unknown extent) by commodities transported through the pipeline system and other transport modes that interface with pipelines, yet TxDOT is currently limited in its ability to impact the pipeline system. Texas' pipeline network is extensive, and often even pipeline companies do not know exactly where they all are, their age, or condition. The public is subjected to increasing risks associated with continued operation of aging pipelines.

It is possible that TxDOT could successfully assert a broader role in pipeline regulation, especially one that pertains to their mandate to coordinate the overall transportation system within the state. For example, intermodal truck-pipeline facilities and operations might be regulated in some fashion regarding operational times or reporting requirements. However, careful planning and consideration is required to ensure that any authoritative action by TxDOT relative to pipelines is in the public interest.

PIPELINE INDUSTRY PERSPECTIVES

AIChE 2001 Spring Meeting and PetroExpo

Members of the research team participated in the American Institute of Chemical Engineers 2001 Spring National Meeting and PetroExpo that was held in Houston, Texas, in April 2001. A researcher from TTU presented a paper at the technical session on "Transportation Safety – Safe Transportation of Hazardous Materials by Pipeline, Truck, Railroad, and Marine Vessels." The subject of the paper and presentation was the *State of the Art Analysis of Current Research Trends in Pipeline Safety*. Appendix D provides copy of the paper presented at the conference.

Research for the paper and presentation focused on identification of the current state of pipeline research using an analysis of trends and models. TTU researchers believe that such research is fundamental to further research in pipeline safety because it allows for identification of historical research topics and the attention given such topics by industry, government, and media. This session discussion presented the research topic relative to pipeline safety issues of contributions and limitations of technology advances, identified problems, and research demands and needs.

Another paper was presented regarding evaluation of transient pressures in pipeline systems. Transient pressures result from momentary disruptions in pipeline operations and may result in exceedence of allowable pressures in the pipeline system. This is particularly pertinent to pipeline systems that have undergone changes to operating parameters from which the system was originally designed for, such as changes in commodity or flow rates. Methods by which transient pressures are determined relative to analytical software was presented and discussed.

In addition to pipeline-specific presentations, industry experts made presentations regarding the transportation of petroleum and chemical commodities by other modes. Discussed were methods of evaluating risk in commodity transport by various modes, including pipeline. Sources of risk were identified in addition to tools used to identify and quantify risk. Another presentation focused on methods by which hazardous material carriers can reduce risk. Case histories of commodity transport accidents and methods of improving commodity transport were also discussed. The perspective of emergency response personnel relative to commodity transport incidents and incident planning methods were presented.

The discussions at the session were principally from an industry perspective, and the researchers discussed with the session participants whether and how commodity transport impacts risk identification and planning in the public sector. It was generally concluded that, in the experience those consultants and industry representatives who presented at the session, such planning activities are often lacking or accounted for at only qualitative levels, at least at municipal and regional levels, and vary among state agencies.

In addition to participating in the AICHE conference, TTI researchers developed contacts with an array of pipeline industry experts and resources. These included officials with the US Department of Transportation's Office of Pipeline Safety, pipeline industry suppliers, pipeline company employees, and consultants. Based on interviews and discussions with industry experts, the following section summarizes industry perspectives on pipeline operations and the business environment. Industry perspectives regarding the role of state agencies in pipeline operations and oversight are discussed in Chapter 8 of this report.

Additional Considerations

The pipeline transmission network in the U.S. transports vast quantities of commodities, both liquid (petrochemical) and gaseous (natural gas), safely and inexpensively. Pipelines are major investments in both initial capital outlay for materials and time to construct the system. Pipelines provide very small margins on the individual units of transportation; to be profitable, pipelines need to supply large quantities of product on a continual basis.

Because of the large investments required and the small profit margins, the private investment community requires a substantial market commitment from pipeline customers; that is, investors want to see very long term and stable conditions for pipelines, a 50 year supply of product at or very near the origin, and a perpetual customer base along the route of the pipeline. The stable criteria needed to attract investment capital is absolutely consistent with the lowest operating cost design for pipelines, that is, one-way flow from source to market. This basic view, if violated by the builder, will ultimately lead to the financial failure of the pipeline.

The competitive business environment, private nature, and the drive for cost minimization and revenue maximization of pipeline companies creates a dynamic within the industry that tends to optimize the factors that determine business survival with respect to the reciprocal goals of stable operating conditions and lowest operating cost. Considerations such as minimizing network transmission distances, energy use, and maintenance expenditures, coupled with maximizing tons of commodity transported for the highest price determine how companies fare in the competitive marketplace of pipeline transmission.

CHAPTER 6 - PIPELINE UTILIZATION

INTRODUCTION

Pipelines are an essential, yet largely unseen, element of the transportation system. The volumes of commodities transported through pipelines would otherwise require massive amounts of highway, rail, and waterway transportation infrastructure and vehicles. The information that is reported regarding pipeline commodity transport is largely confidential, and that which is not confidential is often of limited value to the public at the state level in determining critical issues of specific condition, capacity, or efficiency of particular pipeline companies. Rather, they are most useful for painting a broad picture of the industry as a whole.

Report 1858-1 and this report have covered an overview of the pipeline system characteristics, identified a knowledge base of the pipelines, including pertinent literature and information sources, the extent of Texas pipeline network and its connections with other transportation modes, reviewed the state and federal regulatory framework for pipeline safety and operations, and discussed the perspectives of the pipeline industry. In summary, the Texas pipeline network and associated industry is large, complex, and most significantly, private.

A general review of pipeline system characteristics has been presented for natural gas and crude and petroleum product lines. Crude gathering and transmission lines represent the smallest fraction of pipelines in Texas. Because of product contamination issues, these lines are restricted to crude oil and unrefined products transportation. Natural gas gathering, transmission, and distribution operations represent the largest fraction of pipelines in Texas. There is little opportunity for alternative product transport in these lines.

Product lines are currently configured to handle a wide variety of petroleum products in slugs or batch transmission. However, there are few allowances for product lines to readily flow in the opposite direction from which they are designed to flow. The problem of changing direction for typical gas and petroleum pipelines includes such engineering problems as reversing the compressor systems' inlets and outlets in pipes of incompatible size or analyzing impacts of differential pressure changes throughout the reconfigured pipeline system. Therefore, direction reversal does not usually present an economic opportunity for pipeline operation.

UTILIZATION TRADE-OFFS

This research has assumed that an intensely competitive business environment dictates that pipeline companies are likely utilizing available infrastructure and capacity to the extent that is economically practical. It has also been shown that what may appear to be excess capacity in pipeline networks and storage facilities is actually necessary for maintaining operation of the pipeline system. Further, technological and commodity-specific issues do not lend themselves to simply transferring commodities from other transportation modes to abandoned pipelines, or reversal of flow directions by just flipping some switch. Rather, this involves detailed engineering assessments.

A recommendation to increase the utilization of pipelines is thus to minimize the restrictions placed on pipeline companies only to the point of ensuring efficient competition. However, this must be balanced with the other side of the business model – the premise that pipeline companies will comply with environmental and public welfare regulations only as necessary. Therefore, a careful assessment of the effectiveness of pipeline safety regulations relative to public and environmental well-being is critical. With regard to maintaining safety and effective operations of Texas' pipelines, those agencies with industry expertise and regulatory authority over pipelines and pipeline companies should be sure to allocate adequate resources to allow for consistent and comprehensive regulatory enforcement as defined by state and federal rules and legislation.

CHAPTER 7 - POTENTIAL NEW ROLES AND RESPONSIBILITIES FOR TXDOT RELATIVE TO PIPELINE TRANSPORTATION

In addition to establishing the industry's characteristics, location, and dynamics, a key question posed in the current research was, "What, if any, additional roles might there be for State of Texas agencies that would better capitalize on the strengths of pipeline transportation for the benefit of Texas?" The state's other transportation modes, highways, waterways, and railroads each have strong points and serve the transportation sector in a unique way. However, as transportation expenditures are stretched to meet the ever-growing needs of Texas, greater demands are placed on every mode. From a public policy perspective, the balance and optimization of each mode becomes increasingly important, as does the efficient interconnection between modes.

Two key questions that speak to this issue are:

1. Is there a role for State of Texas agencies beyond that role already defined in the safety / regulatory arena?
2. Are there transportation benefits to be realized by greater coordination between state transportation planners and pipeline companies?

PIPELINE INDUSTRY PERSPECTIVE ON STATE AGENCY PARTICIPATION

During the course of this research, TTI developed contacts with an array of pipeline industry experts and resources. These included officials with the U.S. Department of Transportation's Office of Pipeline Safety, pipeline industry suppliers, pipeline company employees, and consultants. Based on interviews and discussions with industry experts, the following observations can be made relative to the question of an increased role for Texas state agencies in pipeline transportation,

As a private, regulated industry, pipeline operators must attune to the prescriptive safety guidelines established by state and federal authorities to avoid penalties for non-compliance. While safety regulations establish the context and define the limits of construction, operating, and maintenance practices for pipeline operations, they do not alter a fundamental priority found within most companies – profit maximization. Profit maximization naturally creates the conditions that emphasize cost control and reduction measures and, unless otherwise provided for by internal or external forces, these measures may unintentionally compromise safety.

In most industries that require the monitoring and control of working conditions and operations to ensure public and employee safety, there is a regulatory role for government through regulatory agencies. This is true of aviation and rail transportation, and it is certainly true of the pipeline industry. Given the hazardous nature of the commodities transported in the nation's pipeline network and the increasingly common proximity of pipelines to highly populated areas, public safety requires scrutiny and oversight. This regulatory role often places the public sector in juxtaposition to the industry it oversees. Anytime fines or penalties are involved for non-compliance, there develops a natural contention between the parties. This is true even when the industry concedes that it is in their best interest to operate as safely as possible.

Pipeline systems operate in a competitive marketplace, seeking to maximize profit for the transportation service they provide. This profit-maximization motive includes an implicit drive to minimize the costs associated with construction, operation, and maintenance of the system. The profit motive (and cost minimization) has the effect of optimizing the use of a pipeline network by focusing employees on the detail of the operation and eliminating unnecessary elements, procedures, or practices. Given this reality, there seems to be very little room for an active role by state agencies in day-to-day pipeline operations.

University-Based Pipeline Safety and Operations Research Consortium

It is the pipeline industry's consensus that ample oversight is provided under the current regulatory environment, and additional interaction with government is not particularly desirable. However, our discussions with industry principals indicate there would be industry support for a publicly funded, university-based consortium dedicated to research pertaining to pipeline safety and operations. Such a consortium could serve to accelerate the rate at which technological innovation is introduced to the pipeline transportation industry by directly engaging top researchers and scientists from a variety of engineering disciplines in pipeline safety issues. It could catalog and communicate key industry needs and goals to researchers who would then seek to apply the latest advances in safety technologies to pipeline's needs in order to enhance system integrity, improve system reliability, and elevate system safety.

ROLES FOR STATE OF TEXAS AGENCIES

Current Situation

Currently, the Railroad Commission of Texas has state-level jurisdiction over pipeline safety and operations in Texas. In cases where federal regulations do apply to intrastate pipelines but allow a certified state agency to enforce the regulations, RRC is also the certified state entity in Texas. Certain aspects of new pipeline construction, existing pipeline operation, or pipeline upgrade and change-of-use plans may be regulated by other agencies such as GLO or TNRCC.

As described previously, TxDOT does not currently participate significantly in the state regulation of petroleum pipelines. Although TxDOT's mission statement refers to the desire to provide safe, effective, and efficient movement of people and goods in general, the precedent for pipeline regulation in Texas lies with RRC.

State Agencies Other Than TxDOT

As discussed previously, while some aspects of pipeline safety and operations are currently unregulated in Texas, this under-regulation is probably not due to a lack of a well-evolved, relatively complete regulatory scheme. Although it could be argued that aspects of existing regulations have problems and need revision, over-regulation can interfere with efficiency and even harm the public well being. Also, regulation by multiple agencies can unduly complicate matters. With regard to maintaining safety and effective operations of Texas' pipelines, those agencies with industry expertise and regulatory authority over pipelines and pipeline companies should be sure that adequate resources are allocated to allow for consistent and comprehensive regulatory enforcement as defined by state and federal rules and legislation.

Potential Roles and Responsibilities for TxDOT

It is possible that TxDOT could successfully assert a broader role in pipeline regulation, particularly with regard to coordinating pipelines' interactions with other transportation modes in the state of Texas. In doing so, TxDOT may be able to address some of the impacts of pipelines on transportation infrastructure in conjunction with the Texas RRC or other agencies. For example, intermodal truck-pipeline facilities and operations might be regulated in some fashion regarding operational times or reporting requirements.

Given the potential to affect the private business of pipeline companies and at the same time the public and environmental well-being, any pipeline regulatory authority or agency oversight role for TxDOT should be very carefully considered. The following have been identified as areas for potential involvement by TxDOT in pipeline transportation of natural gas and petroleum commodities.

Monitor the Impact of Trucks on State Roadways at Wells and Terminals

Truck traffic on rural Texas highways increases damage to those highways. In areas with many operational crude-oil wells, tanker trucks often removed the crude from the wellhead storage tanks. Significant damage may take place over a short period of time to roadways and highways that lead to heavily producing wellheads, resulting in direct impacts to TxDOT's roadway maintenance budget. Because of the nature of oil drilling operations, these wellheads may produce at varying rates for unspecified lengths of time. Transportation planners may have difficulty accounting for the cost and scheduling of maintenance activities that are required as a result of such traffic.

Currently, transporters are required to report pick-up and delivery information on a monthly basis to RRC using T-1 forms. This public information includes field, operator and lease identification, and volumes received and delivered. The lease identification information could be cross-referenced against publicly available lease location information to determine the location and monthly throughput of leases having access to Texas roadways and highways.

The reporting requirements do not include provisions for reporting detailed travel log information such as exact routes taken. While an "optimal routing analysis" might be performed to describe the route that would likely be used by drivers between pickup and delivery of wellhead crude, many drivers do not travel directly between wellhead and the delivery locations, except for the largest producing wells. A driver might visit a number of different wellheads before making delivery.

Modifications to existing reporting requirements to detail routes taken might provide additional detail regarding which locations are visited, how often, and what state roads are utilized by trucks. While this might meet with resistance from truck drivers because it would add to their record-keeping requirements, it would not have to be overly burdensome to be of value.

Alternately, TxDOT may wish to consider additional study pertaining to the economic operating radius of petroleum product distribution trucks around pipeline terminals, as discussed previously in this report. Local truck traffic shifts due to changing terminal pricing shifts should be available so that TxDOT planners can act in a predictive mode rather than a reactive state. Information from wellhead servicing vehicles or development of a terminal economic radius model could be used as follows:

- Assist in scheduling repairs and assessing infrastructure lifetime with knowledge of the extent of well-head truck traffic.
- Help in determining what costs result from operation of wellheads that have access to the state highway system.
- Provide a measurement system useful for recovering costs associated with wellhead operation (say, as a fee for certain classes of tanker trucks that operate at wellheads, or in a cost per volume fee).

Assess Modification of Private Well Systems to Mitigate Truck Traffic

As mentioned, truck traffic for servicing crude oil wellhead storage tanks results in damage to the Texas highway system. One method to reduce this traffic is to require that wellheads and storage tanks that are within a certain proximity to one another all be linked by pipeline to a central storage site. This would result in reduced tanker truck traffic to a larger number of wellheads and confine the traffic to certain corridors. This would reduce costs by mitigating damages to roadways over a large area, confine the damage to certain corridors, and assist in roadway maintenance planning activities.

Continue Development of an Accurate GIS-Based Pipeline and Facilities Location Database

As discussed previously, the GIS database of pipeline locations continues to evolve. The current database of the Texas pipeline network, initially provided by the Texas Railroad Commission, has been integrated with other surface transportation networks. The location of facilities with pipeline connections to other transportation modes also been added to the database.

TxDOT engineers and planners have expressed interest in an accurate GIS database of the Texas pipeline network. In its current form, the accuracy of the database is limited to +/-50 feet in some areas, and is no greater than +/- 500 feet in most. However, TxDOT can work with RRC to maintain the GIS database and continue to update it regarding pipeline locations found during maintenance or construction activities. The agency can also coordinate with RRC to integrate the most up-to-date information regarding location of new pipeline alignments or updates to locations of existing alignments, or through any survey efforts undertaken by TxDOT. In addition, TxDOT can continue the effort to document the location of pipeline interconnection facilities.

Further Assess Potential for Commodities Shift

Report 1858-1 discusses that commodity transfer to pipelines from other transportation modes faces operational and infrastructure limitations. Pipelines are designed to accomplish a specific transportation mission with respect to a specific commodity and market. The range of substances transported through a particular system is, therefore, limited to a generally related class of materials that has close physical and chemical similarities.

While the confidentiality of pipeline throughput data restricts the ability for evaluating potential for commodity transfer, both technical issues and an intensely competitive business environment dictate that pipeline companies are likely utilizing available infrastructure and capacity to the extent that is economically practical. While this leads to the conclusion that the competitive business practices of pipelines results in little excess capacity for commodity shift, there may be some limited potential for commodity transfer in certain aspects of the pipeline industry. This has been identified as a potential area for future study should there be significant changes in pipeline technology or business practices.

Plan for Pipeline Integration with Multiuse Freight Transportation Corridors

TxDOT can facilitate pipeline transportation to a limited, but important, extent by planning the inclusion of new transmission lines within the right-of-way of multiuse freight corridors. The inclusion of pipeline transportation in multiuse freight corridors offers the opportunity to provide significantly higher security to the pipeline, which ultimately reduces the risk of accidents involving the pipeline.

CHAPTER 8 - REVIEW OF COMPLETED WORK, RECOMMENDATIONS, AND CONCLUSION

RESEARCH REVIEW

This two-year research effort has been undertaken to assist TxDOT in its understanding of the scope of the Texas pipeline system, how it interfaces with other transportation modes, and whether the pipeline system can be further integrated in the State's transportation system. This report and Report 1858-1 present the findings of this research.

