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Temporary Saltwater Pipelines: Current Practice and Recommendations

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16. Abstract

Drilling and completing oil and gas wells, particularly when using horizontal and hydraulic fracturing techniques, requires enormous amounts of water. Generally, it is cheaper for the industry to move fluids by pipeline than by truck, hence the interest in using permanent and/or temporary pipelines to transport water in areas where oil and gas developments take place. The Texas Department of Transportation (TxDOT) uses two types of lease agreements for the installation of saltwater pipelines on the right of way. Short-term leases (up to 180 days) are used for aboveground temporary saltwater pipelines, mainly intended to carry non-produced water. Longer-term leases are used for underground saltwater pipelines, mainly to carry produced water. Prior to temporary leases becoming operational in summer 2016, TxDOT used temporary permits for aboveground temporary pipelines.

The purpose of research project 0-6886 was to review temporary pipeline installation practices, develop a guidebook to install and operate temporary pipelines, and recommend potential changes to policies and regulations based on field data collection and stakeholder feedback. The research included a review of standards, specifications, and practices in Texas and other states; data collection in the field to extract information about typical installation trends; a hydraulic analysis to estimate the impact of temporary pipelines in the hydraulic capacity of culverts; a review of the characteristics and impact of saltwater on the roadside; and stakeholder meetings to discuss trends and the draft guidebook.

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TEMPORARY SALTWATER PIPELINES: CURRENT PRACTICE AND RECOMMENDATIONS

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Cesar Quiroga, P.E. (Texas Registration #84274).

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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LIST OF ACRONYMS, ABBREVIATIONS, AND TERMS

BLM	Bureau of Land Management
BPM	Barrels per Minute
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
EC	Electric Conductivity
ESP	Exchangeable Sodium Percentage
FAO	Food and Agriculture Organization
FM	Farm-to-Market
GCD	Groundwater Conservation District
GIS	Geographic Information System
GPM	Gallons per Minute
GPS	Global Positioning System
GWDB	Groundwater Database
HB	House Bill
HDPE	High-Density Polyethylene
HRS	Hose Reel System
IPDS	Inland Petroleum Distribution System
ISCO	In-Situ Chemical Oxidation
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
OPDS	Offshore Petroleum Distribution System
PPK	Post Processed Kinematic
PSI	Pounds per Square Inch
PST	Petroleum Storage Tank
RHiNo	Road-Highway Inventory Network
RIFTS	Rapidly Installed Fluid Transfer System
RM	Ranch-to-Market
RQ	Reportable Quantity
RRC	Railroad Commission of Texas
RTN	Real-Time Network
SB	Senate Bill
SDRDB	Submitted Drillers Reports Database
SOP	Standard Operating Procedure
SH	State Highway
TAC	Texas Administrative Code
TBC	Trimble Business Center
TCEQ	Texas Commission on Environmental Quality
TCP	Traffic Control Plan
TDLR	Texas Department of Licensing and Regulation
TDS	Total Dissolved Solids
TMUTCD	*Texas Manual on Uniform Traffic Control Devices*
TSCe	Trimble Survey Controller
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
UIR	Utility Installation Review

USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

CHAPTER 1. INTRODUCTION

One of the effects of using horizontal drilling and hydraulic fracturing techniques to extract oil and gas resources has been a significant increase in traffic volumes. These traffic increases have been particularly noticeable in the form of large numbers of heavy loaded trucks providing transportation services to develop and operate energy sites.

Most of well development-related traffic in Texas occurs on rural roads. These rural roads, such as farm-to-market (FM) roads, ranch-to-market (RM) roads, and county roads, were never designed to carry the huge amount of truck traffic associated with energy developments. Most of those roads were built decades ago to serve mostly local low-volume traffic needs, not repetitive heavy truckloads. The result has been accelerated degradation of pavements and roadside infrastructure, as well as increases in congestion and crash and fatality rates (*1*, *2*, *3*, *4*).

The number of trucks needed to develop and operate oil and gas wells varies depending on the region in the state where the energy development is taking place. Based on several estimates gathered over the last few years, Table 1 provides a high-level depiction of the number of heavy trucks needed to develop a typical horizontal well in the Barnett Shale, Eagle Ford Shale, and Permian Basin Regions (*1*, *3*).

Table 1. Number of Trucks Needed to Develop a Well.

Well Development	**Number of Trucks**		
	Barnett Shale	**Eagle Ford Shale**	**Permian Basin**
Drilling pad and construction equipment	70	70	70
Drilling rig, equipment, materials, and fluid	117	117	117
Fracking equipment: pump trucks, tanks	74	74	74
Fracking water	533	1,021	527
Fracking sand	57	147	66
Other additives and fluids	4	24	11
Flowback water removal	133	255	132
Total	**988**	**1,708**	**997**

Water is used for many oil and gas activities, including but not limited to enhanced recovery applications, drilling, and completion of oil and gas wells. Water is also one of the byproducts of the operation of a well. Drilling a well can require anywhere from 65,000–600,000 gallons of water. Hydraulic fracturing involves pumping into the formation large volumes of water that includes components such as a friction reducer, surfactant and clay stabilizer, and sand. Hydraulic fracturing of a horizontal well can require 2–6 million gallons of water (*3*). Moving these enormous amounts of water and other fluids requires considerable resources. As Table 1 shows, carrying water for hydraulic fracturing accounts for a significant percentage of all the heavy truckloads typically needed to develop a well.

Generally, it is cheaper for the industry to move fluids by pipeline than by truck; thus, the industry's expressed interest is in using permanent and/or temporary pipelines to transport water in areas where oil and gas developments take place. Some of those pipelines are located within the right of way of public roads. The Texas Department of Transportation (TxDOT) has also noticed that in areas where temporary pipelines have been installed to carry water needed for drilling or fracking, the result has been less pavement degradation; consequently, the department is very interested in enabling the installation of temporary pipelines within the state right of way.

TxDOT uses two types of lease agreements for the installation of saltwater pipelines on the right of way (*5*). Short-term leases (up to 90 days) are used for aboveground temporary saltwater pipelines mainly intended to carry non-produced water. These leases can be extended once for another 90 days. Long-term leases (for periods less than two years, between two and five years, or greater than five years) are used for underground saltwater pipelines, mainly to carry produced water. Prior to temporary leases becoming operational in summer 2016, TxDOT used temporary permits for aboveground temporary pipelines.

Lease agreements include provisions to facilitate the installation of the pipelines while trying to ensure minimum impact or damage to the right of way or highway infrastructure. Because temporary aboveground pipelines have been allowed on the right of way since 2011, much of the experience with saltwater pipeline installations has been with aboveground temporary pipelines. In practice, districts have observed a wide range of ways in which temporary pipelines are installed, used, and maintained.

The purpose of Research Project 0-6886 was to review temporary pipeline installation practices, develop a guidebook to install and operate temporary pipelines, and recommend potential changes to policies and regulations based on field data collection and stakeholder feedback.

This report summarizes the work completed throughout the research. Subsequent chapters cover the following topics:

- Chapter 2 describes current practices related to the use of temporary pipelines, with a focus on temporary pipelines that occupy the state right of way.
- Chapter 3 describes current practices at other federal and state agencies.
- Chapter 4 describes the results of a sample field data collection exercise.
- Chapter 5 describes the hydraulic analysis conducted to determine the impacts of temporary pipelines occupying culverts.
- Chapter 6 summarizes a literature review on characteristics of water transported on temporary pipelines.
- Chapter 7 summarizes feedback received from meetings with stakeholders.
- Chapter 8 provides conclusions and recommendations for guidelines and changes to policies, procedures, and accommodation rules.

CHAPTER 2. USE OF TEMPORARY PIPELINES IN TEXAS

INTRODUCTION

This chapter provides an overview of trends related to the use of temporary pipelines in Texas. For completeness, the chapter also provides a summary of recent oil and gas energy development trends in the state as well as a summary of relevant Texas laws and regulations regarding temporary pipelines.

ENERGY DEVELOPMENTS IN TEXAS

In conjunction with other initiatives, the researchers received data from the Railroad Commission of Texas (RRC) documenting the locations and information on the attributes of oil and gas wells in Texas (*1*). As Figure 1 shows, the location of completed oil and gas wells tends to be clustered in specific regions of the state. Much of the activity related to the development of horizontal wells over the last 10 years has taken place in three regions: the Barnett Shale Region in North Texas, the Eagle Shale region in South Texas, and the Permian Basin Region in West Texas.

In practice, the level of oil or gas development activity has varied widely by region. Table 2 provides a summary of trends in the Barnett Shale, Eagle Ford Shale, and Permian Basin Regions by comparing the change in the number of completed wells from 2006–2009 to 2010–2013 (*2*). For completeness, Table 2 also shows the change in the number of completed wells in Karnes County, one of the most active areas of the Eagle Ford Shale Region. In the Barnett Shale Region (Figure 2), the development of new gas wells has been slower in recent years compared to the late 2000s, mirroring trends in natural gas prices. In the Eagle Ford Shale Region (Figure 3), oil well development activities were significant until 2014, when oil prices began to decrease substantially. In the Permian Basin Region (Figure 4), oil well development has included both vertical wells and horizontal wells. The level of activity also peaked in 2014 and decreased rapidly after that in response to the collapse in oil prices. With the recent increase in the price of oil, well development activity has also increased, but most of the new activity has been in the Permian Basin Region.