Literature Review

The literature review for this research effort has developed a comprehensive listing of national and Texas state agencies, organizations, and commercial entities involved in collecting and cataloging data regarding Texas pipelines. Also included are national and state entities that currently have a role in pipeline transportation policymaking and rules in Texas. The particular physical, business, and policy issues that have been outlined in published research have been identified, and an annotated bibliography of pertinent literature sources has been presented along with a listing of industry contacts for each area. Also included in the literature review are an overview of basic pipeline design parameters and commodity flow information.

Pipeline Network and Facility GIS Database

The Texas Railroad Commission initially provided a GIS database of the Texas pipeline network to the researchers. The database has been expanded through addition of state highway, roadway and rail networks, and locations of pipeline facilities that have connections with other transportation modes. The GIS database has been partitioned with the capability of division into individual TxDOT districts.

The research also included work toward establishing a comprehensive inventory of pipeline facilities with connections to other transportation modes. The natural gas and petroleum transport methods and infrastructures have been discussed, and petroleum storage and distribution terminals have been identified as the primary locations of pipeline interconnectivity.

Pipeline facilities with connections with other transportation modes have been identified. This work has synthesized available information from several different sources. While the level of information that was available did not permit completion of a comprehensive state-wide inventory of such facilities, it is believe that the inventory for pipeline facilities with port and waterway connections in the Houston-Galveston area is relatively complete.

On a state-wide basis, information for126 pipeline facilities has been integrated with the GIS database to show facility locations relative to pipeline, road, rail, and waterway networks. Because some of the information used in the database is proprietary, this information is not available for use by the general public. It is believed that this information represents between one-third to one-half of the pipeline facilities in Texas that have connections with other transportation modes, and that a relatively limited research effort in the near future could result in a much more complete data set for the entire state.

Pipeline Industry Operational and Regulatory Issues

Characteristics of Pipeline Operations

A general review of pipeline system characteristics has been presented for natural gas and crude and petroleum product lines. Crude gathering and transmission lines represent the smallest fraction of pipelines in Texas. Because of product contamination issues, these lines are restricted to crude oil and unrefined products transportation. Natural gas gathering, transmission, and distribution operations represent the largest fraction of pipelines in Texas. There is little opportunity for alternative product transport in these lines.

Product lines are currently configured to handle a wide variety of petroleum products in slugs or batch transmission. However, there are no allowances for product lines to readily flow in the opposite direction from which they are designed to flow. The problem of changing direction for typical gas and petroleum pipelines includes such engineering problems as reversing the compressor systems' inlets and outlets in pipes of incompatible size or analyzing impacts of differential pressure changes throughout the reconfigured pipeline system. Therefore, direction reversal does not usually present an economic opportunity for pipeline operation.

In addition, the private and intensely competitive nature of pipeline companies dictates that there is likely little excess capacity for commodity shift. Further, it has been shown that what may appear to be capacity for product storage and throughput based on facility and pipeline capacity is actually not available due to inventory and operational limitations.

State and Federal Pipeline Regulations

Safety and operation of natural gas lines are regulated at the federal and state levels, and the Railroad Commission of Texas currently has state-level jurisdiction over pipeline safety and operation in Texas. In cases where federal regulations do apply to intrastate pipelines but allow a certified state agency to enforce the regulations, RRC is also the certified state entity in Texas. Certain aspects of new pipeline construction, existing pipeline operation, or pipeline upgrade and change-of-use plans may be regulated by other agencies such as the Texas General Land Office and Texas Natural Resource Conservation Commission. The Texas Department of Transportation does not appear to currently play a significant role in the state regulation of petroleum pipelines. Although TxDOT's mission statement refers to the desire to provide safe, effective, and efficient movement of people and goods in general, the precedent for pipeline regulation in Texas lies with RRC.

Pipeline Industry Perspective

The competitive business environment, private nature, and the drive for cost minimization and revenue maximization of pipeline companies creates a dynamic within the industry that tends to optimize the factors that determine business survival with respect to the reciprocal goals of stable operating conditions and lowest operating cost. Considerations such as minimizing network transmission distances, energy use, and maintenance expenditures, coupled with maximizing tons of commodity transported for the highest price determine how companies fare in the competitive marketplace of pipeline transmission. The profit motive (and cost minimization) has the affect of optimizing the use of a pipeline network by focusing employees on the detail of the operation and eliminating unnecessary elements, procedures, or practices. Given this reality, there seems to be very little room for an active role by state agencies in day-to-day pipeline operations.

It is the pipeline industry's consensus that ample oversight is provided under the current regulatory environment and additional interaction with government is not particularly desirable. However, discussions with industry principals indicates there would be industry support for a publicly funded university-based consortium dedicated to research pertaining to pipeline safety and operations. Such a consortium could serve to accelerate the rate at which technological innovation is introduced to the pipeline transportation industry by directly engaging top researchers and scientists from a variety of engineering disciplines in pipeline safety issues. It could catalog and communicate key industry needs and goals to researchers who would then seek to apply the latest advances in safety technologies to pipeline's needs in order to enhance system integrity, improve system reliability, and elevate system safety.

Pipeline Utilization

Utilization of pipelines might be enhanced by minimizing the restrictions placed on pipeline companies only to the point of ensuring efficient competition. However, this must be balanced with the other side of the business model - the premise that pipeline companies will comply with environmental and public welfare regulations only as necessary. Therefore, a careful assessment of the effectiveness of pipeline safety regulations relative to public and environmental well-being is critical. With regard to maintaining safety and effective operations of Texas' pipelines, those agencies with industry expertise and regulatory authority over pipelines and pipeline companies should be sure that adequate resources are allocated to allow for consistent and comprehensive regulatory enforcement as defined by state and federal rules and legislation.

Potential New Roles and Responsibilities for TxDOT

TxDOT may be able to play some role in coordinating pipelines' interactions with other transportation modes in the state of Texas, in conjunction with the Texas RRC or other agencies. The following have been identified as areas for potential involvement by TxDOT in pipeline transportation:

- monitoring the impact of trucks on state roadways at wells and terminals,
- assessing modification of private well systems to mitigate truck traffic,

- participating in the development of an accurate GIS-based pipeline and facilities location database,
- investigating further the potential for commodities shift with a change in technological and business practices, and
- planning for pipeline integration with multiuse freight transportation corridors.

CONCLUSION

The pipeline industry is a very private and very competitive business environment. Given the industry's overriding goals of cost minimization, revenue maximization, and pipeline network optimization, there seems to be very little room for an active role by state agencies in day-to-day pipeline operations. Unless otherwise provided for by internal or external forces, these measures may unintentionally compromise safety, thus creating a role for regulatory oversight of pipeline safety and operations at the state and federal levels.

The Railroad Commission of Texas currently has state-level jurisdiction over pipeline safety and operation in Texas. In cases where federal regulations do apply to intrastate pipelines but allow a certified State agency to enforce the regulations, RRC is also the certified state entity in Texas. The RRC has developed a GIS database that shows pipeline locations and includes liquid and gas transmission, gathering, and flow pipelines under RRC's jurisdiction. Positional accuracy of +/- 500 feet for pipeline locations has been attempted by the RRC efforts; however, the spatial accuracy of the pipeline segments in the database will vary greatly by the data acquisition method or source material. Not all pipeline companies use electronic maps to inventory their pipeline systems, and, according to the RRC, very few use GIS.

One area where RRC has made efforts to increase accuracy to a very high level is around rivers and waterways where they have received federal funding to map to a +/- 3 feet level. The hazards associated with dredging, floating debris, construction, or other items or activities creating safety concerns makes understanding the locations of pipelines in river and waterway areas especially important. When completed, this information may be particularly useful to TxDOT in its function as the state sponsor for dredging activities and obtaining properties for dredged material storage areas, as applicable.

RRC provided researchers with the pipeline location GIS database. The researchers supplemented the RRC database with pipeline facility information, additional mapping layers, and TxDOT district data. Because some of the information regarding pipeline facilities was purchased under this effort from a private company, the information is considered proprietary and is not permitted for public release.

Regarding oversight of pipeline companies with regard to maintaining safety and effective operations of Texas' pipelines, the research team recommend that those agencies with industry expertise and regulatory authority over pipelines and pipeline companies should be sure that adequate resources are allocated to allow for consistent and comprehensive regulatory enforcement as defined by state and federal rules and legislation. While TxDOT's role in such oversight is currently limited, TxDOT may be able to play some role in coordinating pipelines' interactions with other transportation modes in the state of Texas, in conjunction with the Texas RRC or other agencies. Areas identified for potential involvement by TxDOT in pipeline transportation include:

- monitoring the impact of trucks on state roadways at wells and terminals,
- assessing modification of private well systems to mitigate truck traffic,
- participating in the development of an accurate GIS-based pipeline and facilities location database,
- investigating further into the potential for commodities shift with a change in technological and business practices, and
- planning for pipeline integration with multiuse freight transportation corridors.

Pipelines are certainly carriers of large volumes of commodities that are essential to local, regional, and national economies, and they serve as the principle transporters of fuels for other transport modes between their origin and distribution centers. Without pipelines, extensive demands would be placed on other land-based transportation modes. Given future anticipated demands for usage of commodities that are principally transported by pipelines, the importance of this mode to the overall transportation picture is not likely to diminish. Integral to its goals to provide safe, effective, and efficient movement of people and goods in general, it is critical that TxDOT consider the impact that pipelines have on other transport modes, and work with pipeline companies and other state agencies to maintain effective and safe operation of pipeline networks.

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APPENDIX A – GIS FILE METADATA

SECTION I. TEXAS PIPELINE SYSTEM AND PIPELINE INTERMODAL CONNECTIONS OVERVIEW

Pipelines are a major transporter of commodities not only in Texas, but also in the entire United States. According to the 1997 Commodity Flow Survey, over 22 thousand tons of commodities were moved via pipeline in the U.S. A modal breakdown indicates that pipelines transport almost a quarter of the commodities moved, second to only trucks with 50 percent. The total pipeline mileage in Texas approaches 270,000 miles, which represents as much as 17 percent of the total pipeline mileage in the U.S. and links many segments of the country with energy sources located on the Gulf Coast.

The critical role of pipeline transportation, and the largely unseen nature of the system, makes it increasingly important for TxDOT to understand the scope of pipeline operations and relationship to other modes of transportation. Knowledge of the location and interaction dynamics of pipelines with other forms of transportation is essential for TxDOT to be able to plan and execute transportation improvements in the future. The products of this research, including reports and GIS databases, are designed to provide TxDOT with an understanding of the location, function, and inter-connectivity of the State's pipeline system.

This document describes the two GIS databases created for TxDOT Research Project 0-1858, *The Value of Pipelines to the Transportation System of Texas*. The GIS databases represent Research Product 1858-P1.

The two GIS databases are:

1) Texas Pipeline System, and
2) Texas Pipeline Intermodal Connections.

SECTION II. TEXAS PIPELINE SYSTEM

1. File Description

The Railroad Commission of Texas (RRC) created the Texas Pipeline System GIS database by acquiring digital data from pipeline companies and incorporating data through research, data collection, and data transformation.

The following sections describe the state-level efforts by the RRC and national efforts by the U.S. Department of Transportation (USDOT), Office of Pipeline Safety (OPS).

Railroad Commission of Texas

The RRC developed the statewide pipeline GIS database that includes liquid and gas transmission, gathering, and flow pipelines under their jurisdiction. Additionally, the RRC has completed an agreement with OPS to become the state repository for Texas' interstate pipelines, nearly 80,000 miles in length.

The database acquired from the RRC for this project currently includes over 210,000 miles of inter- and intrastate pipelines. Estimates indicate Texas contains over 270,000 miles of pipelines, of which 80,000 cross into bordering states. Continuing efforts by the RRC will increase the amount of information and degree of accuracy of the initial data and add information on the remaining pipelines.

U.S. Department of Transportation – Office of Pipeline Safety

An effort to create a national pipeline GIS is currently being undertaken by the USDOT Office of Pipeline Safety and is titled the *National Pipeline Mapping System* (NPMS). For the NPMS, pipeline operators contribute data voluntarily to either a state repository or the national repository. As stated previously, the RRC is the Texas state repository. The purpose of the NPMS is for tracking all natural gas transmission pipelines, hazardous liquid trunklines, and LNG facilities in the United States for use in assessing the risks associated with the Nation's liquid and gas pipeline infrastructure.

Accuracy

Positional accuracy of +/- 500 feet has been attempted for both the RRC and NPMS efforts. The spatial accuracy of the pipeline operators' submissions and other available sources dictate the actual positional accuracy. For the NPMS, positional accuracy is designated in categories ranging from "Excellent" (within 50 feet) to "Poor" (501-1000 feet). The Railroad Commission does not provide incremental accuracy levels in any publications or the pipeline database.

Coordinate System

Projection: Geographic
Units: Decimal Degrees
Datum Name: North American Datum 1983 (NAD83)
Ellipsoid Name: GRS1980

File Format

Files developed by TTI and submitted to TxDOT are in the Environmental Systems Research Institute (ESRI) shape file (.shp) format created in the ArcView Version 3.2a software package.

File Naming Convention – Pipeline polylines

1) Statewide Pipeline System: Pipeline_State.shp; .shx; .dbf; .prj

2) Pipeline System by TxDOT District: Pipeline_<TxDOT District Abbreviation>.shp; .shx; .dbf; .prj

TxDOT District Abbreviations:

- ABL – Abilene
- AMA – Amarillo
- ATL – Atlanta
- AUS – Austin
- BMT – Beaumont
- BWD – Brownwood
- BRY – Bryan
- CHS – Childress
- CRP – Corpus Christi
- DAL – Dallas
- ELP – El Paso
- FTW – Fort Worth
- HOU – Houston
- LRD – Laredo
- LBB – Lubbock
- LFK – Lufkin
- ODA – Odessa
- PAR – Paris
- PHR – Pharr
- SJT – San Angelo
- SAT – San Antonio
- TYL – Tyler
- WAC – Waco
- WFS – Wichita Falls
- YKM – Yoakum

2. Railroad Commission of Texas Digital Map Information User's Guide

RAILROAD COMMISSION OF TEXAS

INFORMATION TECHNOLOGY SERVICES DIVISION

USER'S GUIDE

DIGITAL MAP INFORMATION

PUBLICATION NUMBER: OGA094

PUBLISHED BY THE
RAILROAD COMMISSION OF TEXAS
P.O. BOX 12966
AUSTIN, TEXAS 78711

The Information Technology Services Division (ITS) developed this publication for the general public in response to inquiries concerning the availability of digital map data. Any request for assistance with using the manual will be given every consideration.

First Edition: January 2000

The Railroad Commission of Texas complies with Federal, and State laws applicable to race, religion, national origin, sex, and disability. Information is available upon request by calling (512)463-7288 or 1-800-735-2989 if special assistance is required.

Publication Number: OGA094

TABLE OF CONTENTS

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I. GENERAL INFORMATION

IDENTIFICATION

Developed For:	Users of RRC Mapping Information
By:	RRC of Texas, Information Technology Services Division, Hope Morgan, Dir.
Computer:	Digital Alpha Workstation, UNIX 4.OD Operating System

OUTPUT MEDIUMS

The Digital Well Location Mapping information is available for output onto the following mediums:

CD-ROM (Compact Disk)
FTP (File Transfer Protocol)

TAR and GZIP

The Railroad Commission uses the UNIX commands TAR and GZIP on all GIS export files. TAR, an acronym for "tape archiving", is commonly used to combine – or "archive" -- two or more files for storage or distribution. The RRC uses GZIP to compress TARed files.

RRC GIS data files can be uncompressed and unarchived on UNIX operating systems with the following commands:

```
gunzip <file_name>.tar.gz
tar xf <file_name>.tar
```

The Railroad Commission has successfully uncompressed and unarchived GIS export files using WinZip 6.3 and PKZip 2.6 on an IBM-compatible PC. It is assumed more recent versions of both WinZip and PKZip retain their previous extract capabilities.

Once the original RRC GIS digital data file is uncompressed and unarchived, the user will have all requested data layers in the appropriate format for a particular county or USGS quadrangle.

Disk Size Requirements

Documentation for the UNIX command GZIP states, in part, "The GZIP command uses the Lempel-Ziv algorithm used in the ZIP and PKZIP commands. The amount of compression obtained depends on the size of the input and the distribution of common substrings." GZIP compresses the typical RRC shapefile data set 55 percent - 65 percent and .E00 files 80 percent - 90 percent. Therefore, users should expect and plan for uncompressed RRC GIS export files to occupy, depending on the export format, anywhere from 1.5 to almost twice the disk space of the compressed files.

Also, ESRI software users should be aware that ArcInfo and ArcView may require considerable amounts of free disk space to successfully execute commands. For example, ArcInfo documentation states that the CLEAN command "requires free disk space around 13 times the size of (the) <in_cover> to create temporary scratch files."

SYSTEM DESCRIPTION

The Railroad Commission of Texas exports double-precision map data from ARC/INFO version 7.2.1 mounted on a Digital Alpha workstation operated by UNIX ver. 4.0D. Exports are to Environmental Systems Research Institute's (ESRI) ARC/INFO interchange file (.E00) and shapefile (.SHP) formats.

Interchange files, used to transfer ARC/INFO coverage information amongst machines, is a fixed-length ASCII file. Each interchange file has an .E00 file extension and contains all coverage information and appropriate INFO file information.

Shapefiles, developed by ESRI for use with its ARCVIEW software, store a feature's geographic location and attribute information. The shapefile format is a collection of three different files:

<shape_file>.SHP – contains a feature's geometry.
<shape_file>.SHX – contains a feature's geometry index.
<shape_file>.DBF – contains a feature's dBase attribute information.