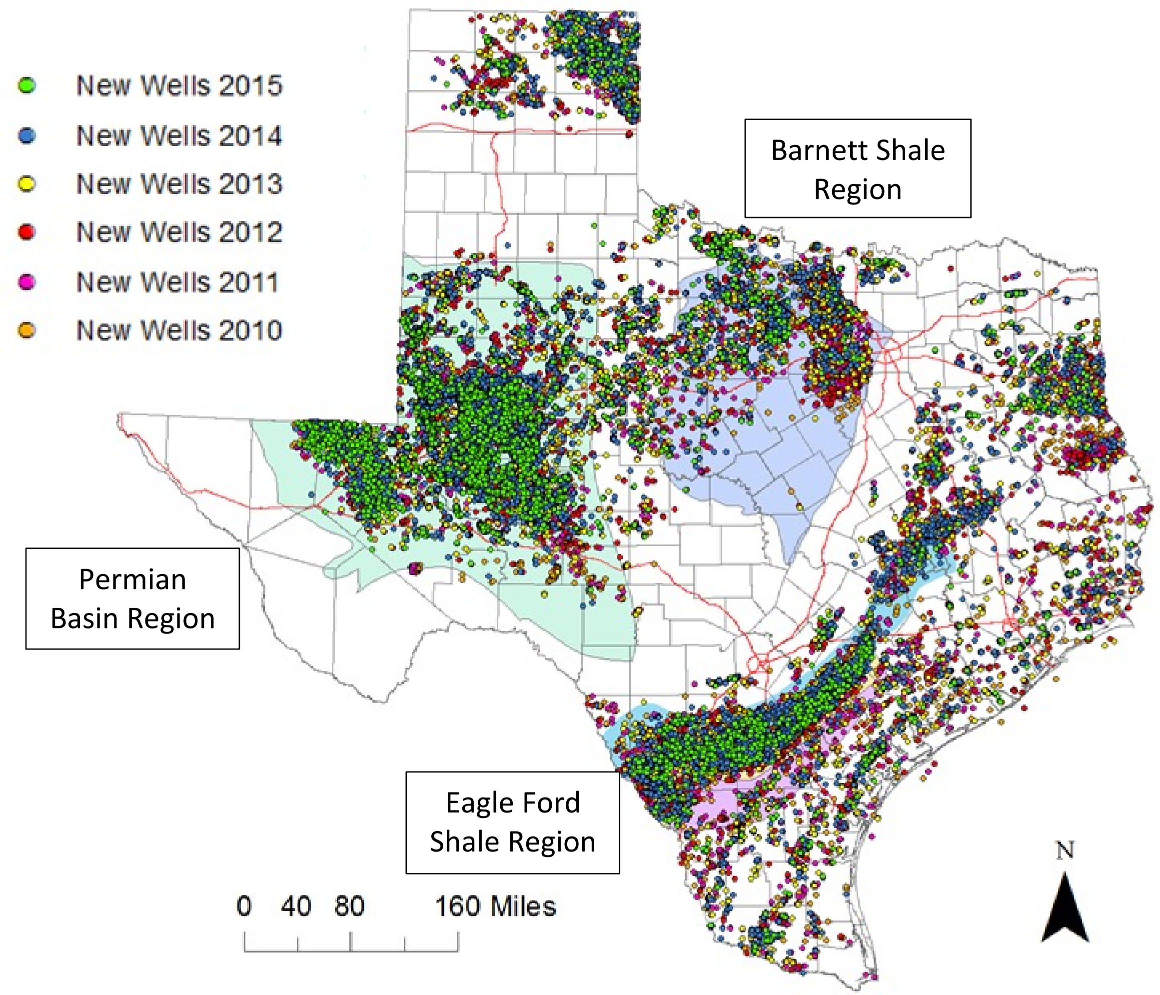


Figure 1. Completed Oil and Gas Wells in Texas from 2010 to 2015.

Table 2. Changes in the Number of New Completed Wells (*2*).

Region	Number of Horizontal Wells			Number of Vertical Wells			Total Number of Wells		
	2006-09	2010-13	Diff.	2006-09	2010-13	Diff.	2006-09	2010-13	Diff.
Barnett Shale	8,663	4,490	-48%	1,482	698	-53%	10,145	5,188	-49%
Eagle Ford Shale	854	8,886	941%	4,595	3,689	-20%	5,449	12,575	131%
Permian Basin	951	3,230	240%	14,381	21,396	49%	15,332	24,626	61%
Other	1,761	3,356	91%	18,706	9,653	-48%	20,467	13,009	-36%
Grand Total	**12,229**	**19,962**	**63%**	**39,164**	**35,436**	**-10%**	**51,393**	**55,398**	**8%**
Karnes County	28	1,312	4586%	38	50	32%	66	1,362	1964%

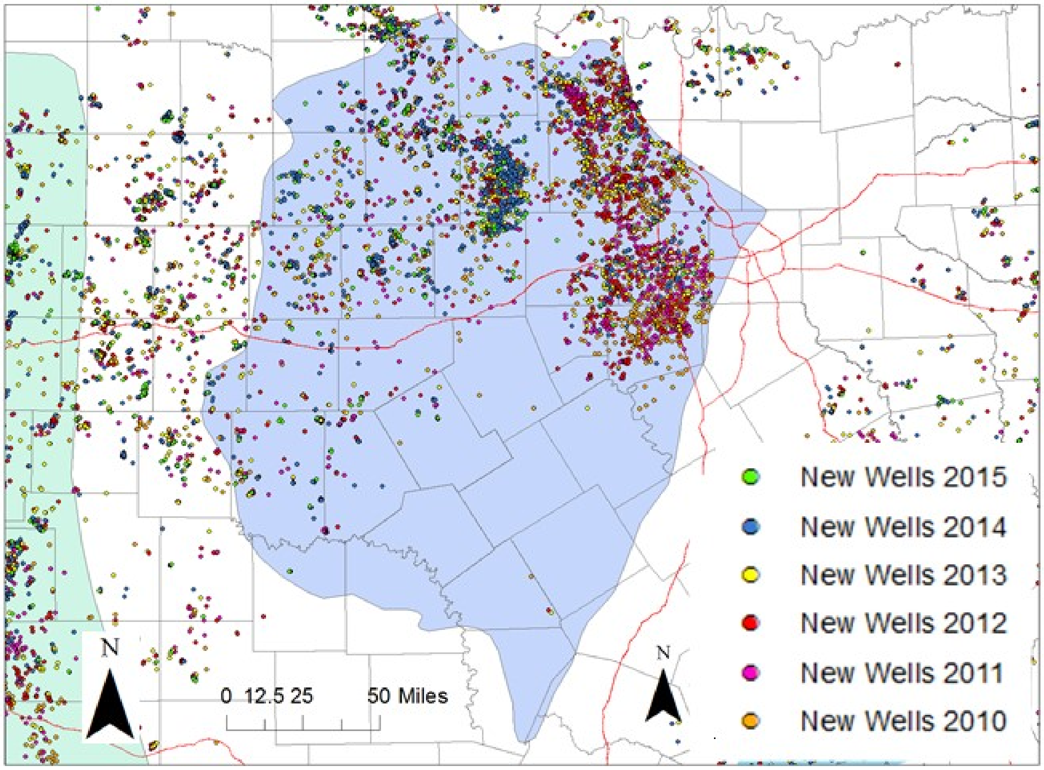


Figure 2. Completed Oil and Gas Wells in the Barnett Shale Region from 2010 to 2015.

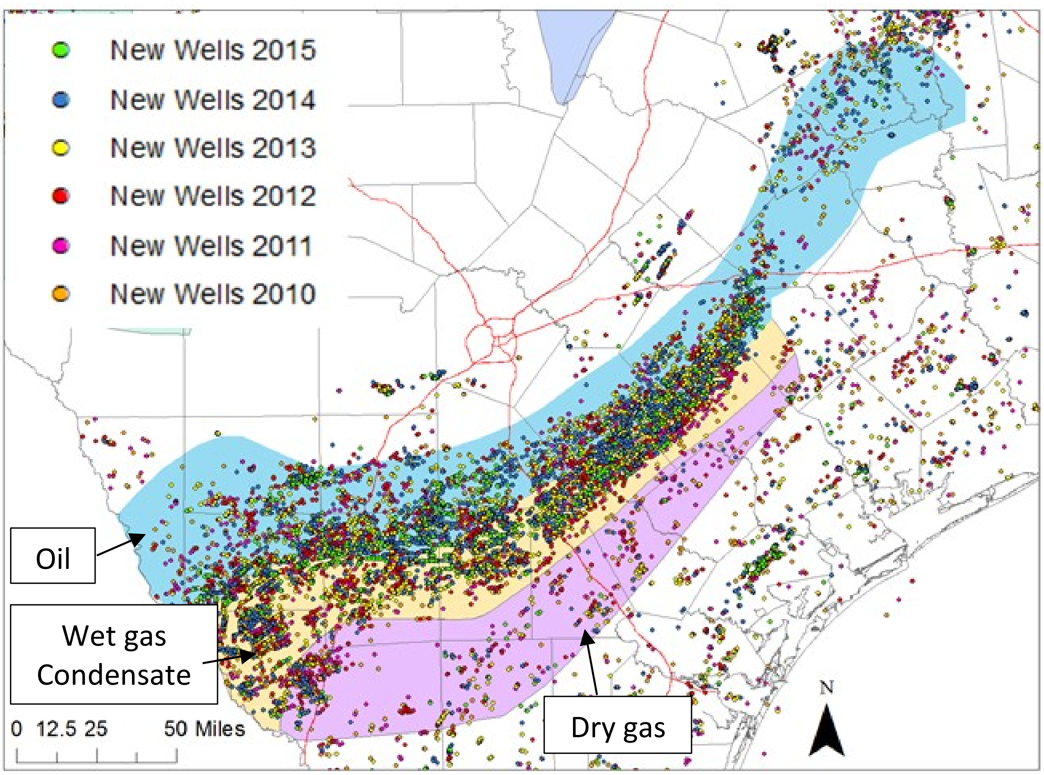


Figure 3. Completed Oil and Gas Wells in the Eagle Ford Shale Region from 2010 to 2015.

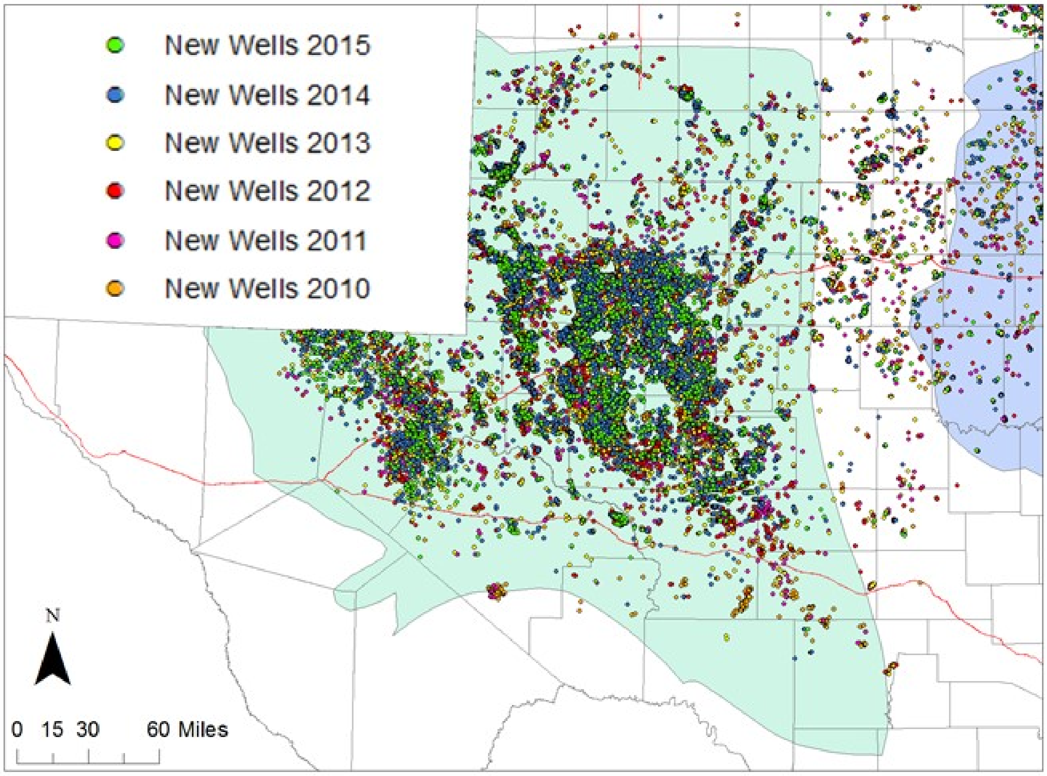


Figure 4. Completed Oil and Gas Wells in the Permian Basin Region from 2010 to 2015.

RELEVANT TEXAS LAWS AND REGULATIONS

Texas Department of Transportation

In 2013, Senate Bill (SB) 514 was enacted authorizing saltwater pipeline operators to install, maintain, and operate pipeline facilities through, under, along, across, or over a public road (*6*). In SB 514, saltwater pipelines were defined as those carrying produced water. To implement SB 514, TxDOT amended Chapter 21 of the Texas Administrative Code (TAC) in October 2014, more specifically by amending Sections §21.31–21.40, concerning utility accommodation, and by adding Sections §21.961–21.972, concerning leasing the right of way to saltwater pipeline operators (*7*). Relevant provisions included the following:

- §21.31. This provision added definitions for saltwater, saltwater pipeline facility, and saltwater pipeline operator. It also broadened other definitions to include saltwater and saltwater pipeline facilities and expanded the definition of a private utility to include saltwater pipeline facilities (while excluding saltwater pipeline facilities from the definition of a public utility).

- §21.36. This provision authorized saltwater pipeline operators to place saltwater pipeline facilities over, under, or across a highway, subject to highway purposes, as well as longitudinally within a highway right of way, but only by lease.

- §21.39. This provision required the operator of a saltwater pipeline facility located by lease within the state right of way to obtain the department's written approval before transferring ownership of the facility.

- §21.961. This provision enabled highway right of way not being used for highway purposes to be leased to saltwater pipeline operators.

- §21.963. This provision authorized TxDOT to execute a lease for installing, operating, and maintaining a saltwater pipeline facility if (a) there is sufficient area within the right of way to accommodate the saltwater pipeline facility; (b) the area to be leased is not needed for highway purposes during the term of the lease; and (c) the lessee's use of the right of way is consistent with safety, maintenance, operation, and beautification of the state highway system. The section also required the lease payment to be at least equal to the fair market value and that TxDOT could include administrative costs in the lease amount. It set a maximum lease term of 180 days for aboveground saltwater pipeline facilities.

- §21.964. This provision described the procedure for each request and outlined information needed to evaluate the lease request, including but not limited to a description of the saltwater pipeline facility, engineering plans, and a description of the highway right of way to be leased.

- §21.965. This provision described the agreement between TxDOT and the saltwater pipeline operator, including the requirement to comply with all federal, state, and local environmental laws and regulations, as well as the requirement not to impair the state's use of the state right of way for highway uses.

- §21.966. This provision required all lease payments to be deposited in the state highway fund.

- §21.967. This provision outlined the conditions under which an agreement may be terminated and the requirement that, upon termination, the saltwater pipeline operator must remove the saltwater pipeline facility and restore the highway right of way, at no cost to the department.

- §21.968. This provision clarified that all matters relating to leasing of federal-aid highway right of way would be subject to FHWA approval.

- §21.969. This provision declared that the use of leased right of way would not constitute abandonment of the property by the department or create a property interest in the lessee.

- §21.970. This provision required saltwater pipeline facilities to comply with existing utility accommodation rules, including not to interfere with the safety and free flow of traffic on the highway facility and not to adversely affect the use, safety, and appearance of the highway facility.

- §21.971. This provision required TxDOT's approval of all markers or tracking devices to be located within the highway right of way.

- §21.972. This provision provided that a saltwater pipeline facility may not require a change in alignment or profile of an existing highway facility without department approval. This section also requires that during construction the saltwater pipeline facility must permit access to the highway facility.

As mentioned, TxDOT uses two types of lease agreements for saltwater pipelines (*5*): short-term leases (up to 180 days) for aboveground pipelines and long-term leases (for periods less than two years, between two and five years, or greater than five years) for underground pipelines. Aboveground temporary pipelines are for non-produced water. According to TxDOT officials who were involved in the initial implementation of the temporary pipeline permits (which predated the temporary aboveground pipeline leases), the intent was for aboveground temporary pipelines to carry mainly fresh water (or, in any case, non-produced water with relatively low salinity).

In the current practice, operators submit a lease application form to a district office (*5*). The application includes a checkbox for the kind of lease (e.g., short-term or long-term) the operator is requesting. The application package, which includes Form ROW-SW-APP and attachments such as a map showing the pipeline route and a narrative of the installation location and procedures, is reviewed by district officials for technical feasibility. The review might include several rounds of discussions with and resubmission of the documentation by the operator. Once a district is satisfied with the application, the Right of Way Division (whose representative might be physically located within the district office) uses Form ROW-SW-LeaseTemp to prepare the lease agreement. Upon payment of the lease amount, TxDOT and the operator execute the lease, and the operator proceeds with the installation of the saltwater pipeline.

In 2015, House Bill (HB) 497 expanded the definition of a saltwater pipeline from any pipeline that carries produced water to any pipeline that carries water for drilling or operating a well (*8*). The bill allows pipelines to occupy the right of way via a lease agreement requiring the pipeline operator to pay a fair market value for the land being occupied and administrative costs.

As mentioned, while the lease agreement procedures were being developed, TxDOT allowed the installation of saltwater pipelines using temporary installation requests (i.e., Form 1082-T). Specific provisions in the temporary permit form, which are now included as an exhibit to the Form ROW-SW-LeaseTemp, include the following:

- Temporary requests automatically expire 91 days after the date of TxDOT approval unless extended in writing by the district.

- The pipeline and all appurtenances have to be removed and all damage to the right of way, highway, and privately owned facilities have to be repaired within 10 working days after the date of expiration.

- Maintenance of vegetation adjacent to the pipeline and other areas within the right of way has to follow specific instructions by the district.

- Access driveways, including access gaps in adjacent fences, cannot be blocked or open cut without authorization by the owner. Temporary road crossing manifolds cannot exceed 4 inches in height, have to span the entire width of the driving surface or fence gap, and have to have sufficient load carrying capacity.

- Bridge spans, drainage culverts, or crossing facilities such as livestock and vehicle passages cannot be used without written authorization by the district.

- Leaks in pipelines and appurtenances have to be reported to TxDOT and repaired immediately. If the district identifies a hazardous condition, the operator has to mitigate this condition in a timely fashion or TxDOT will mitigate the condition at the operator's expense.

In addition to these general provisions, some districts developed specific requirements for signage, mowing, the number of pipelines that could be installed in parallel, the sizes of culverts that could be used for crossings, and distance from right-of-way fences to pipeline alignment.

Railroad Commission of Texas

The Railroad Commission regulates the exploration, production, and transportation of oil and natural gas in Texas. The agency also regulates oil field injection and disposal wells as well as gas pipelines (*9*). The commission is not responsible for temporary pipelines. However, in the list of conditions and instructions for drilling permits, the Railroad Commission notifies well developers that if they intend to transport water to the well site using a temporary pipeline on the state right of way, they must obtain prior approval from TxDOT (*10*).

Texas Commission on Environmental Quality

In Texas, the state owns and manages surface water and grants permits for the right to use the surface water. The Texas Commission on Environmental Quality (TCEQ) evaluates water right applications and issues water right permits. TCEQ is also responsible for monitoring surface and underground water quality as well as water discharges and wastewater treatment plants.

Texas Department of Licensing and Regulation

In Texas, groundwater belongs to the owners of the land above it (i.e., the owners of the surface rights), who may use the water or sell it as private property. Groundwater production and use is managed and regulated differently depending on the use. For domestic uses, a water well drilled on a well owner's own property does not need a license. However, the well owner still needs to submit a well report to the Texas Department of Licensing and Regulation (TDLR) for registration within 60 days of drilling completion. For non-domestic uses, a license is required from TDLR when the well owner uses the water for applications such as irrigation, livestock, or industrial use or when a well operator drills a water well on someone else's property. The well owner or operator must submit a license application within 60 days of drilling completion.

Groundwater Conservation Districts

Groundwater production and use may also be subject to the rules outlined by local or regional groundwater conservation districts (GCDs). The Texas Legislature authorized the formation of GCDs to manage aquifers. A groundwater conservation district may be started by local landowners after petitioning to TCEQ or be initiated by TCEQ if no actions are taken by local landowners (*11*). The Texas Water Development Board (TWDB) is responsible for approving groundwater management plans that all GCDs are required to develop.