ESRI considers their interchange file format to be proprietary and the shapefile format cannot be adequately explained here. If necessary, users can access detailed information about both file formats at:

http://www.geocities.com/~vmushinskiy/fformats/fformats.htm

ARCVIEW shapefiles are created from the RRC's ARC/INFO map data. Features are translated from ARC/INFO to ARCVIEW in the following manner:

A/I Feature Class	A/V Shapefile Type
Points	Type 1 – Point
Tic	Type 1 – Point
Node	Type 1 – Point
Arcs	Type 3 – Line
Polygons	Type 5 – Polygon
Region	Type 5 – Polygon
Annotation	**NOT SUPPORTED**

COORDINATE SYSTEM

MIMS: The Railroad Commission exports all map data to the Geographic projection (Latitude/longitude). The following parameters define the Geographic projection:

Projection:	Geographic
Units:	Decimal Degrees
Datum:	NAD27

Region subclasses (.PAT<subclass_name>) were not supported by ESRI prior to Rev. 7.0 and will not import into ARC/INFO versions prior to Rev. 7.0.

Annotation subclasses will import into versions prior to Rev. 6.0 but will not function the same way they do at Rev. 6.0.

PC ARC/INFO, Rev. 3.4.2D or higher, will import RRC double-precision .E00 interchange files but will create single-precision coverages.

ArcCAD 11.2 and 11.3 and versions of PC ARC/INFO prior to Rev. 3.4.2D require single-precision interchange files. Please contact the Railroad Commission for assistance.

DISCLAIMER

The digital data described in this manual was generated by the Geographic Information System of the Railroad Commission of Texas. Base map information was obtained directly from U.S. Geological Survey 7.5 minute quadrangle maps. Patent Survey lines from Texas General Land Office maps were interpreted as accurately as possible over the U.S. Geological Survey base. Oil and gas well data or pipeline data (if included) was obtained from public records of the Railroad Commission. The mapping system from which this data was extracted is currently under development. The data is intended solely for the internal use of the Railroad Commission, which makes no claim as to its accuracy or completeness.

II. DISCUSSION OF FILES

AVAILABLE MAP DATA

****
Please note that GIS feature layers may not necessarily exist in all counties or in all USGS quadrangles. If a GIS feature layer - such as railroads or government lands - does not exist in a particular county or USGS quadrangle, you will not receive a file for that feature layer. The absence of feature layers in particular counties and USGS quadrangles is already accounted for in the data pricing.
****

The digital data used to create the files was taken from the forms system within the RRC, from the General Land Office (GLO) county survey maps, and, United States Geological Survey (USGS) quadrangle maps.

ESRI's export formats are recognized and accepted industry-wide and are easily imported to and used in many GIS and CAD software packages. However, the user is responsible for confirming that their specific GIS or CAD software fully supports the importation and use of either interchange files or shapefiles.

Available digital map data layers includes:

1. Basemap:
   - a. Airports
   - b. Cemeteries
   - c. Cities
   - d. Government Lands
   - e. Political Boundaries (includes, where applicable, county, state, offshore and gulf area boundaries.)
   - f. Railroads
   - g. Roads
   - h. Ship Channels
   - i. Subdivisions
   - j. Surveys (Includes, where applicable, abstracts and bay tracts.)
   - k. Water Features
2. Wells:
   - a. Utility Well Locations
   - b. Surface Well Locations
   - c. Bottom Well Locations
   - d. For horizontal and directional wells, arcs connecting surface and bottom locations.
3. Pipelines:
   - a. Pipelines – Abandoned
   - b. Pipelines – Liquid
   - c. Pipelines – Gas

FILE NAMING CONVENTIONS

The archived and compressed files you receive from the Railroad Commission are named as follows:

If you ordered data by county:

1. The 1st letter is a "C"
2. The county FIPS code follows the initial letter.
3. If you ordered .E00 interchange files, "_e00" follows the FIPS or quad number
4. If you ordered .SHP shapefiles, "_shp" follows the FIPS or quad number
5. All files have the suffix ".tar.gz"

   Examples:

   a. Harris County exported to .E00 files: c201_e00.tar.gz
   b. County FIPS code 307 exported to .SHP files: c307_shp.tar.gz

If you ordered data by USGS quadrangle:

1. The 1st letter is a "Q"
2. The USGS quad number follows the initial letter
3. If you ordered .E00 interchange files, "_e00" follows the FIPS or quad number
4. If you ordered .SHP shapefiles, "_shp" follows the FIPS or quad number
5. All files have the suffix ".tar.gz"

   Examples:

   a. USGS quad SOUTHMOST exported to .E00 files: 597432_e00.tar.gz
   b. USGS quad number 3099142 exported to .SHP files: q3099142_shp.tar.gz

A. Exports by *County FIPS Code* to ArcInfo .E00 interchange files and *County Name* to ArcInfo .E00 interchange files:

1. Airport arcs:	air<fips_number>.e00
2. Cemetery arcs/points:	cem<fips_number>.e00
3. City arcs:	cit<fips_number>.e00
4. County Boundary arcs/polys/regions:	cty<fips_number>.e00
5. Government Land arcs:	gov<fips_number>.e00
6. Railroad arcs:	rail<fips_number>.e00
7. Road arcs:	road<fips_number>.e00
8. Ship Channel arcs:	ship<fips_number>.e00
9. Subdivision arcs/points:	subd<fips_number>.e00
10. Survey arcs/polygons/regions:	surv<fips_number>.e00
11. Water arcs/polygons:	watr<fips_number>.e00
12. Wells:	
Utility Well points:	well<fips_number>u.e00
Surface Well points:	well<fips_number>s.e00
Bottom Well points:	well<fips_number>b.e00
Surface/Bottom arcs:	well<fips_number>l.e00
13. Pipelines:	

B. Exports by *County FIPS Code* to ArcView Shape files and *County Name* to ArcView Shape files:

1. Airport arcs:	air<fips_number>.shp; .shx; .dbf
2. Cemetery arcs:	cem<fips_number>l.shp; .shx; .dbf
points:	cem<fips_number>p.shp; .shx; .dbf
3. City arcs:	cit<fips_number>.shp; .shx; .dbf
4. County Boundary arcs:	cty<fips_number>l.shp; .shx; .dbf
polygons:	cty<fips_number>a.shp; .shx; .dbf
coastal regions:	cty<fips_number>g.shp; .shx; .dbf
counties regions:	cty<fips_number>h.shp; .shx; .dbf
gulfareas regions:	cty<fips_number>i.shp; .shx; .dbf
offshore regions:	cty<fips_number>j.shp; .shx; .dbf
state regions:	cty<fips_number>k.shp; .shx; .dbf
5. Government Land arcs:	gov<fips_number>.shp; .shx; .dbf
6. Railroad arcs:	rail<fips_number>.shp; .shx; .dbf
7. Road arcs:	road<fips_number>.shp; .shx; .dbf
8. Ship Channel arcs:	ship<fips_number>.shp; .shx; .dbf
9. Subdivision arcs:	subd<fips_number>l.shp; .shx; .dbf
points:	subd<fips_number>p.shp; .shx; .dbf
10. Survey arcs:	surv<fips_number>l.shp; shx; dbf
polygons:	surv<fips_number>a.shp; shx; dbf
abstract region:	surv<fips_number>s.shp; shx; dbf
baytract region:	surv<fips_number>b.shp; shx; dbf
11. Water arcs:	watr<fips_number>l.shp; .shx; .dbf
polygons:	watr<fips_number>a.shp; .shx; .db
12. Wells:	
Utility Well points:	well<fips_number>u.shp; .shx; .dbf
Surface Well points:	well<fips_number>s.shp; .shx; .dbf
Bottom Well points:	well<fips_number>b.shp; .shx; .dbf
Surface/Bottom arcs:	well<fips_number>l.shp; .shx; .dbf

File Naming Convention For Exports By USGS Quadrangle To .E00 Interchange Files:
Exported by USGS quadrangle to .E00 interchange files comply with 8.3 naming conventions. Information about the 8.3 naming convention can be found in Appendix E.

<feature_layer_letter>{well_feature_type_number}<latitude_identifier>
<five_digit_quadrangle_number>

<feature_layer_letter>: A single letter identifying one of the 13 possible GIS data layers. This letter always occupies the first position in the shapefile name. Feature layer letters are:

a = airports	b = cemeteries	c = cities
d = boundaries	e = government lands	f = railroads
g = roads	h = ship channels	i = subdivisions
j = surveys	k = water	l = wells
m = pipelines		

{well_feature_type_number}: Only horizontal/directional arcs and utility, surface and bottom well point locations require feature type numbers. No other feature type other than wells will have a feature type number. Well feature type numbers always occupy the second position in the filename. Well feature type numbers are:

utility well points	1
surface well points	2
bottom well points	3
surface/bottom arcs	4

<latitude_identifier>: A single letter identifying one of 12 possible latitudes in Texas. This letter always occupies the second position in the shapefile name except for well .E00 interchange files, where the latitude identifier occupies the third position . Latitude identifiers are:

a = 25th latitude	b = 26th latitude	c = 27th latitude
d = 28th latitude	e = 29th latitude	f = 30th latitude
g = 31st latitude	h = 32nd latitude	i = 33rd latitude
j = 34th latitude	k = 35th latitude	l = 36th latitude

<five_digit_quadrangle_number>: The last five digits of a USGS quadrangle number.

EXAMPLES

1. Airport .E00 files are created for USGS quadrangle number 3501231. The airport file is named:

ak01231.e00
a: Is the feature layer letter for Airports
k: Is the latitude identifier for the 35th latitude – the USGS quadrangle number's first two digits.
01231: The USGS quadrangle's last five digits.

2. Cemetery .E00 files are created for USGS quadrangle number 2798112. The cemetery file is named:
bc98112.e00

b: Is the feature layer letter for Cemeteries
c: Is the latitude identifier for the 27th latitude – the USGS quadrangle number's first two digits.
98112: The USGS quadrangle's last five digits.

3. Bottom well location .E00 files are created for USGS quadrangle number 3294321. The bottom well location file is named:
l3h94321.e00

l: Is the feature layer letter for Wells

3: Is the feature type number for Bottom Wells
h: Is the latitude identifier for the 32nd latitude – the USGS quadrangle number's first two digits.
94321: The USGS quadrangle's last five digits.

Naming Convention for Quadrangle Exports to Shapefiles: Exports by USGS quadrangle to .SHP shapefiles comply with 8.3 naming conventions. Information about the 8.3 naming convention can be found in Appendix E.

<feature_layer_letter><feature_type_number><latitude_indentifier>
<five_digit_quadrangle_number>

<feature_layer_letter>: A single letter identifying one of the 13 possible GIS data layers. This letter always occupies the first position in the shapefile name. Feature layer letters are:

a = airports	b = cemeteries	c = cities
d = boundaries	e = government lands	f = railroads
g = roads	h = ship channels	i = subdivisions
j = surveys	k = water	l = wells
m = pipelines		

<feature_type_number>: A single number identifying the feature type. Feature types are always point, line or polygon. (Shapefiles do not support annotation features.) Since feature layers may contain multiple point or polygon shapefiles, refer to the table below for specific feature type numbers for particular feature layers. The feature number always occupies the second position.

FEATURES	FEATURE LAYER LETTERS	TYPES	FEATURE TYPE NUMBERS
airport	a	arcs	1
cemeteries	b	arcs	1
		points	2
cities	c	arcs	1
boundaries	d	arcs	1
		polygons	2
		coastal polygons	3
		county polygons	4
		gulfareas polygons	5
		offshore polygons	6
		state polygons	7
government land	e	arcs	1
railroads	f	arcs	1
roads	g	arcs	1
ship channels	h	arcs	1
subdivisions	i	arcs	1

		points	2
surveys	j	arcs	1
		polygons	2
		abstract polygons	3
		baytracts polygons	4
water	k	arcs	1
		polygons	2
Wells	l	utility well points	1
		surface well points	2
		bottom well points	3
		surface/bottom arcs	4
pipelines	m	arcs	1

<latitude_identifier>: A single letter identifying one of 12 possible latitudes in Texas. This letter always occupies the third position in the shapefile name. Latitude identifiers are:

a = 25th latitude	b = 26th latitude	c = 27th latitude
d = 28th latitude	e = 29th latitude	f = 30th latitude
g = 31st latitude	h = 32nd latitude	i = 33rd latitude
j = 34th latitude	k = 35th latitude	l = 36th latitude

<five_digit_quadrangle_number>: The last five digits of a USGS quadrangle number.

EXAMPLES

1. Airport shapefiles are created for USGS quadrangle number 3501231. The airport arc shapefiles are named:

    a1k01231.shp, .shx, .dbf

    a: Is the feature layer letter for Airports
    1: Is the feature type number for Airport arcs
    k: Is the latitude identifier for the 35th latitude – the USGS quadrangle number's first two digits.
    01231: The USGS quadrangle's last five digits.

2. Cemetery shapefiles are created for USGS quadrangle number 2798112. The cemetery point shapefiles are named:

    b2c98112.shp, .shx, .dbf

    b: Is the feature layer letter for Cemeteries
    2: Is the feature type number for Cemetery points
    c: Is the latitude identifier for the 27th latitude – the USGS quadrangle number's first two digits.

98112: The USGS quadrangle's last five digits.

3. Boundary shapefiles are created for USGS quadrangle number 3294321. The offshore polygon shapefiles are named:

d6h94321.shp, .shx, .dbf

d: Is the feature layer letter for Boundaries
6: Is the feature type number for Offshore polygons
h: Is the latitude identifier for the 32nd latitude – the USGS quadrangle number's first two digits.
94321: The USGS quadrangle's last five digits.

III. RAILROAD COMMISSION MAPPING TERMS

MAPPING TERMS USED AT THE RRC

Survey

A survey is a certified measured description of a piece of land. The term sometimes refers to the land itself. In Texas, original surveys were performed as part of the patenting process whereby land was transferred from the public domain. These "*patent surveys*," recorded at the Texas General Land Office, constitute an official land grid for the State and are the basis for subsequent land surveys.

Block

A block is a defined set of original land surveys. A block has an identifying name and/or number, and surveys within it are usually consecutively numbered, mile-square sections. Land grants from the State of Texas to railroad companies were often patented in blocks and sections. The term block is also used as a unit of a subdivision, i.e., subdivision/block/lot.

Section

A section refers to a square land survey measuring exactly one mile on each side. Some of the land transferred from the public domain by the state of Texas was surveyed and patented in units of square miles. The Texas General Land Office officially considers these units sections. Also, it was common that larger land grants, such as school lands and capitol lands, were subsequently surveyed into square mile units for the convenience of sale; these surveys are also called sections. In addition, the term "*section*" is commonly used to describe surveys in a group that have been assigned consecutive survey numbers, even though some of them do not have the proper shape or size to truly be sections.

Abstract

In Texas, the term abstract refers to an original land survey describing an area transferred from the public domain by either the Republic of Texas or the State of Texas. These surveys are recorded in the "*State Abstract of Land Titles*," which is maintained by the Texas General Land Office. Each survey so recorded is assigned an abstract number, which is unique within the county in which the survey falls. Because Texas has never performed a uniform statewide land survey, these original surveys called "*Patent Surveys*" constitute the State's Official Land Survey System.

IV. FILE LAYOUT AND DATA DICTIONARY

DATA DICTIONARY

This data dictionary defines unique RRC map attribute items and is structured as follows:

<ITEM NAME> <INPUT WIDTH, OUTPUT WIDTH, TYPE {NUMBER_OF_DECIMALS}>

Item Name:
The name of an attribute item in a data file

Input Width:
Number of spaces (or bytes) used to store item values.

Output Width:
Number of spaces used to display the item values.

Type:
One of the following data types:

- B – Whole numbers stored as binary integers.
- C – Character
- D – Dates
- F – Decimal numbers stored in internal floating-point.
- I – Integers
- N – Decimals

Number_of_Decimals:
Number of digits to the right of the decimal place for data types holding decimals.

GENERAL ARC ATTRIBUTE INFORMATION

All coverage arc attribute tables (<COVERAGE_NAME.AAT>) have the following two items:

DTYPE: (2,3,B)
Data type. All data types are given in Appendix A. (Arcs where DTYPE and LTYPE both = 0, are USGS quad boundary arcs.)

LTYPE: (2,3,B)
Line type. All line types are given in Appendix A. (Arcs where DTYPE and LTYPE both = 0, are USGS quad boundary arcs.)

COUNTY BOUNDARY ATTRIBUTE INFORMATION

Data Items in the <COVERAGE_NAME>.PATCOASTAL AND
<COVERAGE_NAME>.PATGULFAREAS AND
<COVERAGE_NAME>.PATOFFSHORE:

FIPS: (3,3,C)
Federal Information Processing Standard code (FIPS) is a three character county code. FIPS codes are listed in Appendix B.

COUNTYNAME1: (14,14,C)
(named C_NAME1 in shape files) The county name is in upper case letters.

DISTRICT: (2,2,C)
RRC field office territories or designated areas.

SPZONE: (1,1,C)
The State Plane Coordinate System is based on the Lambert Conformal Conic projection. This coordinate system includes five horizontal state plane coordinate zones following the county boundaries throughout Texas. Measurements are in feet. The zones are named and numbered as follows:

STATE PLANE ZONE	ZONE NAME	ZONE NUMBER	FIPS ZONE
1	North	5326	4201
2	North Central	5351	4202
3	Central	5376	4203
4	South Central	5401	4204
5	South	5426	4205

COUNTYNAME2: (14,14,C)
(Named C_NAME2 in shape files). The county name where only the first letter of the name is capitalized.

DATA ITEMS IN THE <COVERAGE_NAME>.PATGULFAREAS:

AREANAME: (50,50,C)
The FIPS code and county name for a gulf area. FIPS codes and names are listed in Appendix B.

RAILROAD ATTRIBUTE INFORMATION

DATA ITEMS IN THE <COVERAGE_NAME>.AAT:

RAIL_COID: (4,5,B)
Railroad company identification number

SUBDIVISION ATTRIBUTE INFORMATION

DATA ITEMS IN THE <COVERAGE_NAME>.PAT:

FIPS: (3,3,C)
Three character county code. FIPS codes are listed in Appendix B.

NAME: (55,55,C)
The subdivision name.