As part of its groundwater management plan, each groundwater conservation district must establish a permitting process for groundwater wells. There are exemptions to the requirement to have a permit, including wells used solely to supply water for oil or gas exploration or drilling rigs (*12*). There is some ambiguity as to whether the permit exception includes water used for hydraulic fracturing because this is considered a completion activity. Two recent House bills attempted to clarify that water used for hydraulic fracturing was exempt from a permit, but neither bill was enacted, leaving the decision of whether to require permits for hydraulic fracturing up to each water conservation district (*13*, *14*).

BASIC TERMINOLOGY

In the review of the literature and existing laws and regulations, as well as interviews with a wide range of stakeholders, the researchers identified multiple situations where terminology was not used consistently or situations where different terms were used to refer to the same concepts. For example, fresh water is commonly referred to as water having up to 1,000 mg/L of total dissolved solids (TDS), but some stakeholders place the threshold at 3,000 mg/L. There is also ambiguity about what saltwater is and what types of water can be carried in temporary and permanent pipelines within the state right of way.

The following are definitions of terms used throughout this report. As needed, additional commentary provides clarification about potential sources of confusion in terminology.

- **Salinity.** Salinity is the total amount of salts (inorganic matters) dissolved in water (*15*). TDS is a measure of both dissolved inorganic and organic matters. TDS is widely used to express salinity and is therefore used throughout the report.

- **Produced water**. Produced water is water that is extracted from the ground along with liquid and gas hydrocarbons. Produced water includes flowback water (i.e., water that is extracted from a well being developed or completed) and recycled water (i.e., produced water that has been treated to remove certain components).

- **Non-produced water**. Non-produced water is water that is not produced as a byproduct of drilling, completing, or operating an oil or gas well.

- **Source water**. Source water is groundwater or surface water that has not been used previously for another purpose. Source water is a subset of non-produced water (i.e., all source water is non-produced water, but not all non-produced water is source water).

- **Fresh water**. Section 27.0516 of the Texas Water Code defines fresh water as "surface water or groundwater, without regard to whether the water has been physically, chemically, or biologically altered, that (a) contains a TDS concentration of not more than 1,000 milligrams per liter; and (b) is otherwise suitable as a source of drinking water supply" (*16*). Another commonly used definition is water that contains TDS up to 500 mg/L, which is a threshold in a non-mandatory national drinking water standard used to identify the point beyond which humans begin to taste salt dissolved in water (*17*). Some energy industry stakeholders use a more relaxed definition of fresh water as water containing TDS up to 3,000 mg/L. Because of the wider acceptance of the first threshold mentioned above, the researchers recommend adopting 1,000 mg/L as the threshold for fresh water.

- **Brackish water**. Brackish water is water that contains TDS more than 1,000 and up to 10,000 mg/L (*18*). Some stakeholders consider brackish water if it contains TDS up to 35,000 mg/L, but this definition does not appear to be very common.

- **Saline water**. Saline water is water that contains TDS more than 10,000 and up to 35,000 mg/L (*19*).

- **Brine**. Brine is water that contains TDS more than 35,000 and up to 300,000 mg/L (*20*). Water with TDS greater than 300,000 mg/L is considered saturated brine with undissolved salt.

- **Saltwater**. According to Section 91.901(1) of the Texas Natural Resources Code, saltwater is "water that contains salt and other substances and is intended to be used in drilling or operating a well used in the exploration for or production of oil or gas, including an injection well used for enhanced recovery operations, or is produced during drilling or operating an oil, gas, or other type of well. The term includes a pipeline facility that conducts flowback and produced water from an oil or gas well on which a hydraulic fracturing treatment has been performed to an oil and gas waste disposal well for disposal" (*21*).

  According to 43 TAC 21.31, saltwater is "water that contains salt and other substances and that is intended to be used in the exploration for oil or gas or that is produced during the drilling or operation of an oil, gas, or other type of well" (*7*). Because the definition in the Texas Natural Resources Code is more inclusive, the researchers recommend adopting it. However, it is worth noticing that this definition of saltwater does not provide any guidance as to the amount of salt in the water. Subsequent chapters in this report address this issue.

- **Saltwater pipeline**. A saltwater pipeline is a pipeline that carries saltwater.

- **Temporary saltwater pipeline**. A temporary saltwater pipeline is an aboveground saltwater pipeline that satisfies the requirements of 43 TAC 21.57, which are that the outer diameter does not exceed 12 inches, it operates at a pressure less than 60 pounds per square inch (psi), and it is not in place for more than 180 days (*7*). As discussed in subsequent chapters, it is problematic to include pressure (and to a lesser extent) size thresholds in this definition. The researchers recommend restricting the definition of a temporary saltwater pipeline to a pipeline that is not in place for more than 180 days and specifying pressure and size thresholds in other documents such as manuals and standard operating procedures (SOPs).

TEMPORARY PIPELINE STATISTICS AND TRENDS

The researchers requested copies of temporary pipeline permits from TxDOT districts to develop a geographic information system (GIS)-based database of temporary pipeline locations in Esri® ArcGIS® format. The database includes data attributes such as district, county, road, temporary pipeline location, size, length, and number of pipelines included in the permit. The Corpus Christi and Yoakum districts maintain digital records of every permit application submitted. However, this is not an agency-wide practice. Other districts with significant energy developments do not maintain digital records, so only a handful of permits were reviewed from the Fort Worth, Laredo, Lubbock, Odessa, and San Angelo Districts. Table 3 shows the number of permits and pipelines per district included in the database.

Table 3. Temporary Pipeline Permits Provided by Districts.

District	Number of Permits	Number of Pipelines	Start Date	End Date*
Corpus Christi	747	1008	July 2011	July 2016
Fort Worth	6	11	January 2015	April 2016
Laredo	21	27	January 2015	April 2016
Lubbock	8	8	May 2012	August 2015
Odessa	25	28	August 2015	August 2016
San Angelo	33	40	February 2014	March 2016
Yoakum	251	304	March 2012	June 2016
Total	**1091**	**1426**	**July 2011**	**August 2016**

* End Date refers to 90 days after the start date of the latest permit received from each district.

In most cases, temporary permit applicants provided a summary of where the pipeline was to be located, including distance from nearby intersections and which culverts would be used if crossing under a road. The application also included coordinates where the temporary pipelines would enter and exit the state right of way as well as a map depicting the proposed location of the temporary pipeline.

Most operators attached a printout of a Google Earth® map depicting the temporary pipeline location. However, the quality of the map information provided was frequently inadequate. For example, some operators provided rough sketches showing approximate pipeline locations in relation to surrounding roads. In other cases, permits had incomplete or illegible maps that did not clearly depict the location of the temporary pipelines. Figure 5 provides examples of maps that were illegible or lacked crucial information to identify where pipelines were to be located. The top map did not include any road labels and was too aggregated spatially, making it impossible to tell on what route or even on what side of the road the temporary pipeline would be located. The bottom map had a very low image resolution, making the road label illegible. Neither map showed the coordinates of the beginning or ending of the pipeline.

Generally, permit applications could be grouped into one of the following categories:

- The permit application included coordinates of the starting and ending points and a description, but the map was missing or illegible.
- The permit application included a map, but not coordinates of the starting and ending points.
- The permit application included coordinates, a description, and a map, but the pipeline route was not shown in adequate detail (e.g., the side of road was unknown or culvert crossings were not shown). This was the most common situation.
- The permit application included coordinates, a description, and a map.

(a) Map lacking road labels and adequate scale

(b) Map lacking adequate image resolution

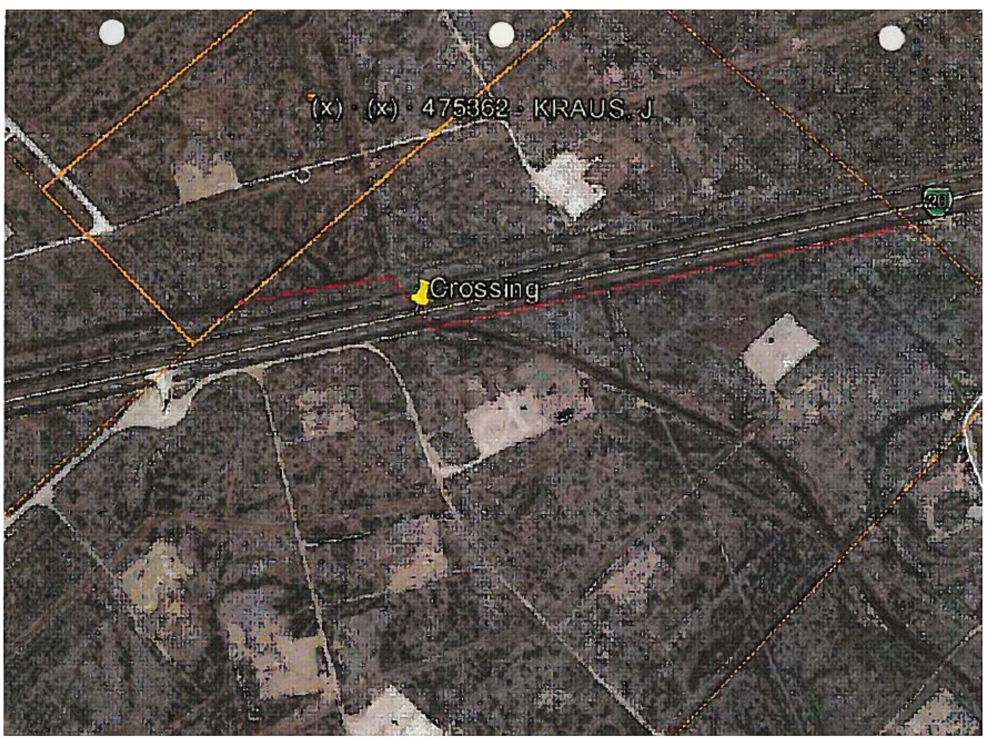


Figure 5. Examples of Problematic Maps Submitted by Operators.