SURVEY ATTRIBUTE INFORMATION
DATA ITEMS IN THE <COVERAGE_NAME>.PATABSTRACT:

ANUM: (12,12,C)
Abstract Number, e.g., A-0000. Assigned to the surveyed parcel by the General Land Office at the time of patenting. If the abstract number field contains a "?" or is blank, then no abstract number was found.

L1SURNAM: (32,32,C)
Survey name. The name of the original grantee or the name of the company, individual or eleemosynary institution that is common among a formed group of surveys as shown on the General Land Office (GLO) county patent survey map or the GLO State Abstract of Land Titles.

L2BLOCK: (10,10,C)
Block Number. The number or letter used in description of a group of surveys identified as a Block on the GLO map. Example: 101

L3SURNUM: (8,8,C)
Section number. Further describes an abstracted surveyed parcel. Or, when preceded by "SUR", a surveyed parcel further divided into numbered abstracted areas. Example: SUR 101

L4SURNAM: (32,32,C)
Sub-Survey name of the grantee when the survey is a part of a larger refined area surveyed by a common party, and is only added if it is shown on the GLO map. A scrap file number corresponding to GLO records may also appear in the field.

L5SFOMF: (9,9,C)
Scrap or mineral file number from the GLO Abstract of Land Titles

FIPS: (3,3,C)
Three character county code. FIPS codes are listed in Appendix B.

DATA ITEMS IN THE <COVERAGE_NAME>.PATBAYTRACT:

BAYNUM: (9,9,C)
Provided by the General Land Office

BAYID: (3,3,C)

Bay area name abbreviations.

TRACTNUM: (6,6,C)
Provided by the General Land Office

WATER ATTRIBUTE INFORMATION

DATA ITEM IN THE <COVERAGE_NAME>.PAT:

TYPE: (1,1,C)
Identifies a polygon as either land (L) or water (W).

WELL ATTRIBUTE INFORMATION

****
For some historical wells, fields such as APINUM and CWELLNUM may be blank due to the limited amount of research time to capture this information.
****

UTILITY WELLS:

API: (8,8,C)
(Utility, Bottom and Surface Wells .PAT) Eight-character field equivalent to APINUM minus the 2 digit STATE Code and minus the 2 digit STCODE.

COUNTY: (3,3,C)
(Utility, Bottom and Surface Wells) Three character FIPS county code. FIPS codes are listed in Appendix B.

RELIAB: (2,2,C)
(Utility, Bottom and Surface Wells .PAT) Indicates the reliability of the well spot (the accuracy of the location of the well). Valid reliability codes are listed in Appendix C.

SURFACE-ID: (4,7,B)
(Utility, Bottom and Surface Wells .PAT) Surface well identification number.

SYMNUM: (2,3,B)
(Utility, Bottom and Surface Wells .PAT) Indicates the type of well under Datatype 50 in Appendix A.

WELLID: (5,5,C)
(Utility, Bottom and Surface Wells .PAT) Character field equal to APINUM's last five digits.

BOTTOM WELLS:

API: (8,8,C)
(Utility, Bottom and Surface Wells .PAT) Eight character field equivalent to APINUM minus the 2 digit STATE and minus 2 digit STCODE.

API10: (10,10,C)
(Bottom Wells .PAT) Ten character field equivalent to APINUM minus the 2 digit STATE Code.

APINUM: (12,12,C)
(Bottom Wells .PAT) The American Petroleum Institute (API) number of the wellbore in which the well is located. This 12-digit number includes a two-digit state code (Texas=42), an eight-digit API code, and a two-digit sidetrack code. (A sidetrack code identifies wells drilled from within a wellbore.)

BOTTOM-ID: (4,7,B)
(Bottom Wells .PAT) Bottom well identification number.

COUNTY: (3,3,C)
(Utility, Bottom and Surface Wells) Three character FIPS county code. FIPS codes are listed in Appendix B.

CWELLNUM: (6,6,C)
(Bottom Wells .PAT) Current well number as assigned by the operator.

FRESHWTR: (1,1,C)
(Bottom Wells .PAT) If given the value "Y", indicates a well converted to a fresh water well.

LAT: (8,12,F,7)
(Bottom and Surface Wells .PAT) Latitudinal position of the well. Datum is 1927.

LONG: (8,12,F,7)
(Bottom and Surface Wells .PAT) Longitudinal position of the well. Datum is 1927.

RADIOACT: (1,1,C)
(Bottom Wells .PAT) Whether the well is radioactive (if the bore contains any known radioactive material).

Y - well is radioactive.
N - well is not radioactive.

RELIAB: (2,2,C)
(Utility, Bottom and Surface Wells .PAT) Indicates the reliability of the well spot (the accuracy of the location of the well). Valid reliability codes are listed in Appendix C.

STATE: (2,2,C)
(Bottom Wells .PAT) Two character API-assigned identifier. Texas = 42

STCODE: (2,2,C)
(Bottom Wells .PAT) Side Track Code. Side tracks are numbered incrementally from 1 to 9, then from A through Z.

<u>POSITION 1:1</u>	<u>POSITION 2:2</u>
D = Directional	1 to 9 or,
H = Horizontal	A to Z
W = Well	

SURFACE-ID: (4,7,B)
(Utility, Bottom and Surface Wells .PAT) Surface well identification number.

SYMNUM: (2,3,B)
(Utility, Bottom and Surface Wells .PAT) Indicates the type of well under Datatype 50 in Appendix A.

WELLID: (5,5,C)
(Utility, Bottom and Surface Wells .PAT) Character field equal to APINUM's last five digits.

WELLID7: (7,7,C)
(Bottom Wells .PAT) Character field equal to APINUM's last five digits plus STCODE.

SURFACE WELLS:

API: (8,8,C)
(Utility, Bottom and Surface Wells .PAT) Eight character field equivalent to APINUM minus the 2 digit STATE Code and minus the 2 digit STCODE.

COUNTY: (3,3,C)
(Utility, Bottom and Surface Wells) Three character FIPS county code. FIPS codes are listed in Appendix B.

LAT: (8,12,F,7)
(Bottom and Surface Wells .PAT) Latitudinal position of the well. Datum is 1927.

LONG: (8,12,F,7)
(Bottom and Surface Wells .PAT) Longitudinal position of the well. Datum is 1927.

RELIAB: (2,2,C)
(Utility, Bottom and Surface Wells .PAT) Indicates the reliability of the well spot (the accuracy of the location of the well). Valid reliability codes are listed in Appendix C.

SURFACE-ID: (4,7,B)
(Utility, Bottom and Surface Wells .PAT) Surface well identification number.

SYMNUM: (2,3,B)
(Utility, Bottom and Surface Wells .PAT) Indicates the type of well under Data type 50 in Appendix A.

WELLID: (5,5,C)
(Utility, Bottom and Surface Wells .PAT) Character field equal to APINUM's last five digits.

WELL ARCS:

API_NUM: (12,12,C)
(Well Arcs .AAT) The American Petroleum Institute (API) number of the wellbore in which the well is located. This 12-digit number includes a two-digit state code (Texas=42), an eight-digit API code, and a two-digit sidetrack code. (A sidetrack code identifies wells drilled from within a wellbore.)

BOTT-ID: (4,7,B)
(Well Arcs .AAT) Bottom well identification number.

LTYPE: (2,3,B)
(Well Arcs .AAT) Line type of the directional well line

SURF-ID: (4,7,B)
(Well Arcs .AAT) Surface well identification number.

PIPELINE ATTRIBUTE INFORMATION

****
The Texas Railroad Commission is currently in the process of modifying and updating pipeline attributes to conform with the National Pipeline Mapping System (NPMS). Users of RRC pipeline data can expect specific items within the pipeline attribute table to be updated at any time.
****

DATA ITEMS IN THE <PIPELINE>.AAT

LINE_TYPE: (2,3,B)
Line type. All line types are given in Appendix A.

T4PERMIT: (5,5,C)
RRC-assigned five-digit pipeline permit number.

DIAMETER: (5,5,C)
Nominal diameter, in inches, of the pipeline segment.

FLUIDS: (20,20,C)
Abbreviation for the primary commodity carried by the pipeline system. The following is a listing of fluid categories and their systypes. Appendix D has a complete listing of specific products within the fluid categories.

Fluid Category	Land Systypes	Offshore Systypes
Acetylene	Q	
Alcohols	P	
Ammonia	P	
Benzenes	P	
Butanes	Q	
Carbon Dioxide	K	
Condensate	K	
Crude	L (Gathering)	A
Crude	O (Transmission)	A
Diesels	P	
Ethanes	Q	
Ethlyene	Q	
Ethylene (Gas)	T	
E/P Mix	Q	
Feedstock	P	
Fuel Oil	P	
Gasoline	P	
Hydrogen Gas	T	
Jet Fuel	P	
Kerosene	P	
LPG	Q	
Natural Gas	T (Transmission)	Z
Natural Gas	G (Gathering)	Z
Natural Gas Liquids	Q	
Nitrogen	P	
Oxygen	T	
Pentanes	Q	
Propanes	Q	
Refined Products	P	

SYSTEM: (35,35,C)
Operator-assigned name for a functional grouping of pipelines.

SUBSYSTEM: (35,35,C)
Operator-assigned name for a smaller subsection of a pipeline system. A subset of the SYSTEM attribute.

SYSTYPE: (2,2,C)
Abbreviation for the system type description. The character "A" is added to the abbreviation if the segment is abandoned.

G = Gas Gathering
K = Carbon Dioxide
L = Crude Gathering
O = Crude Transmission
P = Non_HVL Liquid Products
Q = HVL Products
T = Gas Transmission

See Appendix D for full listing of systypes.

COUNTY: (3,3,C)
The County FIPS code. FIPS codes are listed in Appendix B.

INTRA: (1,1,C)
Designates a pipeline as either inter or intrastate. "Y" indicates an intrastate pipeline, "N" indicates an interstate pipeline.

IDLE: (1,1,C)
Designates a pipeline as either idle or active. "Y" indicates an idle pipeline, "N" indicates a pipeline that is active but not currently in use. "Idle" does not mean the pipeline is abandoned. Idle pipelines are included in total pipeline miles permitted, abandoned pipelines are not.

MODDATE: (10,10,C)
Date pipeline segment was digitized or last modified (YYYY-MM-DD)

MILES: (4,8,F)
Pipeline length, in miles. Generated by the Arc/Info software.

SYS-ID: (16,16,I)
A six-digit RRC-generated system identifier. This item may not be present in all pipeline attribute files. The first number is the region number. Second is the system-type number. A four digit RRC assigned sequence number completes the item.

Region Numbers	Region Name
1	Amarillo
2	Midland
3	Kilgore
4	Austin
5	Houston
6	Dallas
7	Corpus Christi
8&9	Multi-Regional

System Type Number	System Type Name
3	Gas
4	Liquid
5	

V. APPENDIX A

DATA AND LINE TYPE ASSIGNMENTS

This appendix lists all data and line types. Data and line types are RRC defined data categories relevant to RRC mapping. Line types are listed beneath data types. For example, data type 10 represents the general data type, political boundaries. Line type 37 of data type 10 represents national political boundaries; line type 2 of data type 10 represents state political boundaries, etc.

Data Type

	Data Type Name:
10	**POLITICAL BOUNDARIES**
	2 - State
	3 - County
	21 - City
	37 - National
	58 - Offshore - Three League Line
11	**POLITICAL BOUNDARY ANNOTATION**
	29 - County, State
	81 - Town
	84 - City
	113 - Major Cities
12	**ORIGINAL LAND SURVEYS**
	5 - Block Line
	6 - Overlap Block Lines
	7 - Survey, Section Lines
	8 - Abstract Division Lines
	28 - Offshore Abstract Division
	29 - Offshore Tract, Survey Line
	30 - Offshore Block Line
	32 - Offshore Overlap Tract, Survey Line
	77 - Annotation Outline Arrow
	113 - Overlap Survey, Section Lines
	126 - Survey Annotation Outline
13	**SURVEY ANNOTATION**
	2 - Ex. Small Survey
	5 - Small Survey

6 - Small Offshore Tract/Survey
55 - Medium Survey, Section
56 - Medium Offshore Tract/Survey
62 - Medium Survey, Section
64 - Small Overlap Survey
96 - Abstract Annotation for Multi-Parcel Abstracts
102 - Large Block, Grant, League
111 - Large Offshore Block
112 - Large Block, Grant, League

17 **WATER FEATURES**
10 - Creeks
11 - Coastline
12 - Canals
27 - Rivers
31 - Lakes
35 - Original River Course Under Lake
55 - Dam Structures

18 **WATER ANNOTATION**
42 - Creeks and Small Lakes
44 - Rivers and Lakes

19 **TRANSPORTATION LINES**
14 - Heavy/Medium Duty
15 - Unimproved Roads
16 - Light Duty Roads and Streets
17 - Railroads
24 - Ship Channel

20 **TRANSPORTATION ANNOTATION**
2 - Highways
14 - Railroads
103 - Highways
107 - Ship Channel

21 **TRANSPORTATION SYMBOLS**
30 - State Highway/3 digit
31 - State Highway/4 digit
32 - Interstate Highway
33 - Farm or Ranch Road
34 - Park or Recreational Road
35 - U.S. Highway

24 **GOVERNMENT LAND**
116 - Parks and Military Reservations

25	**GOVERNMENT LAND ANNOTATION** 26 - Small 30 - Medium 32 - Large
26	**CEMETERIES** 36 - Cemetery Boundary
27	**CEMETERY ANNOTATION** 69 - Cemetery Name
28	**CEMETERY SYMBOLS** 48 - Cemetery Symbol
29	**AIRPORTS** 36 - Runways and Boundaries
30	**AIRPORT ANNOTATION** 69 - Airport Name
31	**SUBDIVISION LINES** 9 - Subdivision Lot Line 124 - Subdivision Outline 125 - Subdivision Labor Line
32	**SUBDIVISION ANNOTATION** 117 - Ex. Small Subdivision 118 - Small Subdivision 119 - Medium Subdivision 120 - Large Subdivision
50	**OIL & GAS WELLS** 2 Permitted Location 3 Dry Hole 4 Oil Well 5 Gas Well 6 Oil/Gas Well 7 Plugged Oil Well 8 Plugged Gas Well 9 Canceled/Abandoned Location 10 Plugged Oil/Gas Well 11 Injection/Disposal 17 Storage from Oil 18 Storage from Gas 19 Shut-In (Oil) 20 Shut-In (Gas)

21	Inj/Disposal From Oil
22	Inj/Disposal From Gas
23	Inj/Disposal From Oil/Gas
36	Geothermal Well
73	Brine Mining
74	Water Supply
75	Water Supply from Oil
76	Water Supply from Gas
77	Water Supply from Oil/Gas
78	Observation
79	Observation from Oil
80	Observation from Gas
81	Observation from Oil/Gas
	1. Storage
	2. Service
90	Service from Oil
91	Service from Gas
92	Service from Oil/Gas
103	Storage from Oil/Gas
104	Inj/Disposal from Storage
105	Inj/Disposal from Storage/Oil
106	Inj/Disposal from Storage/Gas
107	Inj/Disposal from Storage/Oil/Gas
108	Observation from Storage
109	Observation from Storage/Oil
110	Observation from Storage/Gas
111	Observation from Storage/Oil/Gas
112	Service from Storage
113	Service from Storage/Oil
114	Service from Storage/Gas
115	Service from Storage/Oil/Gas
116	Plugged Storage
117	Plugged Storage/Oil
118	Plugged Storage/Gas
119	Plugged Storage/Oil/Gas
120	Brine Mining
121	Brine Mining/Oil
122	Brine Mining/Gas
123	Brine Mining/Oil/Gas
124	Inj/Disposal from Brine Mining
125	Inj/Disposal from Brine Mining/Oil
126	Inj/Disposal from Brine Mining/Gas
127	Inj/Disposal from Brine Mining/Oil/Gas
128	Observation from Brine Mining
129	Observation from Brine Mining/Oil
130	Observation from Brine Mining/Gas

131	Observation from Brine Mining/Oil/Gas
132	Service from Brine Mining
133	Service from Brine Mining/Oil
134	Service from Brine Mining/Gas
135	Service from Brine Mining/Oil/Gas
136	Plugged Brine Mining
137	Plugged Brine Mining/Oil
139	Plugged Brine Mining/Gas
139	Plugged Brine Mining/Oil/Gas
140	Storage Brine Mining
141	Storage Brine Mining/Oil
142	Storage Brine Mining/Gas
143	Storage Brine Mining/Oil/Gas
144	Inj/Disposal from Storage/Brine Mining
145	Inj/Disposal from Storage/Brine Mining/Oil
146	Inj/Disposal from Storage/Brine Mining/Gas
147	Inj/Disposal from Storage/Brine Mining/Oil/Gas
148	Observation from Storage/Brine Mining
149	Observation from Storage/Brine Mining/Oil
150	Observation from Storage/Brine Mining/Gas
151	Observation from Storage/Brine Mining/Oil/Gas
152	Plugged Storage/Brine Mining
153	Plugged Storage/Brine Mining/Oil
154	Plugged Storage/Brine Mining/Gas
155	Plugged Storage/Brine Mining/Oil/Gas

56 **DIRECTIONAL DRILL LINES**

25 - Horizontal Drainhole Line
42 - Directional Well Line
43 - Directional Well Line

57 **GRAPHIC WELL SYMBOLS**

12 - Core Test
13 - Directional Surface Location
15 - Radioactive Symbol
16 - Sulphur Test
86 - Horizontal Drainhole
87 - Sidetrack Well Surface Location

VI. APPENDIX B COUNTY FIPS CODES

COUNTY	FIPS CODE
Anderson	001
Andrews	003
Angelina	005

Aransas	007
Archer	009
Armstrong	011
Atascosa	013
Austin	015
Bailey	017
Bandera	019
Bastrop	021
Baylor	023
Bee	025
Bell	027
Bexar	029
Blanco	031
Borden	033
Bosque	035
Bowie	037
Brazoria	039
Brazos	041
Brewster	043
Briscoe	045
Brooks	047
Brown	049
Burleson	051
Burnet	053
Caldwell	055
Calhoun	057
Callahan	059
Cameron	061
Camp	063
Carson	065
Cass	067
Castro	069
Chambers	071
Cherokee	073
Childress	075
Clay	077
Cochran	079
Coke	081
Coleman	083
Collin	085
Collingsworth	087
Colorado	089
Comal	091
Comanche	093
Concho	095
Cooke	097

Coryell	099
Cottle	101
Crane	103
Crockett	105
Crosby	107
Culberson	109
Dallam	111
Dallas	113
Dawson	115
Deaf Smith	117
Delta	119
Denton	121
Dewitt	123
Dickens	125
Dimmitt	127
Donley	129
Duval	131
Eastland	133
Ector	135
Edwards	137
Ellis	139
El Paso	141
Erath	143
Falls	145
Fannin	147
Fayette	149
Fisher	151
Floyd	153
Foard	155
Fort Bend	157
Franklin	159
Freestone	161
Frio	163
Gaines	165
Galveston	167
Garza	169
Gillespie	171
Glasscock	173
Goliad	175
Gonzales	177
Gray	179
Grayson	181
Gregg	183
Grimes	185
Guadalupe	187
Hale	189

Van Zandt	467
Victoria	469
Walker	471
Waller	473
Ward	475
Washington	477
Webb	479
Wharton	481
Wheeler	483
Wichita	485
Wilbarger	487
Willacy	489
Williamson	491
Wilson	493
Winkler	495
Wise	497
Wood	499
Yoakum	501
Young	503
Zapata	505
Zavala	507

OFFSHORE COUNTY AREAS	FIPS CODE
South Padre Island-SB	600
North Padre Island-SB	601
Mustang Island-SB	602
Matagorda Island-SB	603
Brazos-SB	604
Galveston-SB	605
High Island-SB	606
Sabine Pass-SB	607
South Padre Island-LB	700
North Padre Island-LB	701
Mustang Island-LB	702
Matagorda Island-LB	703
Brazos-LB	704
Brazos-S	705
Galveston-LB	706
Galveston-S	707
High Island-LB	708
High Island-S	709
High Island-E	710
High Island-E-S	711
Mustang Island-E	712

North Padre Island-E	713
South Padre Island-E	714
Sabine Pass-LB	715

VII. APPENDIX C WELL RELIABILITY CODES

WELL RELIABILITY CODES

The reliability of a well's location is determined by the source used to spot the well into the Well Location Database. Valid codes are:

CODES	
10	Historic Map (non-RRC)
15	RRC Hardcopy Map
16	Spotted from Reliability Code 15 wells
17	Location adjusted during survey maintenance
20	WELLBORE Distances
25	Unit or hearing plat, plat with form for another well, or form for this well without a plat.
30	Operator reported location (distances without plat or plat without distances).
40	Operator reported location (distances and plat).
45	Field Inspection by RRC personnel.
48	Spotted from Reliability Code 50 wells
50	U.S.G.S. 7.5 minute quad or aerial photograph.
55	Coordinates from operator.
59	Coordinates – RRC personnel reported 2D GPS (Accuracy of 200-300 feet.)
60	Coordinates – RRC personnel reported 3D GPS (Accuracy of about 15 feet.)

VIII. APPENDIX D: FLUID TYPES AND SYSTYPES

FLUID TYPES	LAND SYSTYPES	OFFSHORE SYSTYPES
Acetylene	Q	
Alcohols	P	
Ammonia	P	
Benzenes	P	
Butanes	Q	
Butadiene		
Butane/Butylene		
Butane/Distillates		
Butane/Pentane		
Butylene		
Iso-Butane		
Isobutane		
Carbon Dioxide	K	

CO2		
Condensate	K	
Slop Oil Water		
Crude	L (Gathering)	A
Crude	O (Transmission)	A
O/G		
Oil		
Petroleum		
Diesels	P	
Ethanes	Q	
Ethlyene	Q	
Ethylene (Gas)	T	
E/P Mix	Q	
E/P Propane		
Ethane/Propane		
Ethane/Propane Mix		
P/P Mix		
EPBC		
Feedstock	P	
Fuel Oil	P	
Bistone		
Fuel Gas		
Fuel Oil/Natural Gas		
Fuel Oils/Gas		
Fuel Residum		
Gasoline	P	
Gasoline/Diesel/Jet		
Gasoline/Fuel Oils		
Hydrogen Gas	T	
Liquid Hydrogen		
Pure H2		
Raw H2		
Jet Fuel	P	
Kerosene	P	
LPG	Q	

Raw LPG		
Natural Gas	T (Transmission)	Z
Natural Gas	G (Gathering)	Z
Dry Gas		
Natural		
Natural Gas/Cond		
Sweet Gas		
Synthesis		
Natural Gas Liquids	Q	
NGL		
Refinery Off Gas		
Nitrogen	P	
Oxygen	T	
Oxygen/Nit.		
Pentanes	Q	
Propanes	Q	
Methyl Propane		
Propadiene		
Propane/Butane		
Propane/LPG		
Propane/Propylene		
Propylene		
Propylene Oxide		
Propyne		
Refined Products	P	
Acnylonitrile		
Cutter Stock		
Cyclohexane		
Deisohex Stock		
Distillates		
Dripoline		
Feed Gas		
HCL Acid Anhydrous		
Hexene		
HPG		
Isoprene		
Methanol		
MTBE		
Naptha		

Products
Raffinate
RPG
Tertiary Butyl Alcohol
Toluene

<u>SYSTYPES</u>

A = Offshore (Liquids)	B = Apartment Complexes
C = Compressor Station	D = Distribution
E = Interstate Transmission Gas	F = Non-Jurisdictional Gathering
G = Gas Gathering	H = Government (Housing Authority)
I = LP Gas Distribution	J = Direct Sales Customer
K = Carbon Dioxide Pipelines	O = Crude Transmission
M = Municipal Distribution	N = City Not Served
L = Crude Gathering	P = Product Lines (NOT Highly Volatile)
Q = Other Liquid Lines (Highly Volatile)	S = Municipal Supply Line
T = Transmission	U = Underground Liquid Storage
V = Underground Gas Storage	W = Mobile Home Parks
X = Liquified Natural Gas	Z = Offshore (Gas) Gathering

IX. APPENDIX E NAMING CONVENTIONS

8.3 NAMING CONVENTION

The 8.3 naming convention stipulates that, exclusive of the filename suffix, a digital filename cannot be more than 8 characters long.

Although some computer operating systems and software programs accept file names longer than 8 characters, the Railroad Commission adheres to the 8.3 naming convention for a number of reasons.

1. ESRI, the manufacturer of ArcInfo and ArcView, suggests that their users adhere to the 8.3 naming convention. ESRI, in various ways to various extents, codes its software to enforce compliance with the 8.3 naming convention.
2. All RRC GIS data is compressed. Unfortunately, some decompression software packages truncate long filenames such as, "water3402112.shp" to meaningless names like, "water34~1.shp"
3. The Railroad Commission is committed to making its digital data accessible and usable to as wide an audience as possible. Adherence to the 8.3 naming convention ensures that at least one major hurdle of data portability is cleared.

3. Data Dictionary Additions

Two additional fields added to the pipeline database will enable easier understanding of the location by indicating the county name, based on the FIPS code provided originally, and the TxDOT District name. Fields identifying segment lengths were also added to the pipeline database.

Data Dictionary Additions

1. COUNTY – County designation (String)

2. TXDOT – TxDOT District designation (String).

   If the County designation represents an offshore location, the TxDOT District is indicated as "Offshore." The 25 TxDOT Districts and "Offshore" designation are listed below as indicated in the database.

   - Abilene
   - Amarillo
   - Atlanta
   - Austin
   - Beaumont
   - Brownwood
   - Bryan
   - Childress
   - Corpus Christi
   - Dallas
   - El Paso
   - Fort Worth
   - Houston
   - Laredo
   - Lubbock
   - Lufkin
   - Odessa
   - Paris
   - Pharr
   - San Angelo
   - San Antonio
   - Tyler
   - Waco
   - Wichita Falls
   - Yoakum
   - Offshore

3. LENGTH – Length in decimal degrees (number, 10 decimal places)

   The software using the designated units defined by the projection generated the length, which are in units of decimal degrees.

4. LENGTH_MET – Length in meters (number, 5 decimal places)

   This measurement is calculated from the LENGTH field.

5. LENGTH_MI – Length in miles (number, 5 decimal places)

   This measurement is calculated from the LENGTH field.

SECTION III. TEXAS PIPELINE INTERMODAL CONNECTIONS

1. File Description

The GIS database developed by TTI will enable TxDOT to identify pipeline intermodal connections by location, type, and modal connections for use in transportation planning activities.

Data Sources

Two main data sources were used to collect this data. The first was Pennwell Corporation. TTI purchased a facility database that contained locations of interconnections between pipeline facilities and other modes of transportation. **Pennwell will allow TxDOT to use the information internally, but will not permit dissemination of the data to outside sources.**

The second data source was a report performed by the Houston-Galveston Area Council (HGAC) titled *Intermodal Facility Inventory.* This report was published in January of 2000 and provides an extensive inventory of intermodal connections within HGAC's Transportation Management Area (TMA), which includes eight counties. TTI personnel examined the document and identified intermodal facilities that involve pipeline connections.

Coordinate System

Projection: Geographic
Units: Decimal Degrees
Datum Name: North American Datum 1983 (NAD83)
Ellipsoid Name: GRS1980

File Format

Files developed by TTI and submitted to TxDOT are in the Environmental Systems Research Institute (ESRI) shapefile (.shp) format created in the ArcView Version 3.2a software package.

File Naming Convention – Pipeline Intermodal Connections points

1) Statewide Pipeline Intermodal Connections: Pipe_Connect_State.shp; .shx; .dbf; .prj

2) Pipeline Intermodal Connections by TxDOT District: Pipe_Connect_<TxDOT District Abbreviation>.shp; .shx; .dbf; .prj

TxDOT District Abbreviations:

- ABL – Abilene
- AMA – Amarillo
- ATL – Atlanta
- AUS – Austin
- BMT – Beaumont
- BWD – Brownwood
- BRY – Bryan
- CHS – Childress
- CRP – Corpus Christi
- DAL – Dallas
- ELP – El Paso
- FTW – Fort Worth
- HOU – Houston
- LRD – Laredo
- LBB – Lubbock
- LFK – Lufkin
- ODA – Odessa
- PAR – Paris
- PHR – Pharr
- SJT – San Angelo
- SAT – San Antonio
- TYL – Tyler
- WAC – Waco
- WFS – Wichita Falls
- YKM – Yoakum

2. Data Dictionary

1. TTI_ID – Unique identification number created by TTI (Number)

2. FAC_NAME – Facility Name (String)

3. FAC_OPERAT – Facility Operator (String)

4. FAC_OWNER – Facility Owner (String)

5. FAC_TYPE – Facility Type (String)

Abbreviation	Definitions
CP	Chemical Plant
PB	Public Port
PP	Private Port
PT	Pipeline Terminal
REF	Refinery
TF	Tank Farm

6. ADDRESS – Facility Address (String)

7. CITY – City designation (String)

8. STATE – State designation (String)

9. ZIP – Zip designation (String)

10. COUNTY – County designation (String)

11. LATITUDE – Latitude designation (Number, 5 decimal places)

12. LONGITUDE – Longitude designation (Number, 5 decimal places)

13. CONNECTION – Modes of Connection (String)

14. RAIL – Rail Connection (String)
A value of "R" indicates a pipeline-railroad intermodal connection.

15. TRUCK – Truck Connection (String)
A value of "T" indicates pipeline-truck intermodal connection.

16. MARINE – Marine Connection (String)
A value of "M" indicates a pipeline-marine intermodal connection.

17. COMM_TYPE – Commodity Type (String)

18. COMM_VOL – Commodity Volume (String)

19. MODE_TYPES – Intermodal connections (String)
Indicates the intermodal connection combinations: "R" = Rail; "T" = Truck; "M" = Marine

e.g. R T = Pipeline connection with both Rail and Truck

20. TXDOT –TxDOT District designation (String)

- Abilene
- Amarillo
- Atlanta
- Austin
- Beaumont
- Brownwood
- Bryan
- Childress
- Corpus Christi
- Dallas
- El Paso
- Fort Worth
- Houston
- Laredo
- Lubbock
- Lufkin
- Odessa
- Paris
- Pharr
- San Angelo
- San Antonio
- Tyler
- Waco
- Wichita Falls
- Yoakum

21. SOURCE – Data Source (String)
The two major sources of data included in the databases are: Pennwell (for TxDOT internal use only) and Houston-Galveston Area Council's (HGAC) *Intermodal Facility Inventory*, January 2000.

APPENDIX B – GIS DATABASE STATEWIDE TXDOT DISTRICT BREAKDOWN

Table B-1. State of Texas Pipeline Mileage.

Texas Pipeline System Totals	
System Type	**Miles of Pipeline**
Carbon Dioxide	750
Crude	
Gathering	10,540
Transmission	23,110
Offshore	3,420
Total	37,070
Natural Gas	
Gathering	67,390
Transmission	64,560
Offshore	6,820
Total	138,770
Refined Products	
Non-HVL Products	12,340
HVL Products	20,720
Total	33,060
Other	4,470
Grand Total	214,110

Table B-2. Abilene District Pipeline Mileage.

Abilene District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	10	1
Crude		
Gathering	1,020	
Transmission	1,950	
Offshore	0	
Total	2,980	8
Natural Gas		
Gathering	3,200	
Transmission	2,660	
Offshore	0	
Total	5,860	4
Refined Products		
Non-HVL Products	310	
HVL Products	1,490	
Total	1,810	5
Unknown	150	3
Grand Total	10,810	5

Table B-3. Amarillo District Pipeline Mileage.

Amarillo District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	530	
Transmission	1,420	
Offshore	0	
Total	1,940	5
Natural Gas		
Gathering	7,540	
Transmission	2,910	
Offshore	0	
Total	10,440	8
Refined Products		
Non-HVL Products	820	
VL Products	1,400	
Total	2,220	7
Unknown	130	3
Grand Total	14,730	7

Table B-4. Atlanta District Pipeline Mileage.

Atlanta District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	40	
Transmission	290	
Offshore	0	
Total	330	1
Natural Gas		
Gathering	3,020	
Transmission	1,600	
Offshore	0	
Total	4,630	3
Refined Products		
Non-HVL Products	110	
HVL Products	70	
Total	180	1
Unknown	510	11
Grand Total	5,650	3

Table B-5. Austin District Pipeline Mileage.

Austin District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	70	
Transmission	260	
Offshore	0	
Total	330	1
Natural Gas		
Gathering	1,100	
Transmission	1,000	
Offshore	0	
Total	2,110	2
Refined Products		
Non-HVL Products	460	
HVL Products	450	
Total	910	3
Unknown	10	0
Grand Total	3,360	2

Table B-6 Beaumont District Pipeline Mileage.

Beaumont District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	570	
Transmission	1,380	
Offshore	1,440	
Total	3,390	9
Natural Gas		
Gathering	1,230	
Transmission	3,150	
Offshore	720	
Total	5,090	4
Refined Products		
Non-HVL Products	2,510	
HVL Products	2,970	
Total	5,480	17
Unknown	630	14
Grand Total	14,590	7

Table B-7. Bryan District Pipeline Mileage.

Bryan District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	270	
Transmission	830	
Offshore	0	
Total	1,100	3
Natural Gas		
Gathering	4,130	
Transmission	1,700	
Offshore	0	
Total	5,830	4
Refined Products		
Non-HVL Products	460	
HVL Products	670	
Total	1,130	3
Unknown	130	3
Grand Total	8,190	4

Table B-8. Brownwood Districy Pipeline Mileage.

Brownwood District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	290	
Transmission	660	
Offshore	0	
Total	950	3
Natural Gas		
Gathering	5,120	
Transmission	2,270	
Offshore	0	
Total	7,390	5
Refined Products		
Non-HVL Products	90	
HVL Products	670	
Total	760	2
Unknown	280	6
Grand Total	9,380	4

Table B-9. Childress District Pipeline Mileage.

Childress District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	180	
Transmission	280	
Offshore	0	
Total	460	1
Natural Gas		
Gathering	1,330	
Transmission	1,080	
Offshore	0	
Total	2,420	2
Refined Products		
Non-HVL Products	90	
HVL Products	10	
Total	90	0
Unknown	0	0
Grand Total	2,970	1

Table B-10. Corpus Christi District Pipeline Mileage.

Corpus Christi District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	490	
Transmission	2,480	
Offshore	800	
Total	3,770	10
Natural Gas		
Gathering	3,340	
Transmission	5,020	
Offshore	1,260	
Total	9,620	7
Refined Products		
Non-HVL Products	1,030	
HVL Products	1,170	
Total	2,190	7
Unknown	830	19
Grand Total	16,410	8

Table B-11. Dallas District Pipeline Mileage.

Dallas District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	100	
Transmission	350	
Offshore	0	
Total	450	1
Natural Gas		
Gathering	270	
Transmission	1,650	
Offshore	0	
Total	1,920	1
Refined Products		
Non-HVL Products	250	
HVL Products	370	
Total	620	2
Unknown	0	0
Grand Total	2,990	1

Table B-12. El Paso District Pipeline Mileage.

El Paso District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	0	
Transmission	580	
Offshore	0	
Total	580	2
Natural Gas		
Gathering	10	
Transmission	1,160	
Offshore	0	
Total	1,170	1
Refined Products		
Non-HVL Products	180	
HVL Products	160	
Total	340	1
Unknown	10	0
Grand Total	2,100	1

Table B-13. Fort Worth District Pipeline Mileage.

Fort Worth District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	60	
Transmission	930	
Offshore	0	
Total	990	3
Natural Gas		
Gathering	5,360	
Transmission	4,070	
Offshore	0	
Total	9,440	7
Refined Products		
Non-HVL Products	810	
HVL Products	480	
Total	1,290	4
Unknown	30	1
Grand Total	11,750	5

Table B-14. Houston District Pipeline Mileage.