The GIS database of historical temporary pipelines facilitated the completion of a variety of analyses. For example, Figure 6 shows a map of temporary pipeline locations in the Eagle Ford Region. For completeness, Figure 6 also shows well locations that were completed in the region from 2011 to 2016. Notice that temporary pipelines were used throughout the region, but the geographic distribution was not uniform.

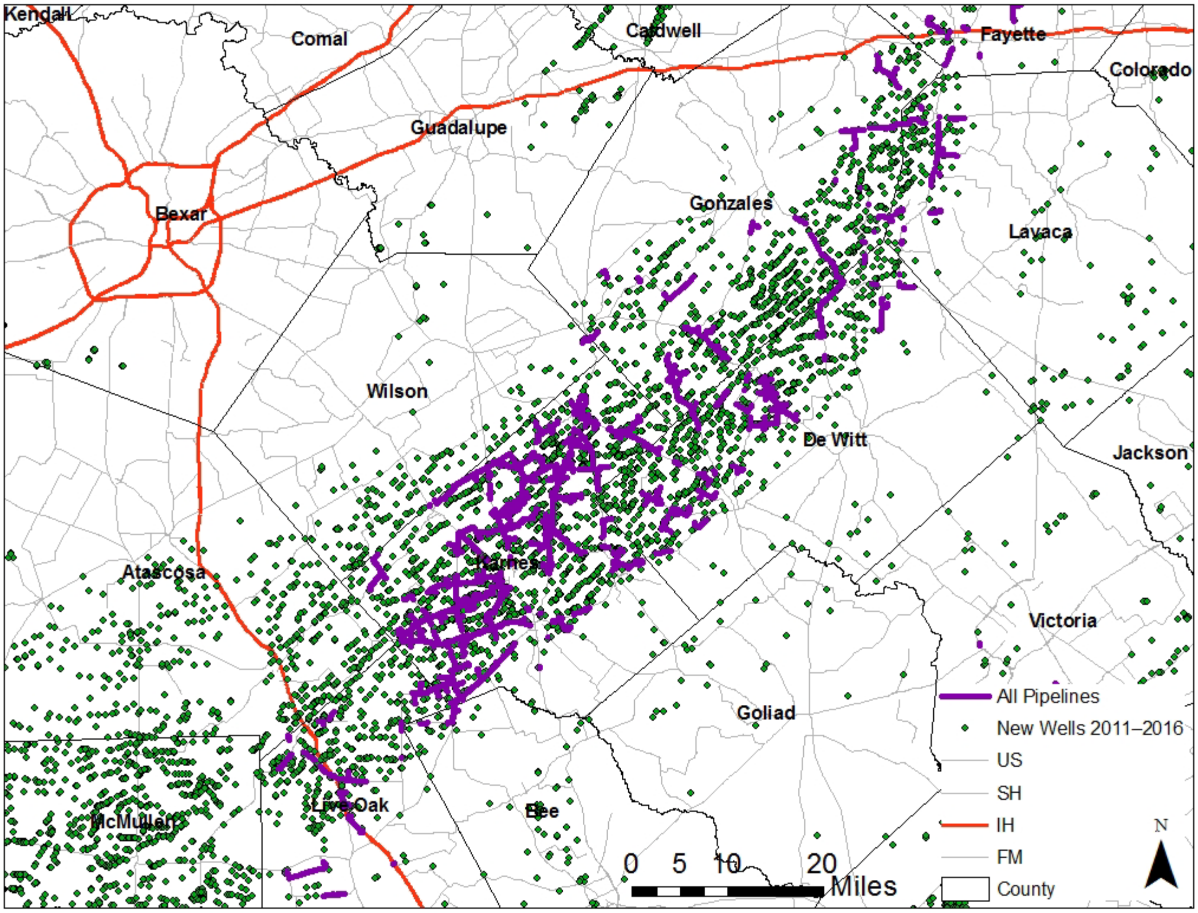


Figure 6. Temporary Pipeline Locations in the Eagle Ford Region.

Figure 7 shows color-coded state roadway segments in the Eagle Ford Region where temporary pipelines were installed. The roadway segments are color-coded depending on the amount of time that temporary pipelines occupied each roadway segment during the entire study period (July 2011 through August 2016). Figure 7 also shows a zoomed-in view of Karnes County and part of DeWitt County that experienced significant temporary pipeline installation activity during the study period. Notice that certain corridors were used extensively (e.g., FM 1144 and FM 882, which experienced temporary pipelines for more than 36 months (i.e., three years). Other corridors experienced temporary pipelines for more than a year (e.g., State Highway [SH] 80, SH 119, FM 99, FM 238, FM 626, FM 1353, and FM 2102).

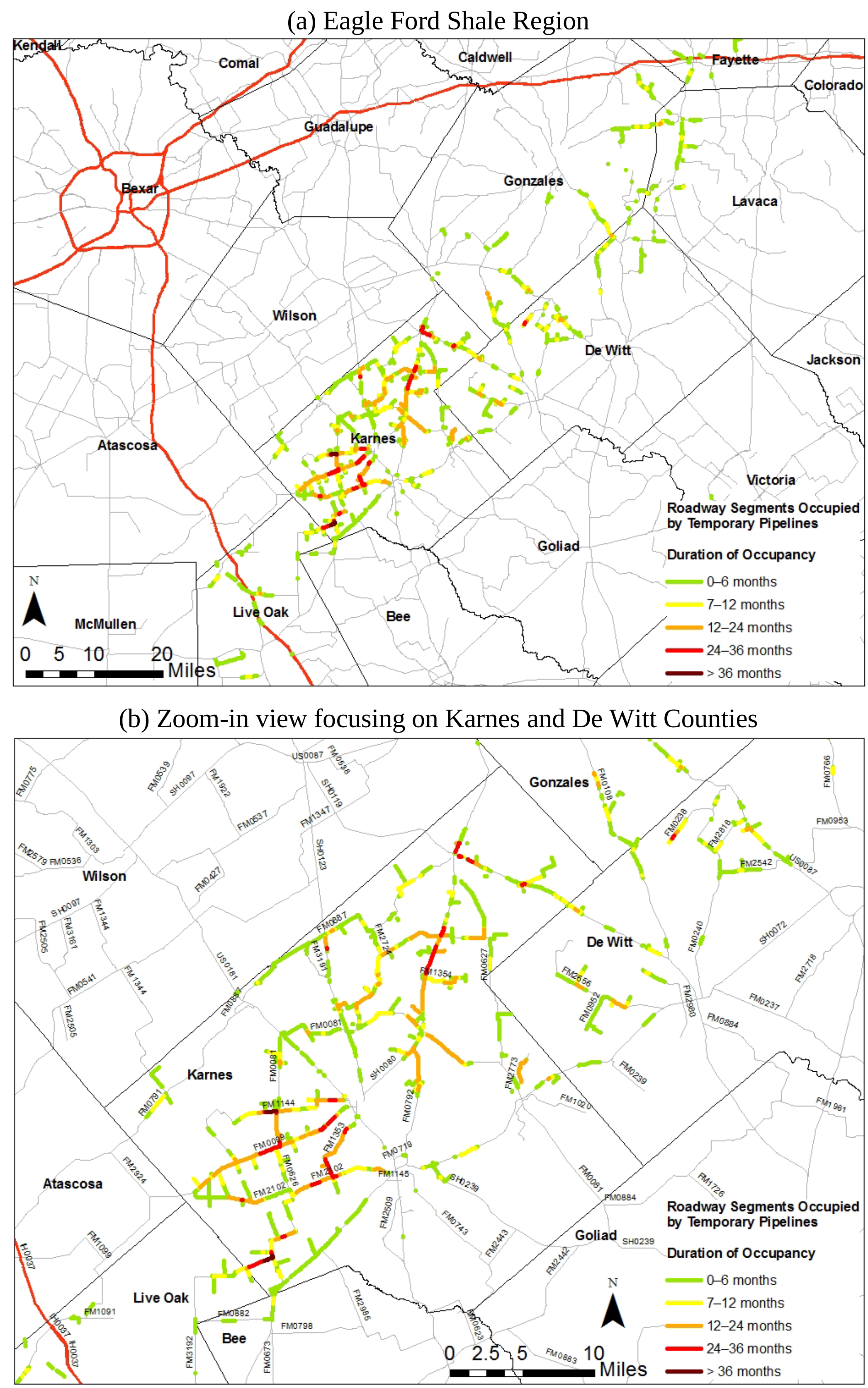


Figure 7. Roadway Segments with Temporary Pipelines in the Eagle Ford Shale Region.

In the absence of exact temporary pipeline installation and removal dates, the main assumption for the development of the map shown in Figure 7 was that each temporary pipeline was installed on the start date indicated on the permit and remained on the right of way for 90 days, which was the duration approved in the permit. Longer occupancy periods were not considered in the analysis except in cases where operators resubmitted a permit application at the same location.

The installation of temporary pipelines varied significantly from year to year, mirroring variations in the level of oil and gas well development activity. As an illustration, Figure 8 through Figure 10 show the location of temporary pipelines installed in the Eagle Ford Region by year from 2011 to 2016. The number of temporary pipelines was particularly noticeable in 2013, 2014, and 2015, when high oil prices resulted in a significant number of wells being developed in the area.

Temporary pipelines installed in Texas varied from 2–12 inches in diameter. Table 4 shows the number of pipelines by size in each district. Smaller sizes (typically 3 or 4 inches in diameter) are used for drilling. Pipelines used for hydraulic fracturing are typically 8 or 10 inches in diameter. Figure 11 shows that 8- and 10-inch temporary pipelines are the most common, followed by 3- and 4-inch temporary pipelines.

Table 5 shows the number of temporary pipelines permitted per district and county. In most cases, the number of temporary pipelines increased in 2014 compared to 2013 and decreased in 2015 compared to 2014. This corresponds with the overall trend in oil prices and drilling activity. Of all the temporary pipeline permits received by the Corpus Christi District, 94 percent of them were for installations in Karnes County. In the Yoakum District, 54 percent of the permits received were for DeWitt County and 25 percent were for Gonzalez County. For the Odessa District, 43 percent of the permits received were for installations in Reeves County.

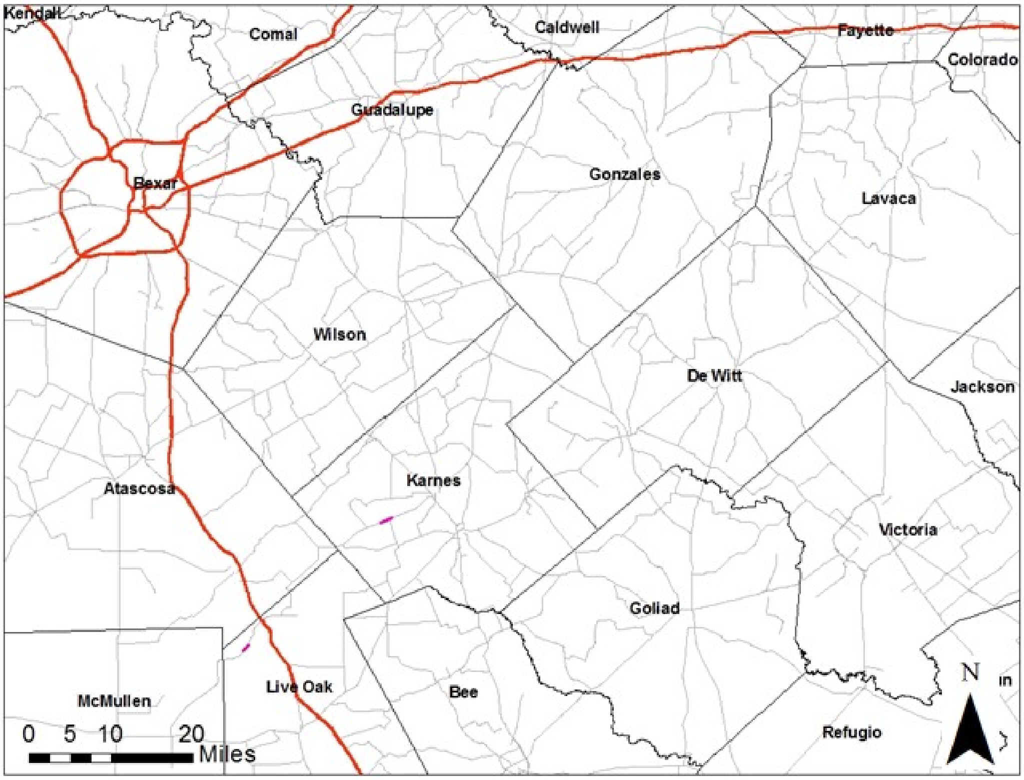
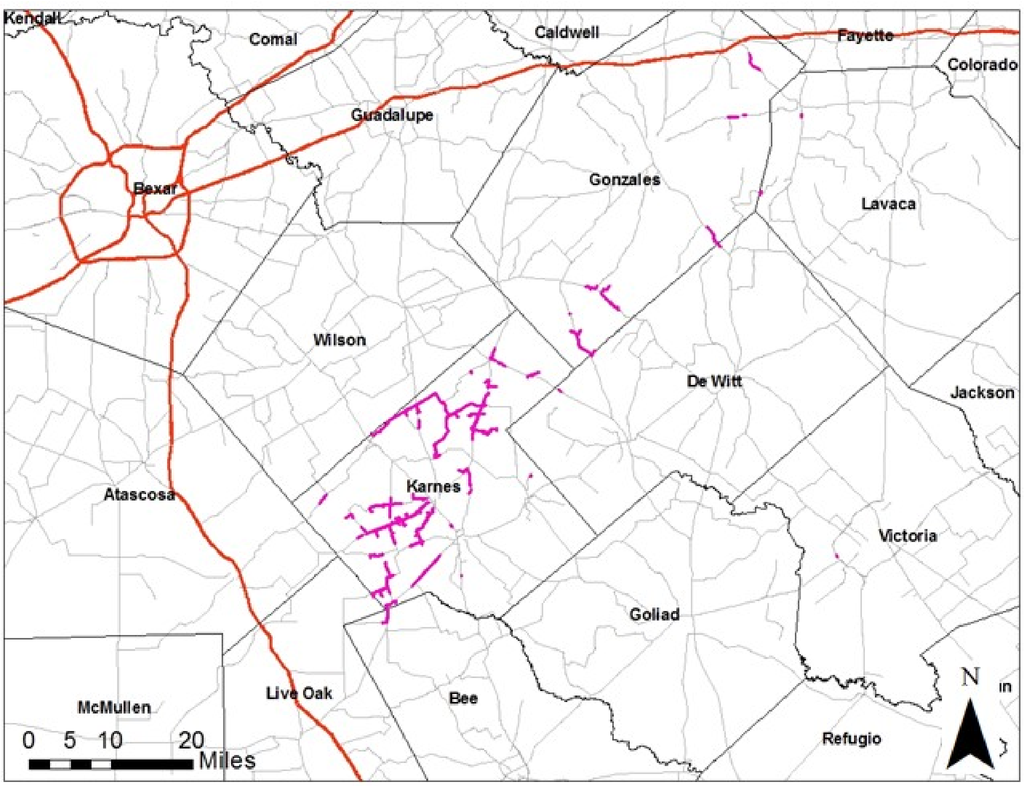
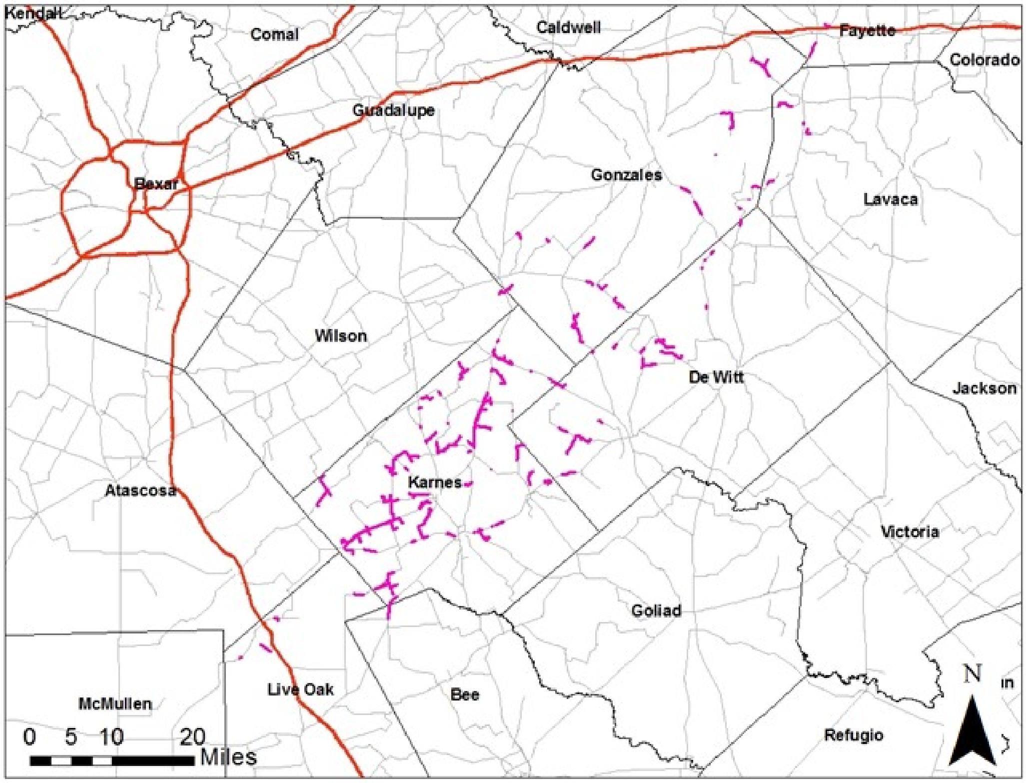
2011	
2012	

Figure 8. Location of Major Temporary Pipeline Concentrations in 2011 and 2012.