Houston District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	960	
Transmission	1,430	
Offshore	610	
Total	3,000	8
Natural Gas		
Gathering	1,050	
Transmission	5,020	
Offshore	2,930	
Total	9,000	6
Refined Products		
Non-HVL Products	2,380	
HVL Products	4,220	
Total	6,600	20
Unknown	290	6
Grand Total	18,890	9

Table B-15. Lubbock District Pipeline Mileage.

Lubbock District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	500	67
Crude		
Gathering	210	
Transmission	690	
Offshore	0	
Total	900	2
Natural Gas		
Gathering	2,060	
Transmission	3,340	
Offshore	0	
Total	5,410	4
Refined Products		
Non-HVL Products	80	
HVL Products	870	
Total	960	3
Unknown	440	10
Grand Total	8,210	4

Table B-16. Lufkin District Pipeline Mileage.

Lufkin District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	0	
Transmission	330	
Offshore	0	
Total	330	1
Natural Gas		
Gathering	720	
Transmission	1,760	
Offshore	0	
Total	2,480	2
Refined Products		
Non-HVL Products	200	
HVL Products	770	
Total	960	3
Unknown	40	1
Grand Total	3,810	2

Table B-17. Laredo District Pipeline Mileage.

Laredo District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	330	
Transmission	310	
Offshore	0	
Total	640	2
Natural Gas		
Gathering	2,020	
Transmission	2,340	
Offshore	0	
Total	4,370	3
Refined Products		
Non-HVL Products	60	
HVL Products	40	
Total	100	0
Unknown	20	0
Grand Total	5,130	2

Table B-18. Odessa District Pipeline Mileage.

Odessa District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	210	28
Crude		
Gathering	2,710	
Transmission	2,540	
Offshore	0	
Total	5,250	14
Natural Gas		
Gathering	8,440	
Transmission	3,940	
Offshore	0	
Total	12,380	9
Refined Products		
Non-HVL Products	210	
HVL Products	1,670	
Total	1,880	6
Unknown	10	0
Grand Total	19,730	9

Table B-19. Paris District Pipeline Mileage.

Paris District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	70	
Transmission	120	
Offshore	0	
Total	190	1
Natural Gas		
Gathering	470	
Transmission	1,210	
Offshore	0	
Total	1,680	1
Refined Products		
Non-HVL Products	150	
HVL Products	90	
Total	240	1
Unknown	10	0
Grand Total	2,120	1

Table B-20. Pharr District Pipeline Mileage.

Pharr District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	70	
Transmission	320	
Offshore	40	
Total	430	1
Natural Gas		
Gathering	2,960	
Transmission	3,500	
Offshore	60	
Total	6,520	5
Refined Products		
Non-HVL Products	110	
HVL Products	150	
Total	260	1
Unknown	370	8
Grand Total	7,580	4

Table B-21. San Antonio District Pipeline Mileage.

San Antonio District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	230	
Transmission	360	
Offshore	0	
Total	590	2
Natural Gas		
Gathering	430	
Transmission	1,900	
Offshore	0	
Total	2,330	2
Refined Products		
Non-HVL Products	400	
HVL Products	190	
Total	590	2
Unknown	0	0
Grand Total	3,510	2

Table B-22. San Angelo District Pipeline Mileage.

San Angelo District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	20	3
Crude		
Gathering	820	
Transmission	1,290	
Offshore	0	
Total	2,110	6
Natural Gas		
Gathering	5,730	
Transmission	2,460	
Offshore	0	
Total	8,190	6
Refined Products		
Non-HVL Products	300	
HVL Products	1,030	
Total	1,330	4
Unknown	0	0
Grand Total	11,650	5

Table B-23. Tyler District Pipeline Mileage.

Tyler District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	10	1
Crude		
Gathering	430	
Transmission	800	
Offshore	0	
Total	1,230	3
Natural Gas		
Gathering	2,770	
Transmission	2,350	
Offshore	0	
Total	5,110	4
Refined Products		
Non-HVL Products	250	
HVL Products	590	
Total	840	3
Unknown	50	1
Grand Total	7,240	3

Table B-24. Waco District Pipeline Mileage.

Waco District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	100	
Transmission	510	
Offshore	0	
Total	620	2
Natural Gas		
Gathering	270	
Transmission	1,340	
Offshore	0	
Total	1,610	1
Refined Products		
Non-HVL Products	430	
HVL Products	240	
Total	670	2
Unknown	110	2
Grand Total	3,010	1

Table B-25. Wichita Falls District Pipeline Mileage.

Wichita Falls District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	660	
Transmission	2,420	
Offshore	0	
Total	3,070	8
Natural Gas		
Gathering	1,480	
Transmission	1,250	
Offshore	0	
Total	2,730	2
Refined Products		
Non-HVL Products	240	
HVL Products	40	
Total	280	1
Unknown	0	0
Grand Total	6,080	3

Table B-26. Yoakum District Pipeline Mileage.

Yoakum District		
System Type	**Miles of Pipeline**	**% of State Total**
Carbon Dioxide	0	0
Crude		
Gathering	330	
Transmission	560	
Offshore	90	
Total	980	3
Natural Gas		
Gathering	3,320	
Transmission	5,880	
Offshore	110	
Total	9,310	7
Refined Products		
Non-HVL Products	400	
HVL Products	920	
Total	1,310	4
Unknown	380	9
Grand Total	11,980	6

APPENDIX C – PIPELINE FACILITY DETAIL SHEETS

Table C-1. GATX Terminal Facility Detail.

FACILITY:	GATX Terminals Corp., Pasadena, 530 N. Witter, Pasadena TX 77506-0351
COMMODITIES:	Petroleum and liquid chemical products
THROUGHPUT:	300,000,000 bbls/year = 4.3 million tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound; 10% outbound • Barge Dock #1 Wharf(Map 3 #249): 6-8″ petroleum lines and 2-8″ petrochemical lines connect wharf to storage tanks described for Barge Dock #2 Wharf • Barge Dock #2 Wharf(Map 3 #248): 2-12″ and 3-8″ petroleum product lines connect wharf to 91 storage tanks (12,226,000 barrel cap.); 2-8″ petrochemical lines connect wharf to 4 tanks (3,108,000 barrel cap.); 2-8″ becoming 1-12″ vapor recovery lines connect wharf to processing unit • Barge Dock #3 Wharf(Map 3 #250): 2-6″, 4-12″, and 2-8″ petroleum products and petrochemical lines and 1-4″ slop line extend from wharf to storage tanks described for Barge Dock #2 Wharf; 2-8″ becoming 1-12″ vapor recovery lines extend from wharf to processing unit
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	5% inbound, 5% outbound • Loop 610, east on Clinton Dr. to Washburn Tunnel, south on Washburn Tunnel to Red Bluff, east on R.B to N Witter. Or, IH-10 south on Federal to Washburn Tunnel.
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% • 1-20″ line connects facility tanks to GATX Galena Park Terminal. • Terminal connects with pipelines operated by Colonial Pipeline Co., Explorer Pipeline Co., and Texas Eastern Products Pipeline Co. • HGAC documents presence of pipeline; no details available.

Source: HGAC *Intermodal Facility Inventory* p. 7; USACE *Port Series No. 24* (*28*), pp. 161-2.

Table C-2. Phillips Pipeline Company Terminal Facility Detail.

FACILITY:	Phillips Pipeline Company, Pasadena, 100 Jefferson St. @ Hwy. 225, Pasadena, TX 77501
COMMODITIES:	Refined products
THROUGHPUT:	200 trucks per day
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 20% outbound • Short term plan in 01-Dec-1999 to increase trucks by 50-100 per day
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	100% inbound, 80% outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #L02, p. 8.

Table C-3. Motiva Enterprises Terminal Facility Detail.

FACILITY:	Motiva Enterprises, LLC, 2661 Stevens St., Houston, TX, 77026
COMMODITIES:	Refined products (fuel): three grades of motor, plus diesel
THROUGHPUT:	350,000,000 gal/year, about 1.2 mil. tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 100% outbound • Trucks distribute fuel to stations, each truck is 80,000 lbs., incl. self wt.
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	100% inbound, 0% outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #L03, p. 9.

Table C-4. Phillips Petroleum Sweeny Complex Terminal Facility Detail.

FACILITY:	Phillips Petroleum Company Sweeny Complex, Highway 35 @ FM#524, Old Ocean, TX 77463
COMMODITIES:	Refined products, crude, NGL, chemicals
THROUGHPUT:	400,000 barrels/day in/out = 21 mil. tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	60% inbound by ship, 2% outbound by ship • Barges and ships dock about 2 miles down San Bernard River
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 1% outbound • No details available
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	• About 100 trucks/day enter/leave plant
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	40% inbound, 97% outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #L07, p. 10.

Table C-5. Exxon E. Almeda Terminal Facility Detail.

FACILITY:	Exxon E. Almeda Pipeline Terminal, 10617 E. Almeda, Houston, TX 77051-2204
COMMODITIES:	Bulk petroleum products
THROUGHPUT:	7,300,000 barrels/year, or about 1.05 million tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	1% inbound, 100% outbound • Access need identified, 98 trucks per day
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	99% inbound, 0% outbound • Penwell lists pipeline connections to be Colonial Pipeline and Rancho Pipeline System.

Source: HGAC *Intermodal Facility Inventory* (27) #L11, p. 13; Penwell Database #MSF3022659-1 (?).

Table C-6. Intercontinental Terminals Company Terminal Facility Detail.

FACILITY:	Intercontinental Terminals Co., Deer Park, 1943 Battleground Rd., Deer Park, TX 77536
COMMODITIES:	Liquid and gas chemicals, petrochemicals, liquid fertilizers
THROUGHPUT:	110,000,000 bbls/yr. = 15.7 million tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • Barge Dock No. 4 Wharf (Map 2, #281): 18 lines extend from wharf to 166 storage tanks (336,000,000 gal. cap.); 4-6″ lines to 13 tanks at Rohm and Haas Co. (Map 2, #280, 19,950,000 gal. cap.). • Barge Dock Nos. 5,#6 Pier (Map 2, #282): 18 pipelines to pier join pipelines described for Barge Dock #4 • Houston Ship Docks No. 1 Wharf and Houston Ship Docks Nos. 2 and 3 Pier (Map 2 #283): 50-6 to 20″ lines extend from pier and wharf to storage tanks described for Barge Dock #4, incl. 1-8″ ethanol line extending to Rohm and Haas tankage • Houston Bunker Dock Wharf (Map 2, #284): one 6" fuel oil and 1-6″ diesel fuel line extends to wharf from storage tanks descr. in Barge #4
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • One surface track at rear joins terminal trackage serving car-loading and unloading racks and a 550-car-capacity storage yard; connect with Port Terminal Railroad.
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • Estimated 1200 trucks/month • Road access: from terminal road and Battleground Road (St. Highway 134)
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o inventory • Estimated half of inbound and outbound volume is by pipeline • Terminal connects with pipeline operated by Texas Eastern Products Pipeline Inc.

Source: HGAC *Intermodal Facility Inventory* #L12, p. 14; USACE *Port Series No. 24,* pp. 176-7.

Table C-7. Chevron – Warren Petroleum Terminal Facility Detail.

FACILITY:	Chevron – Warren Petroleum, Galena Park, 12801 American Petroleum Rd., Galena Park, TX 77547
COMMODITIES:	LPG, ethylene, propylene, butadiene, isoprene, other natural gas liquids
THROUGHPUT:	No data available
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% # unknown • HGAC documents presence of connection; no details available
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	% # unknown • HGAC documents presence of connection; no details available
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	% # unknown • HGAC documents presence of connection; no details available
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% # unknown • Facilities available • Contiguous with Chevron U.S.A. Products Co., Galena Park, a regionally significant pipeline facility

Source: HGAC *Intermodal Facility Inventory*, p. 15.

Table C-8. Chevron USA Terminal Facility Detail.

FACILITY:	Chevron U.S.A. Products Company, Galena Park, 12523 American Petroleum Rd., Galena Park, TX 77547
COMMODITIES:	Gasoline, aviation fuel
THROUGHPUT:	400,000,000 gal./yr = 1.36 million ts/year = 3778 ts/day = 126 trucks/day
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 100% outbound • 126, 9000 gallon trucks per day
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	100% inbound, none outbound • No details available

Source: HGAC *Intermodal Facility Inventory*, p. 16.

Table C-9. ChemPak International Inc. Terminal Facility Detail.

FACILITY:	ChemPak International Inc., 3647 Willowbend Blvd., Houston, TX 77054
COMMODITIES:	Various drum and bay chemical products
THROUGHPUT:	No data available
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • HGAC documents presence of connection; no data available
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • HGAC documents presence of connection; no data available
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • HGAC documents presence of connection; no data available

Source: HGAC *Intermodal Facility Inventory* #L20, p. 17.

Table C-10. CITGO Petroleum Corp. Terminal Facility Detail.

FACILITY:	CITGO Petroleum Corp., 12325 North Freeway, Houston, TX 77060
COMMODITIES:	Refined products
THROUGHPUT:	121,000,000 gal./yr = 412,000 tons/yr = 54 gasoline trucks per working day
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 100% outbound • 9000 gallons per truck, 250 working days per year
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	100% inbound, none outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #L21, p. 18.

Table C-11. Coastal Refining and Marketing Company Terminal Facility Detail.

FACILITY:	Coastal Refining & Marketing Co., 11750 Almeda Rd., Houston, TX 77045
COMMODITIES:	Refined petro. products: LNG, butanes
THROUGHPUT:	At least 100,000s bbls./yr = 14,300 tons/yr = 57 tons/day
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 10% outbound • No data available
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 10% outbound • 57 tons/day = 3 trucks/day
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	80% inbound, 80% outbound • No data available

Source: HGAC *Intermodal Facility Inventory* #L22, p. 19.

Table C-12. Specified Fuels and Chemicals Terminal Facility Detail.

FACILITY:	Specified Fuels & Chemicals, LLC, Channelview, 1201 South Sheldon Rd., Channelview, TX 77530-0429
COMMODITIES:	Makes specialty fuels and distills toluene
THROUGHPUT:	No data available
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • Specified Fuels and Chemicals Wharf (Port Map 24-2 #77): 11 lines extend from wharf to 16 storage tanks at rear, 6-12″ chemical lines to five tanks (6,300,000 gal. cap.), 1-12″ wastewater and petroleum products line to four tanks (9,240,000 gal. cap.), 1-12″ Naptha and 2-8″ fuel oil lines to 7 tanks (105,000 barrels) • HGAC survey indicates pipeline mode exists; details unavailable
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • Two surface tracks serve plant in rear, connect with Port Terminal Railroad
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • Via plant roads; from Sheldon Road; and Interstate Highway 10
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • HGAC indicates pipeline mode exists

Source: HGAC *Intermodal Facility Inventory* #L30, p. 21; USACE *Port Series No. 24,* p. 90.

Table C-13. Martin Gas Sales, Inc. Terminal Facility Detail.

FACILITY:	Martin Gas Sales Inc., Baytown, 9434 Hwy. 146 North, Baytown, TX 77250
COMMODITIES:	Propane, normal butane, ethane/propane, ISO butane
THROUGHPUT:	No data available
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	90% inbound, none outbound • All inbound freight carried by truck, except propane, which is carried by pipeline
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 100% outbound • All outbound freight carried by pipeline

Source: HGAC *Intermodal Facility Inventory* # L35, p. 24.

Table C-14. Mobil Chemical Company Terminal Facility Detail.

FACILITY:	Mobil Chemical Co. La Porte Plant, 9822 La Porte Fwy. (Hwy. 225), La Porte, TX 77017
COMMODITIES:	Makes ethylene, propylene
THROUGHPUT:	1,000,000 tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	5% inbound, none outbound • No details available
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	5% inbound, 2% outbound • Only 70,000 tons/year by truck
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	90% inbound, 98% outbound • No details available

Source: HGAC *Intermodal Facility Inventory* # L51, p. 27.

Table C-15. Enron Methanol Company Terminal Facility Detail.

FACILITY:	Enron Methanol Co. La Porte Rd. Facility, Pasadena, 4403 La Porte Rd., Pasadena, TX 77503
COMMODITIES:	Methane and liquid oxygen inbound, methanol outbound
THROUGHPUT:	584,000 tons/year in, 548,000 tons/year out
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	% i/o unknown • USACE *Port Series No. 24* indicates connection to Occidental Chemical Corp., Houston Ammonia Terminal Wharf (Map #267): 1-8″ becoming 14″ methanol pipeline extend to 4 storage tanks (17,500,000 gal. cap.) at Enron's Pasadena Plant
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 10% outbound • Access need identified. Only 55,000 tns/year by truck = 1833 trucks/yr = 5 trucks/day
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	100% inbound, 90% outbound • USACE *Port Series No. 24* indicates connection to Occidental Chemical Corp., Houston Ammonia Terminal Wharf (Map #267)

Source: HGAC *Intermodal Facility Inventory* #L52, p. 28; USACE *Port Series No. 24* (*28*), p. 170.

Table C-16. DOW Terminal Facility Detail.

FACILITY:	DOW La #Porte Plant, 550 Battleground Rd., La #Porte, TX 77571
COMMODITIES:	Inbound natural gas, special chemicals; outbound polyurethane, thermoplastics
THROUGHPUT:	30,000,000 lbs/month in, out = 180,000 tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 60% outbound • Details of marine mode are not apparent in USACE *Port Series No. 23 or No. 24*
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 20% outbound • No details available
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 20% outbound • Only about 5 trucks/day
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	90% inbound, none outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #L53, p. 29; USACE *Port Series No. 24.*

Table C-17. Shintex Terminal Facility Detail.

FACILITY:	Shintech, Inc. Freeport Facility, 5618 E. S.H. 332, Freeport, TX 77541
COMMODITIES:	PVC, resins
THROUGHPUT:	2.8 billion lbs./year = 1,400,000 tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	• None listed
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	5% inbound, 80% outbound • Probably figure for outbound rail is a bit low
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	5% inbound, 20% outbound • Probably figure for outbound truck is a bit high
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	90% inbound, none outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #L55, p. 31; USACE *Port Series No. 24.*

Table C-18. ST Services Terminal Facility Detail.

FACILITY:	ST Services, Texas City, 201 Main Dock Rd., Texas City, TX 77592
COMMODITIES:	Chemicals, petroleum products, gas products
THROUGHPUT:	2 million tons/year 17,763 "moves" per year. A "move" may be by truck (18 tons), railroad car (90 tons), or barge (1000+) tons. "Ship" figure includes figure for barges.
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	25% inbound, 50% outbound • Texas City Terminal Railway Co., Dock No. 15, operated by StanTrans Inc. (Map 2 #69): approximately 30-4″ to 12″ pipelines extend from wharf to 121 steel storage tanks (1,763,000 barrels cap.) • Texas City Terminal Railway Co., Dock No. 16, operated by Marathon Oil Co., Phibro Energy USA Inc., and Stan Trans, Inc. (Map 2 #70): Approximately 30-4″ to 12″ pipelines extend from wharf to storage tanks described for Dock No. 15 above. Lines also extend to storage facilities of Marathon Oil Co. and Phibro Energy USA Inc. • Texas City Terminal Railway Co., Dock No 19, operated by StanTrans Inc. (Map 2 #72): 15-4″ to 8″ lines extend from wharf to storage tanks described for Dock No. 15 above.
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	50% inbound, 25% outbound • Texas City Terminal Railway trackage serves refinery in rear
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 10% outbound • From Dock Road and State Highway Loop 197
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	15% inbound, 15% outbound • No details available

Source: HGAC *Intermodal Facility Inventory* #P101, p. 40; USACE *Port Series No. 24.*

Table C-19. PAKTANK Terminal Facility Detail.

FACILITY:	PAKTANK, Deer Park, 2759 Battleground Rd., Deer Park, TX 77536
COMMODITIES:	Chemicals, vegetable oils, animal fats, refined products
THROUGHPUT:	8,000,000 bbls/year or 1.143 mil.tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	20% inbound, 30% outbound by ship; 40% inbound, 25% outbound by barge • HGAC notes this facility is a Regionally Significant port with over 500,000 tons/year • Barge Dock No. 4 Wharf (Map 2 #287): 2-10″ lines extend from wharf to 10 caustic soda storage tanks (18,480,000 gall. cap.); 3-8″ and 1-6″ bulk liquids pipelines extend from wharf to storage tanks described under Ship Dock No. 1 wharf below • Ship Dock No. 1 Wharf (Map 2 #288): 1-20″, 3-14″, 2-12″, 13-10″, 25- 8″, and 10-6″ petroleum products and petrochemical pipelines and 1-10″ and 1-6″ vapor recovery pipelines extend from wharf to 276 steel storage tanks at terminal in rear (6,500,000 barrels cap.) • Ship Dock No. 2 Wharf (Map 2 # 289): 1-14″, 2-10″, 18-8″, and 9-6″ lines extend to wharf from storage tanks described under Ship Dock No. 1 wharf above. Four of the 6″ lines also extend from rail unloading racks at rear • Barge Dock No. 2 Pier (Map 2 #290): 4-8″ petroleum products and chemical lines and 1-6″ vapor recovery line extend to pier from tanks described under Ship Dock 1 Wharf above. Pipelines also connect to rail unloading racks at rear. • Barge Dock No. 3 Pier (Map 2 #291): 4-8″ and 2-6″ petroleum products and chemical pipelines extend from pier to storage tanks described under Ship Dock 1 wharf above • Ship Dock No. 3 and Barge Docks Nos. 5 and 6 wharf (Map 2 #292): 37-8″ and 9-6″ lines extend from wharf to storage tanks described under Ship Dock 1.
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 20% outbound • Twenty-six surface tracks serving racks and terminal in rear connect with Port Terminal Railway. • Pipelines connect rail unloading racks to Ship Dock No. 2, Barge Dock No. 2, Barge Dock No. 3, Ship Dock No. 3, and Barge Docks Nos. 5 and 6.
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 20% outbound • Via terminal road, from Battleground Road (State Highway 134); and State Highway 225
PIPELINE OMMODITY MOVEMENT AND INFRASTRUCTURE:	20% inbound, 5% outbound • HGAC notes this facility is not Regionally Significant with only 70-80 trucks per day

Source: HGAC *Intermodal Facility Inventory* #P103, p. 41; USACE *Port Series No. 24* pp. 99-100.

Table C-20. GATX Galena Park Terminal Facility Detail.

FACILITY:	GATX Terminals Corp. Galena Park Terminal, 906 Clinton Drive, Galena Park, TX 77547 TxDOT District
COMMODITIES:	Petroleum and chemical liquid products
THROUGHPUT:	27,000,000 bbls/yr (3.86 million tons/year)
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	30% inbound by ship; 50% outbound by ship. • Ship Dock No. 3 (Map No. 148) has 2-20″ and 10-8″ commodity pipelines that extend to terminal storage tanks • Ship Dock No.1 (Map No. 149) has 5-12″, 1-10″, 6-8″, and 12-6″ commodity pipelines that extend to 16 terminal storage tanks (capacity 635,000 barrels). Also 8-8″ lube oil pipelines extend to 8 terminal storage tanks (capacity 170,000 barrels) • Barge Dock No. 2 (Map No. 150) has 8-12″, 2-10″, 45- 8″, and 4-6″ commodity pipelines that extend to 45 terminal storage tanks (capacity 1,174,000 barrels). Also has 1-3″ pipeline that extends to truck loading rack • Ship Dock No. 2 (Map No. 151) has 8-12″, 1-10″, 19-8″ and 5-6″ commodity pipelines that extend to 24 terminal storage tanks (capacity 1,026,000 barrels)
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound by rail; 10% outbound by rail. • Tank car loading racks are accessed by two Union Pacific Railroad tracks (see map)
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound by truck; 10% outbound by truck (less than 100 trucks per day) • Road Access: East Loop 610 via Clinton Dr.; IH10 via Federal-Clinton Dr.; Highway 288 via Red Bluff-Federal-Clinton Dr. (see map for Clinton Drive location).
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	50% inbound by pipeline; 20% outbound by pipeline • 1-20″ commodity pipeline extends from Ship Dock No. 3 to GATX's Pasadena terminal • 1-8″ aviation fuel pipeline extends from Ship Dock No. 3 to one 10,0000-barrel Texaco storage tank located at 780 Clinton Dr. • Terminal lube-oil storage tanks connected to Texaco facility at 780 Clinton Dr. via pipeline • 1-12″ pipeline extends from terminal storage tanks to Valero Energy Corp. Basis Petroleum refinery near Sims Bayou, Houston • Facility may be located on additional pipelines

Source: HGAC *Intermodal Facility Inventory* #P26, p. 54; USACE *Port Series No. 24,* pp. 118-9.

Table C-21. Houston Fuel Oil Terminal Facility Detail.

FACILITY:	Houston Fuel Oil Terminal
COMMODITIES:	#6 oil, carbon black, bunker blending, crude oil, refinery feedstocks
THROUGHPUT:	200 million barrels/year 1999 = 28.6 million tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	98% inbound, 75% outbound • Barge Dock No. 4 (Map 2 #86): 1-14″, 1-10″, and 1-8″ fuel oil lines and 1-6″ diesel fuel line extend from wharf to 46 steel storage tanks located at terminal (5,200,000 barrels cap.) • Barge Dock No. 3 (Map 2 #87): 1-14″, 1-12″, 1-8″, and 1-6″ line extend from wharf to tankage described for Barge Dock No. 4 • Ship Dock No. 1 (Map 2 #88): 1-24″, 1-12″, and 3-8″ fuel oil lines extend from wharf to tankage described for Barge Dock No. 4; 1-20″ crude line extends from wharf to 10 steel storage tanks (2,000,000 barrel cap.); crude oil pipelines extend from storage tanks to Lyondell-Citgo Refining Co., Valero Energy, Basis Petroleum refinery, and to Shell Oil Co. Deer Park refinery • Barge Dock No. 2 (Map 2 #89): 1-14″, 1-12″, 1-8″, and 1-6″ lines extend from wharf to tankage described for Barge Dock #4; 1-8″ ballast line serves wharf. • Barge Dock No. 1 (Map 2 # 90): 1-14″, 2-10″, and 1-8″ lines extend from wharf to tankage described for Barge Dock #4. • Ship Dock No. 2 (Map 2 #91): 1-14″, 1-14″, and 2-8″ fuel oil lines extend from wharf to storage tanks described under Barge Dock #4; 1-20″ crude oil pipeline extends from wharf to tankage described for Ship Dock No. 2
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	1% inbound, 1% outbound • Two surface tracks serving carloading rack at terminal in rear connect with Union Pacific Railroad and Port Terminal Railroad
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	1% inbound, 1% outbound • Via terminal road, from Jacintoport Blvd, • Access need identified, about 40 trucks/day go through the plant • 1999 daily vehicle count: 5530/day on Sheldon Rd., 9358/day on Jacinto Port Blvd.
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	None inbound, 23% outbound • As noted for Ship Dock No. 1 above, pipelines connect to a variety of nearby refineries

Source: HGAC *Intermodal Facility Inventory* #P32, p. 57; USACE *Port Series No. 24,* P. 93-5.

Table C-22. Oiltanking Houston, Inc. Terminal Facility Detail.

FACILITY:	Oiltanking Houston Inc., 15602 San Jacintoport Blvd., Houston, TX 77015
COMMODITIES:	Crude and refined petroleum products
THROUGHPUT:	163,223,684 bbls/year = 23.3 mil tns/yr
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 26% outbound by ship 24% inbound, 32% outbound by barge • Considered significant as a port by HGAC • Ship Dock No. 6 Wharf (Map 3 #99): 1-16″ and 1-12″ petroleum products lines extend from wharf to 35 storage tanks for miscellaneous commodities at rear (4,701,000 barrels cap.); 1-8″ liquefied petroleum gas and 1-6″ vapor lines extend to Enterprise Co.'s plant at rear, which serves a 12" overland pipeline. Terminal storage tanks and pipeline system connect with 1-16″ and 1-12″ petroleum products lines operated by Colonial Pipeline Co. and Explorer Pipeline Co. • Ship docks Nos. 4 and 5 Pier (Map 3 #100): 3-24″ crude oil, 2-16″ petroleum products, and 1-12″ methanol pipelines extend from pier to storage tanks; 1-16″ and 1-8″ liquefied petroleum gas lines extend to pipelines; 2-12″ and 1-8″ bunker fuel lines extend to pier from storage tanks, all described under Ship Dock No. 6; 1-12″ crude oil pipeline extends from storage tanks to Shell Oil Co.'s Deer Park Refinery on opposite side of Houston Ship Channel • Barge Dock D Wharf (Map 3 #101): 1-16″ and 2-12″ petroleum products, and 1-12″ methanol pipeline extend from wharf to storage tanks, and 2-12″ and 1-8″ bunker fuel lines extend to wharf from storage tanks, all described under Ship Dock No. 6; 1 liquefied petroleum gas line, unused in 1998, extends from wharf to pipelines described under Ship Dock No. 6 • Ship Dock No. 1 Wharf (Map 3 #104): 1-24″ petroleum products, 2-12″ and 1-8″ bunker fuel pipelines extend from wharf to storage tanks described under Ship Dock No. 6; 1-16″ and 1-8″ liquefied petroleum gas lines extend from wharf to pipelines described under Ship Dock No. 6; 1-8″ crude oil and 1-8″petroleum products lines extend from wharf to Barge Dock B Wharf • Barge Docks A and B Wharf (Map 3 #105): 1-12″ crude condensate, 2-12″ and 1-10″ petroleum products, and 2-12″ and 1-8″ bunker fuel lines extend from wharf to storage tanks described under Ship Dock No. 6; 1-8″ crude oil and 1-8″ petroleum products lines extend from wharf to Ship Dock No. 1 Wharf
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	2% inbound, 2% outbound • Six surface tracks serving 3 loading racks in terminal in rear connect with Port Terminal Railroad
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	4% inbound, 4% outbound • Access need identified, only 28 trucks/day avg. • Via terminal road and Jacintoport Blvd.
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	56% inbound, 32% outbound • Ship Dock No. 6 connects with overland pipeline • Penwell lists pipeline connections to be Texas Eastern pipeline and Pipelines to local facilities

Source: HGAC *Intermodal Facility Inventory*, #P41; USACE *Port Series No. 24.*

Table C-23. LBC Petro-United Terminals Inc. Facility Detail.

FACILITY:	LBC Petro-United Terminals Inc., Seabrook, 11666 Port Rd., Seabrook, TX 77586
COMMODITIES:	Refined products, chemicals, petrochemicals, keytones, alcohols, lube additives, all flammable and combustive petrochemicals
THROUGHPUT:	26,000,000 bbls/year = 3.7 million tons/year
MARINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	10% inbound, 26% outbound by ship 24% inbound, 32% outbound by ship • HGAC considers this facility significant as a port • LBC PetroUnited, Bayport Terminal Barge Dock Slip (Map 1 #312): 9-8", 4-6", and 1-4" lines extend from south side to 88 steel storage tanks in terminal (2,100,000 barrels cap.) • LBC PetroUnited Bayport Terminal Ship dock Wharf (Map 1 #313): 4-12", 11-10", 11-8", 38-6", and 1-4" lines extend from wharf to storage tanks described for Barge Dock Slip
RAIL COMMODITY MOVEMENT AND INFRASTRUCTURE:	2% inbound, 2% outbound • Three surface tracks serving carloading racks at rear join 5 surface tracks in storage yard in terminal; connect with Union Pacific
TRUCK COMMODITY MOVEMENT AND INFRASTRUCTURE:	4% inbound, 4% outbound • Access need identified by HGAC, only 28 trucks/day avg. • Via plant road, State Highway 146
PIPELINE COMMODITY MOVEMENT AND INFRASTRUCTURE:	56% inbound, 32% outbound • No details available

Source: HGAC *Intermodal Facility Inventory*, #P45 p. 63, USACE *Port Series No. 24,* p. 189.

APPENDIX D – STATE OF THE ART ANALYSIS OF CURRENT RESEARCH TRENDS IN PIPELINE SAFETY

Paper Number T5a05

"State of the Art Analysis of Current Research Trends in Pipeline Safety"

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Prepared for Presentation at AIChE 2001 Spring National Conference, April 22-26, Process Plant Safety Symposium, Transportation Safety: Safe Transportation of Hazardous Material by Pipeline, Truck, Railroad and Marine Vessels

INTRODUCTION

Recent pipeline accidents such as those near Carlsbad, New Mexico and Abilene, Texas indicate an increased need for research to improve pipeline safety. One of the fundamental elements to further research in pipeline safety is establishing the current state of the field. This paper will describe this fundamental state via an analysis of trends and models reported in the open literature. Pipeline safety issues addressed will include: current research models, contributions and limitations of technology advances, identified problems, research demands and needs, as well as insight to the future of pipeline safety.

CURRENT RESEARCH

This paper describes a preliminary examination of current trends in pipeline safety literature. The method used was a State of the Art Matrix (SAM) analysis, which is "a programmatic chronological and statistical approach to research literature analysis," (Beruvides, 2000). The analysis constituted a review of 321 articles dated from the year 1973 to 2000, and included major research journals such as Pipeline and Gas Journal, Oil and Gas Journal, Pipe Line Gas Industry, and American Gas. Identified research topics pertinent to the field include risk assessment, accident frequency and causation analysis, analysis of regulation trends, database quality analysis, program reviews, reliability analysis, effects of risk management, effects of global positioning system (GPS), integrity assessment, cost/benefit analysis, system safety, computer modeling, effects of quality practices, and risk analysis procedures and methodology. A content analysis of keywords extracted from the literature was undertaken by frequency of occurrence per article to determine trends focused in pipeline safety.

The total number of articles collected for each time period is shown in Figure 1. This graph of articles collected per time period illustrates an exponential growth of the number of articles available in pipeline literature. The growth in pipeline safety literature suggests that there is an increasing effort and interest on the issues in pipeline safety

The result of the preliminary SAM analysis with respect to keywords is provided in Figure 2. In looking at the frequency by time period of the keywords it is clear that 'safety management', 'legislative/regulation', and 'accidents' have increased dramatically in the last 15 years. Between the periods 1986-1990 and 1996-2000 the number of articles with 'safety management', 'legislative/regulation', and 'accidents' increased from 13 to 63, 19 to 54, and 16 to 53 respectively. It should be noticed that 'safety management' has taken a dramatic increase in the last 10 years and currently leads in frequency of keywords in the collected pipeline safety literature.

The percent increases for 'safety management', 'regulation/legislation', and 'accidents' between the 1986-1990 and 1996-2000 time periods were calculated by normalizing for number of articles reviewed per time period. Normalizing the data minimizes variation from the different numbers of articles collected. Results indicated that from keyword 'safety management' increased by 408%, 'regulation/legislation' increased by 237%, and 'accidents' increased by 244%.

Findings demonstrate that literature on 'safety management,' 'legislative/regulation' and 'accidents' have claimed the majority of interest in articles between the periods 1986-1990 and

1996-2000. Fifty-six percent of articles reviewed between 1986-1990 and 44% of articles reviewed between 1996-2000 discussed 'safety management' and 'legislative/regulation' and 'accidents'. These three keywords were cited 43% of the total number of keyword results for the 1996-2000 time period. The implications of this trend are evident in the recent movement of government towards the risk management approach to pipeline safety. The US Department of Transportation has begun a demonstration project to test risk management as an alternative to traditional pipeline safety regulation, ("RSPA mulls risk," 1997). The underlying idea for risk management is to move away from the traditional regulatory approach to safety, (Felder, 1998). Risk management ensures pipeline integrity, identifies sources of risk, identifies and prioritizes effective risk-reduction measure (P&GJ, 1999).