2013



2014

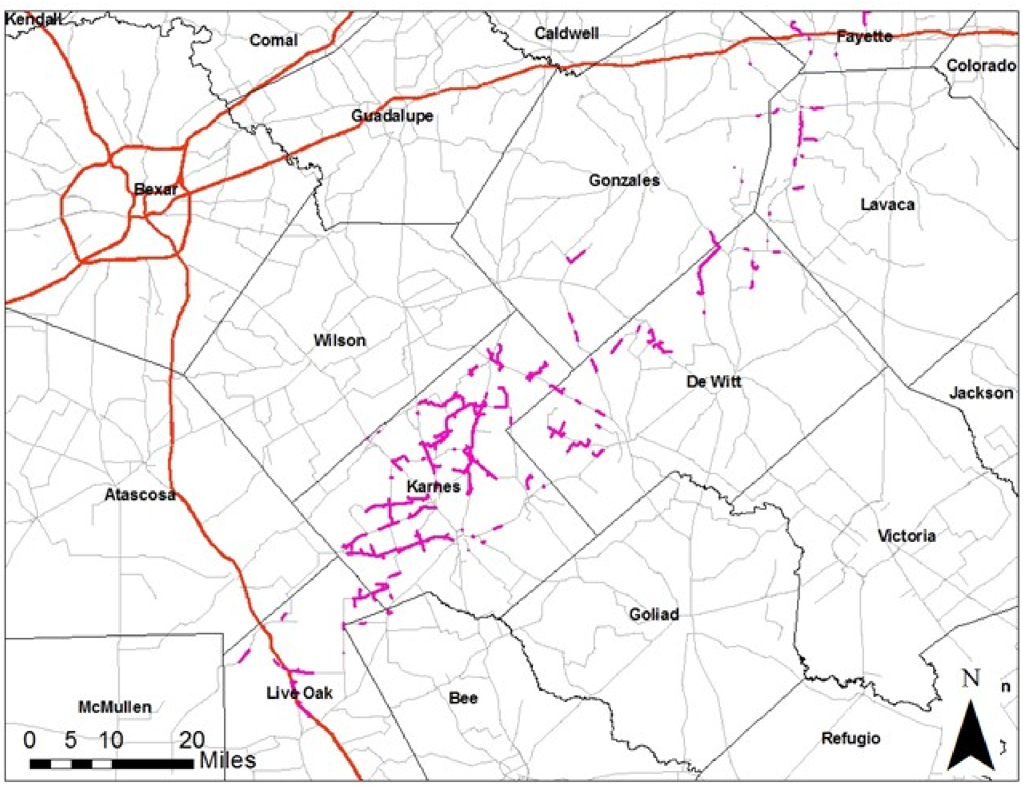
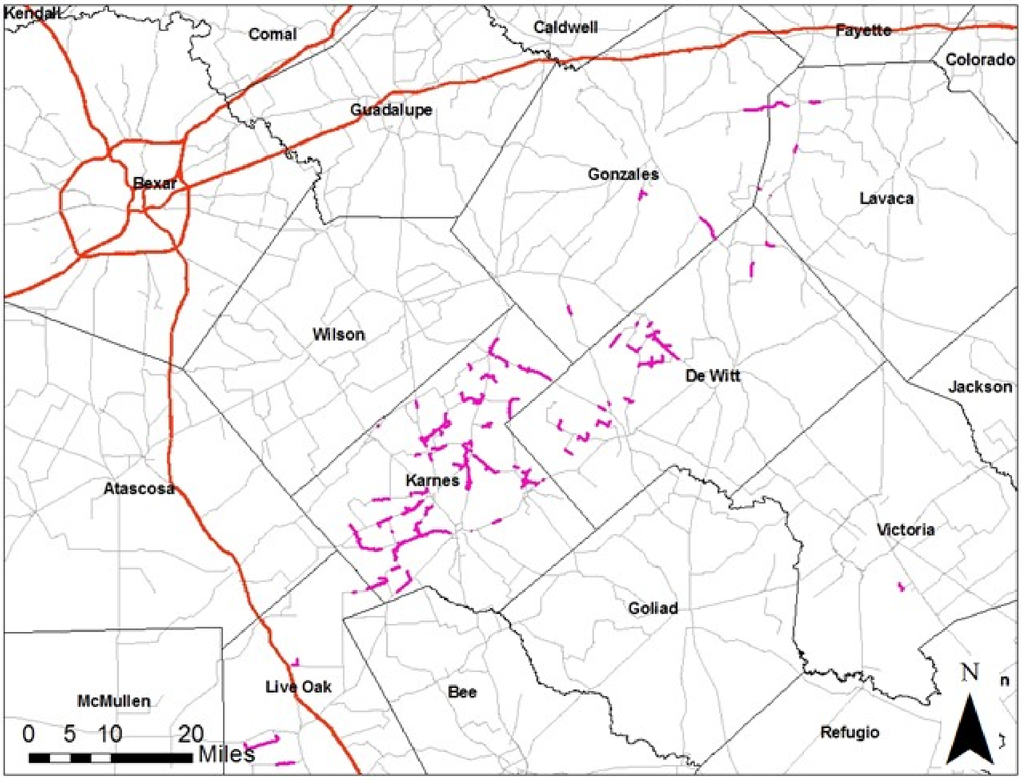


Figure 9. Location of Major Temporary Pipeline Concentrations in 2013 and 2014.

2015



2016

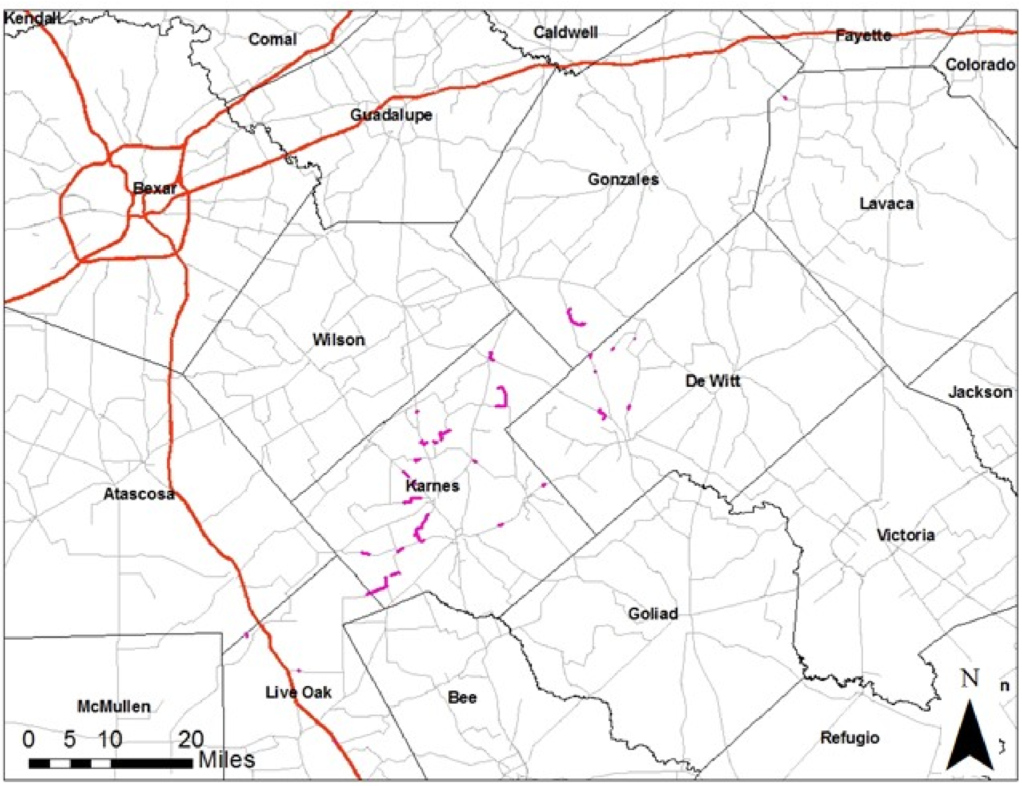


Figure 10. Location of Major Temporary Pipeline Concentrations in 2015 and 2016.

Table 4. Number of Temporary Pipelines of Various Sizes in Each District.

District	Pipeline Diameter (inches)							
	2	**3**	**4**	**6**	**8**	**10**	**12**	**Unknown**
Corpus Christi	1	177	76	2	439	313	0	0
Fort Worth	0	0	2	0	0	9	0	0
Laredo	0	4	3	0	4	15	0	1
Lubbock	0	2	1	1	1	3	0	0
Odessa	0	4	4	0	7	10	3	0
San Angelo	0	4	11	0	9	13	2	1
Yoakum	0	53	46	0	68	126	2	9
Total	**1**	**244**	**143**	**3**	**528**	**489**	**7**	**11**

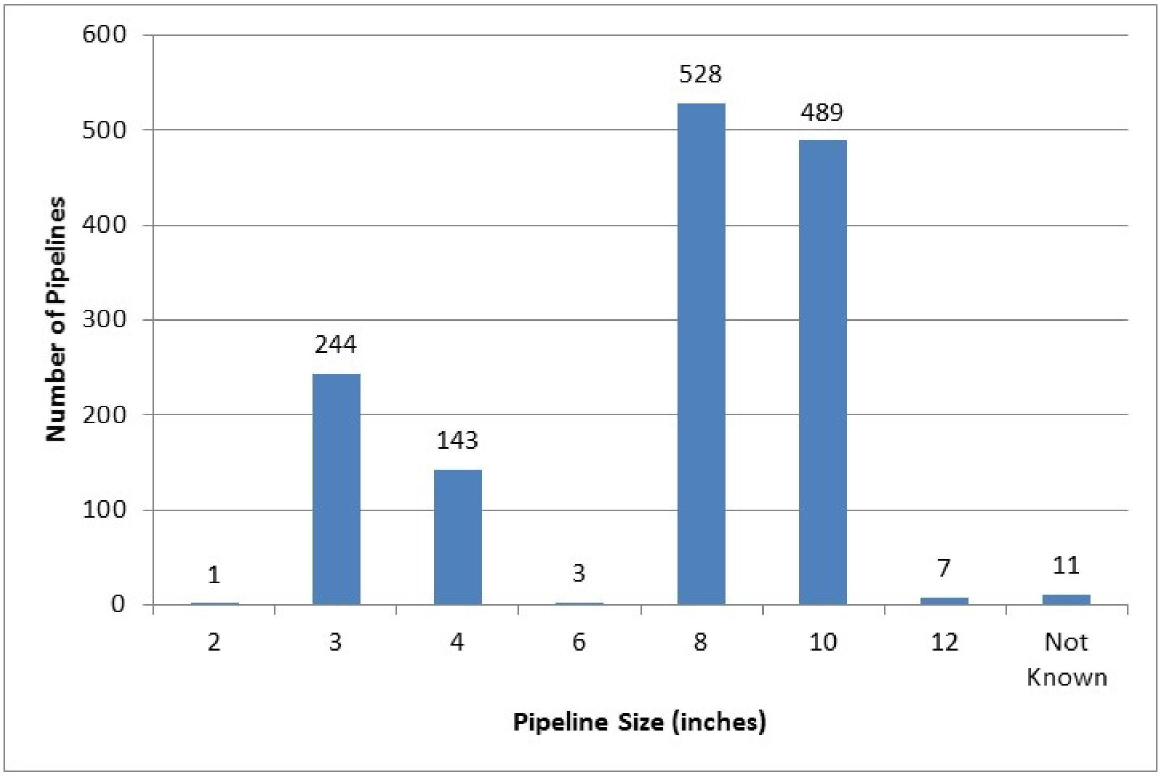


Figure 11. Number of Temporary Pipelines of Various Sizes.

Table 5. Number of Temporary Pipelines Permitted per County Each Year.