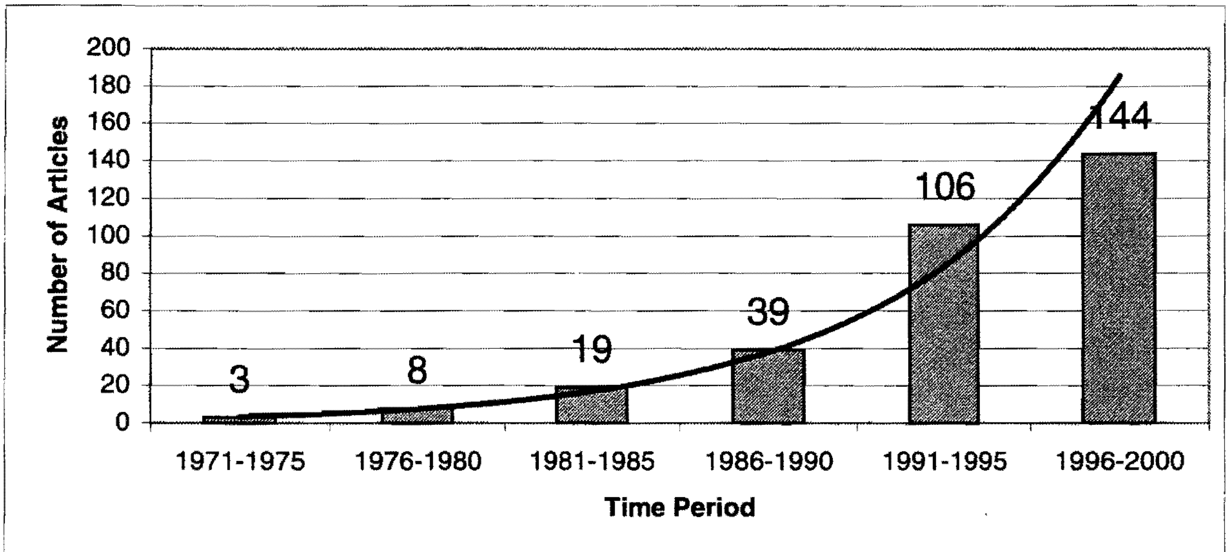

Figure D-1. Total Number of Articles Reviewed Per Time Period.

It should be noted that there is a clear increasing gap between the frequency of 'technology' as a keyword and 'safety management', 'legislative/regulation', and 'accidents' as keywords. The gap suggests that pipeline safety 'technology' has not gained as much attention in literature in the last 20 years and continues to not be a major point of interest in pipeline safety. A steep rise in the frequency of 'technology' literature occurred between 1986-1995 and then levels off with a slight decrease in the years1996-2000, with an average of 9% in frequency out of the keywords analyzed.

'Inspection' and 'corrosion' have continuously risen in the last 20 years and join 'technology' in the middle range of the literature keyword frequencies. Between the years 1981 and 2000 the frequency of 'inspection' increased 416% and the frequency of 'corrosion' increased 169% calculated from normalized data by number of articles reviewed per time period. Inspection even surpasses technology the 1996-2000 time period.

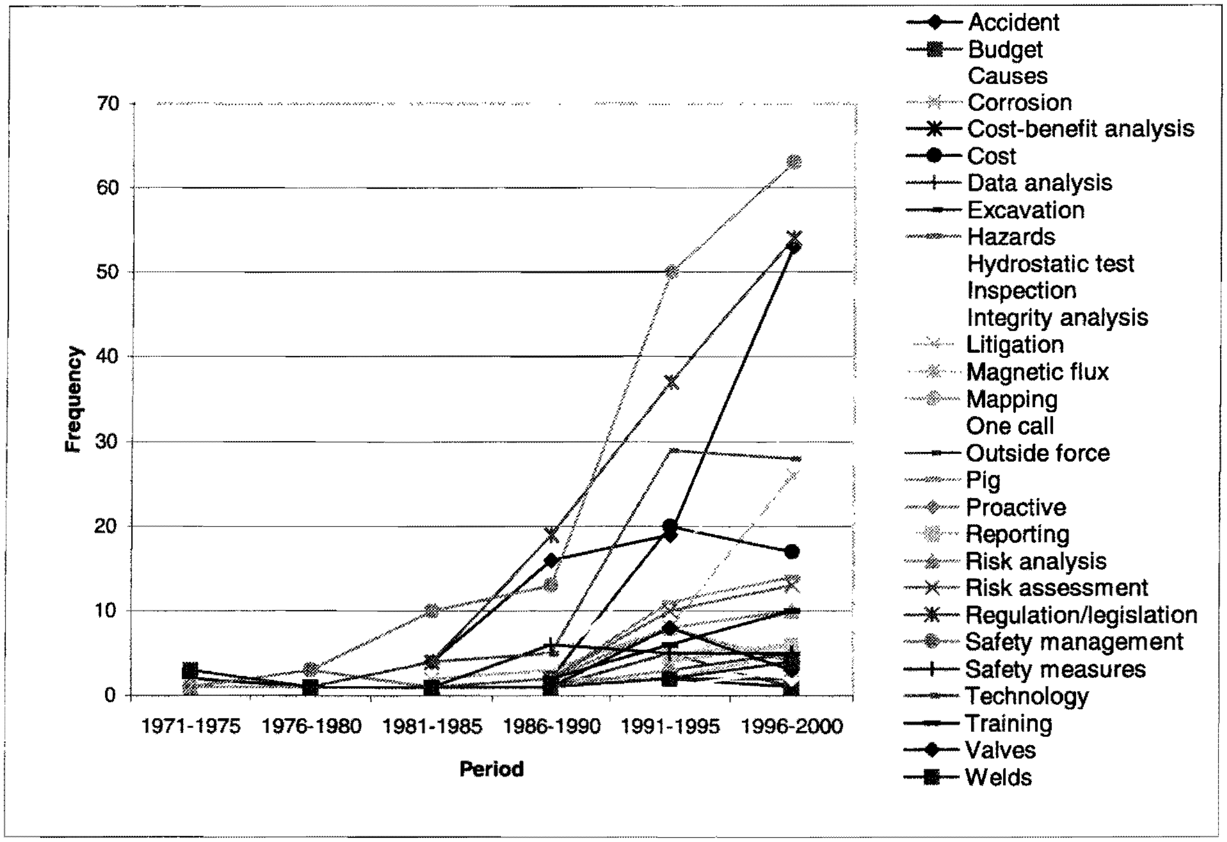

Figure D-2. SAM Analysis Results of Keywords by Frequency.

CONTRIBUTIONS AND LIMITATIONS OF TECHNOLOGY ADVANCES

There have been many incentives for pipeline safety technology developments in recent years. Increasing litigation costs, competition, regulations, and acute public scrutiny resulting from accidents have been obvious incentives. The Pipeline & Gas Journal states that more acute public scrutiny of pipeline operations and less tolerance of error has resulted in operating and maintenance advances, (P&GJ, 2000).

Types of new safety technology include the following,

- Supervisory control and data acquisition (SCADA) systems for remote operation and monitoring of pipelines,
- Magnetic flux leakage inspection pig that can now be used to measure and locate cracks in both circumferential and longitudinal directions,
- Ultrasonic pig used in locating, quantifying, and classifying defects, the lightweight composite-bodied hyperbaric pigs are easier, safer, and more cost effective for dive-based operations on offshore pipelines,
- The Global positioning system (GPS) mapping that uses satellite to catalog accurate locations of pipeline, and

- The Geographic information system (GIS) that supplies specialty databases for storing, retrieving, manipulating, analyzing, and displaying geographically referenced data.

Advances in technology provide many advantages and changes to the way pipelines are maintained and managed. Knowledge-based expert systems and data-mining software are now usable by a wider audience, (P&GJ, 2000). These systems reduce human error resulting from manual calculations and reentry of data. Technology now has the potential to allow pipeline operators not only to detect but also to characterize defects caused by third party damage, (Grimes, 2000). Improved pigs are providing more efficient pipeline operation, prolonging the useful life of the world's pipeline infrastructure, providing adequate safety for the public and environment, (Caldwell, 1999).

When scaled for commercial use, costs, design and operation flaws prohibit many inspection and monitoring technologies from being available for commercial applications. Consequently there is a large gap between the need for technology use and its actual usage. A 1999 report stated that 60% of major oil and gas pipelines around the world are over 20 years old and that only 10-20% of pipelines are pigged regularly, (Caldwell, 1999).

IDENTIFIED PROBLEMS IN PIPELINE SAFETY

In looking at the overall trends, the number of accidents, fatalities, and injuries in the last 14 years has been decreasing for both hazardous liquid and natural gas transmission lines. This trend is illustrated in Figures 3 and 4. These graphs show the results of a regression analysis applied to Office of Pipeline Safety's statistical data from year 1986 to 2000. However, Figure 5 indicates that property damage is increasing at an alarming rate. Increasing property damage could be the result of another problem faced by pipelines, that of population encroachment.

Population encroachment of pipelines that were once located in remote areas creates problems. Ignition from leaks is more likely, availability of pipeline right-of-way land is lower, and costs from accidents are greater due to loss of life, and damage to communities.

Another problem facing pipeline operators is that of public perception. Currently, the public perceives the industry as not technically competent at ensuring pipeline safety, (Reid, 1998). The pipeline industry knows that pipelines are the safest mode of transportation of goods and products. However, public perception does not reflect this reality. A recent Pipeline & Gas Journal article stated that public opposition is increasing though there have been improvements in environmental assessments, construction and restoration practices, as well as reductions of some 50-70% in pipeline spills, (P&GJ, 2000).

Pipeline safety also faces the effects from the struggle between industry and regulators. The approach to pipeline regulation has been dynamic in the past and continues to show signs of reinvention. The literature has shown that tragic sporadic pipeline accidents influence new stringent safety bills. Political pressures from these accidents have added to misdirection from the original philosophy of the establishment of regulation, which was to respond to pipeline safety problems, (Caldwell, 1996). Pipeline official say that many of these federal rules are adversely affecting their industry, (Crow, 1995). According to an article in American Gas, past regulations have proved more costly and less effective in reducing risk than intended, (Kalisch, 1995).

RESEARCH DEMANDS AND NEEDS

Identifying, locating, and distinguishing damage to pipelines is a critical area of focus where pipeline research is lacking. More improvement is needed on current technologies in locating and distinguishing between crack-like defects and other anomalies. There is also a need for 24-hour pipeline monitoring methods because approximately 70 percent of encroachment incidents on transmission pipelines occur without prior notice to the pipeline owner (P&GJ, 1999). External damage by outside force is the leading cause in pipeline accidents. The problem is that damage caused by a third party is not associated with the pipeline operation. Therefore damage often goes without warning.

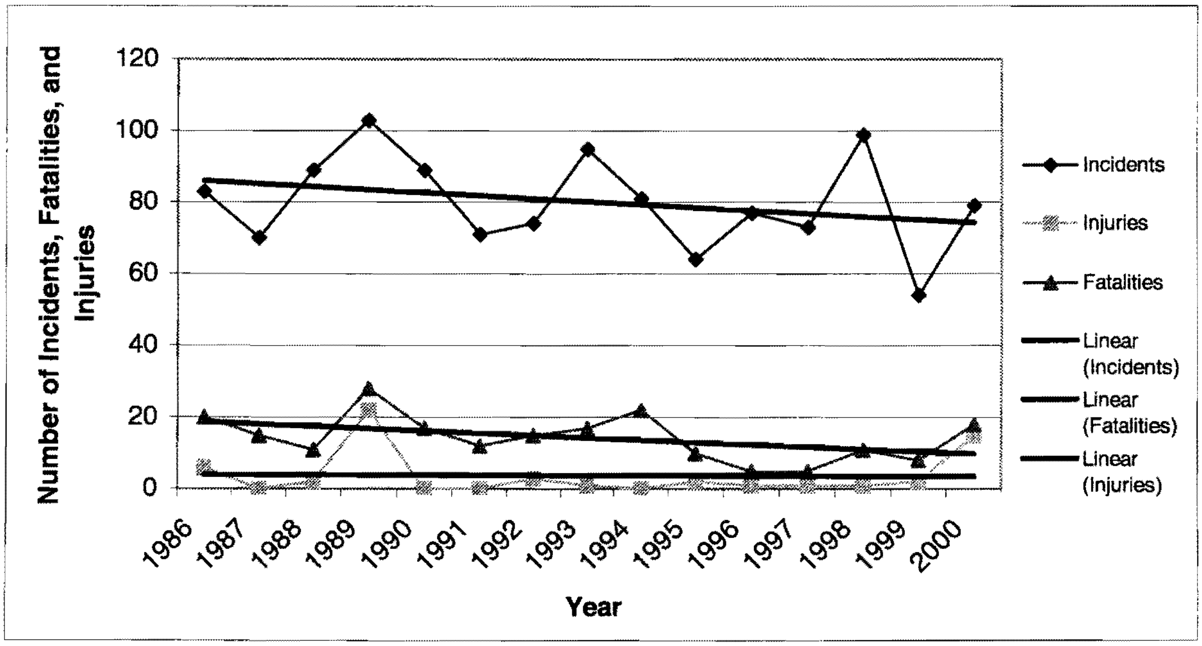

Figure D-3. Natural Gas Transmission Incidents, Fatalities, and Injuries by Year (Adapted from OPS, 2000).

Figure D-4. Hazardous Liquid Pipeline Accidents, Injuries, and Fatalities by Year (Adapted from OPS, 2000).

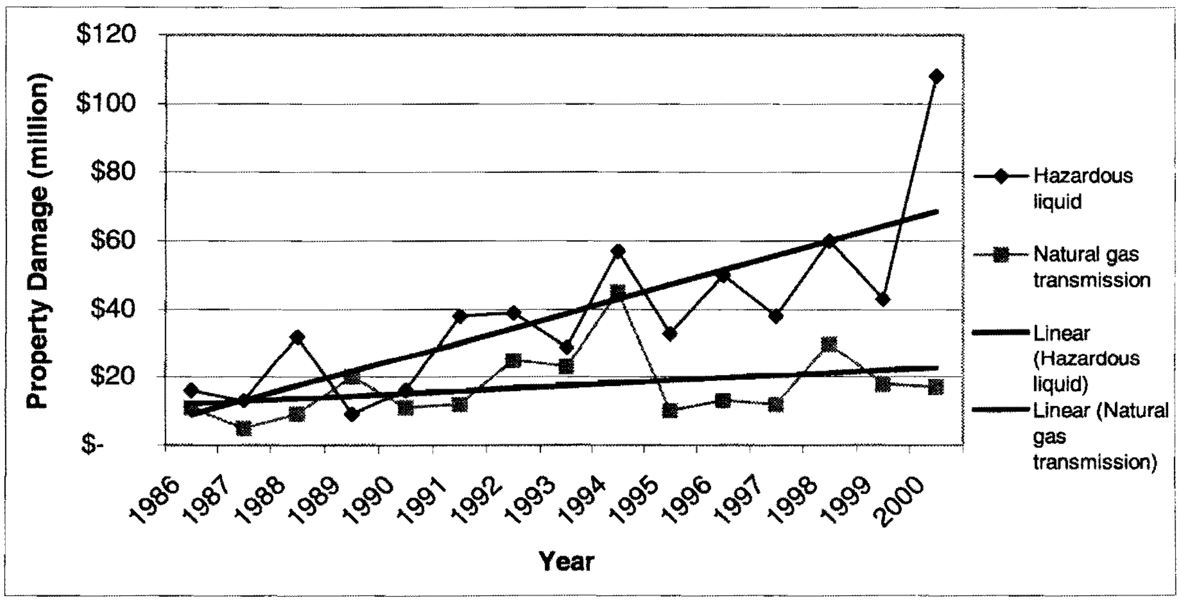

Figure D-5. Hazardous Liquid and Natural Gas Transmission Pipeline Property Damage by Year. (Adapted from OPS, 2000).

FUTURE OF PIPELINE SAFETY

In considering the trends analyzed in the SAM analysis and in reviewing the literature as a whole, we can see that there is a strong need for focus on safety technology. The SAM analysis clearly demonstrates that technology is not one of the leading focuses in pipeline safety. Yet, literature claims that technology is one of the leading needs to ensure pipeline safety. This result from the SAM analysis is both unexpected and a little alarming. This void in research is in itself a topic of research. Why is this happening? What does it mean to the industry?

From the discussion of current safety technology as well as from the problems and needs identified the future will include higher expectations regarding safety and environmental issues from the public, changing regulation, increasing competition, and unparalleled technological change. GIS and automated mapping/facilities technologies will be applied to virtually every aspect in hydrocarbon exploration, production, transportation, and processing. Those include life-cycling monitoring, risk analysis, emergency response planning, ensuring regulatory compliance, and improving operational efficiencies, (Corbley, 2000). Project specific and strategic communication planning will increasingly depend on public consultation programs, (Ford, 1998). New opportunities to lower costs will emerge from integrating GIS, global positioning satellites, low earth-orbiting satellites (LEO), digital mapping software, portable computing power, and new ways of visual communication, (P&GJ, 2000). Future challenges to pipeline safety include an increasing demand for energy, aging pipeline infrastructures, and population encroachment and reduced availability of pipeline right-of-way land, (Caldwell, 1999). In understanding the past and present trends in pipeline safety issues one can ultimately identify unsighted problems and plan for the future to assure that society, the environment and business can cohabitate with the most minimal risk.

Finally it seems evident that the focus as of late has been on accidents, legislation/regulation and safety management. In part some of this is to be expected. Accidents draw attention to the industry. Accidents are usually followed by legislative actions. This is all part of the nature of the business. But what is seriously needed is an analysis of where industry, government and academic entities interested in pipeline safety need to be focusing. There are critical issues involved with safety management, and the literature seems to bear that out. But technology is also critical. Why does there seem to be a tapering of the importance of this issue? In addition, there is very little in the literature with respect to a systems approach to this problem; why? We can only conclude that much research still needs to be addressed with respect to pipeline safety, and many of the critical issues that are either not being addressed or only slightly being researched.

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