County	2011	2012	2013	2014	2015	2016	Total
Corpus Christi District							
Bee	0	0	0	2	0	0	2
Karnes	2	205	202	300	213	37	959
Live Oak	0	0	4	27	8	5	44
Nueces	0	0	0	0	2	0	2
San Patricio	0	0	0	0	1	0	1
District Total	**2**	**205**	**206**	**329**	**224**	**42**	**1008**
Fort Worth District							
Jack	0	0	0	0	0	1	1
Johnson	0	0	0	0	2	0	2
Tarrant	0	0	0	0	4	0	4
Wise	0	0	0	0	2	2	4
District Total	**0**	**0**	**0**	**0**	**8**	**3**	**11**
Laredo District							
Dimmit	0	0	0	0	6	0	6
La Salle	0	0	0	0	14	2	16
Maverick	0	0	0	0	2	0	2
Zavala	0	0	0	0	3	0	3
District Total	**0**	**0**	**0**	**0**	**25**	**2**	**27**
Lubbock District							
Cochran	0	0	0	1	0	0	1
Dawson	0	0	0	2	0	0	2
Gaines	0	1	0	0	0	0	1
Lynn	0	1	1	0	0	0	2
Yoakum	0	0	1	0	1	0	2
District Total	**0**	**2**	**2**	**3**	**1**	**0**	**8**
Odessa District							
Andrews	0	0	0	0	2	1	3
Loving	0	0	0	0	1	1	2
Martin	0	0	0	0	1	1	2
Midland	0	0	0	0	2	1	3
Pecos	0	0	0	0	1	2	3
Reeves	0	0	0	0	7	5	12
Upton	0	0	0	0	0	2	2
Ward	0	0	0	0	0	1	1
District Total	**0**	**0**	**0**	**0**	**14**	**14**	**28**
San Angelo District							
Crockett	0	0	0	7	4	0	11
Glasscock	0	0	0	7	2	0	9
Irion	0	0	0	4	2	0	6
Reagan	0	0	0	12	1	0	13
Tom Green	0	0	0	0	1	0	1
District Total	**0**	**0**	**0**	**30**	**9**	**0**	**40**
Yoakum District							
Cuero	0	0	0	0	1	0	1
DeWitt	0	1	35	75	45	9	165
Fayette	0	0	4	8	0	0	12
Gonzales	0	23	36	11	8	1	79
Lavaca	0	3	7	18	12	2	42
Victoria	0	1	0	0	1	0	2
Wharton	0	0	0	2	0	0	2
Wilson	0	0	1	0	0	0	1
District Total	**0**	**28**	**83**	**113**	**67**	**12**	**304**

The 1426 permitted temporary pipelines covered a total distance of 1876 miles with an average length of 1.3 miles. Most of the temporary pipelines in the San Angelo District were only crossing through a culvert and not longitudinal installations, thus explaining why the average length was 0.2 miles. Table 6 shows the length of temporary pipelines installed on different types of routes. While the type of route does not necessarily dictate whether or not a temporary pipeline is installed, it is important to note that different route types have different geometric characteristics, including roadside widths and slopes. For example, most FM roads in oil producing regions have narrower right-of-way widths than U.S. routes.

Table 6. Length of Permitted Temporary Pipelines by Route Type in Each District.

District	Total Length by Route Type (miles)							Total Length (miles)	Average Permitted Length (miles)
	BI	CR	FM	IH	RM	SH	US		
Corpus Christi	0	0	1046	9	0	377	12	1444	1.4
Fort Worth	0	0	1	3	0	2	1	7	0.6
Laredo	0	0	37	0	0	18	1	56	2.1
Lubbock	0	2	2	0	0	2	0	6	0.8
Odessa	1	0	3	0	0	6	28	38	1.4
San Angelo	0	0	0	0	2	3	2	7	0.2
Yoakum	0	0	193	0	0	31	94	318	1.0
Total	**1**	**2**	**1282**	**12**	**2**	**439**	**138**	**1876**	**1.3**

Figure 12 shows the relative cumulative distribution of temporary pipeline lengths. The median length was 0.94 miles, and the mean length was 1.3 miles. The 80th and 90th percentiles were 2.0 miles and 2.9 miles, respectively. The maximum temporary pipeline length was 11 miles.

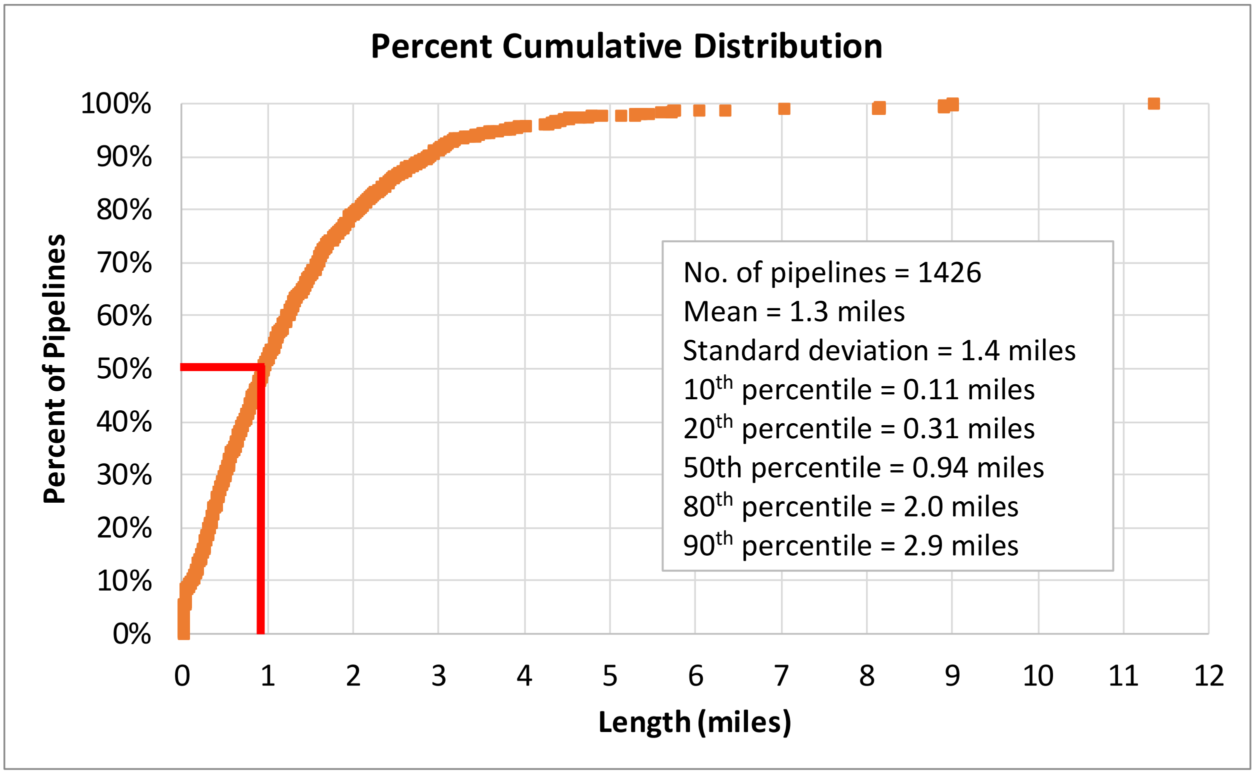


Figure 12. Relative Cumulative Distribution of Temporary Pipeline Lengths.

The researchers conducted a more disaggregated analysis that involved dividing each TxDOT Road-Highway Inventory Network (RHiNo) roadway segment into subsegments at break points that corresponded to the start and end points of each temporary pipeline. The end result was a list of smaller segments, all of which were occupied by temporary pipelines during the period of analysis. Table 7 provides a summary of trends derived from this analysis. A description of each of the columns in this table follows:

- **Roadway Segments by Number of Temporary Pipeline Permits**. This column shows a grouping of different segment types according to the total number of temporary pipeline permits that were issued for each segment during the study period. The range in the number of temporary pipeline permits per segment was 1 through 24.
- **Total Length (miles)**. This column shows the total length of the segments per number of permits. Overall, 415 roadway miles were occupied by one or more pipelines during the study period.
- **Length (%)**. This column shows the total length of the segments as a percentage of the total length of the examined network. For example, segments that involved only one permit covered 51.5 percent of the 415 miles of roadways where there were permits.
- **Cumulative Length (%)**. This column shows the cumulative length percentage for each segment group. For example, segments that involved up to five permits covered close to

90 percent of the 415 miles of roadways where there were permits. Only 10 percent of the 415 miles of roadways where there were permits involved more than five permits.

- **Average Duration (months)**. This column shows the average time period (months) during which segments where occupied by pipelines. For example, segments that had one permit were occupied for three months on average. Segments that had two permits were occupied by pipelines for 5.6 months on average. With a few exceptions, the average duration of pipeline occupancy increased with the number of permits.

- **Duration as Percent of Study Period**. This column shows the average occupancy duration as a percentage of the total study period (5.1 years).

- **Average Number of Operators**. This column shows the average number of operators per segment group. Not surprisingly, the average number of operators increased with the number of permits per segment group.

Table 7. Descriptive Statistics of Roadway Segments Occupied by Temporary Pipelines.

Roadway Segments by Number of Temporary Pipeline Permits	Roadway Length			Duration of Occupancy		Average Number of Operators
	Total Length (miles)	Length (%)	Cumulative Length (%)	Average Duration (months)	Duration as Percent of Study Period*	
Segments with 1 permit	213.9	51.5%	51.5%	3.0	5%	1
Segments with 2 permits	82.5	19.9%	71.4%	5.6	9%	1-2
Segments with 3 permits	37.2	9.0%	80.3%	8.1	13%	1-2
Segments with 4 permits	16.5	4.0%	84.3%	9.9	16%	2-3
Segments with 5 permits	19.4	4.7%	89.0%	13	21%	2-3
Segments with 6 permits	9.2	2.2%	91.2%	15	24%	2-3
Segments with 7 permits	6.9	1.7%	92.9%	17	28%	2-3
Segments with 8 permits	8.3	2.0%	94.9%	18	30%	3-4
Segments with 9 permits	4.8	1.2%	96.0%	21	34%	3-4
Segments with 10 permits	2.4	0.6%	96.6%	21	35%	3-4
Segments with 11 permits	2.3	0.6%	97.2%	22	36%	3-4
Segments with 12 permits	2.6	0.6%	97.8%	25	41%	4-5
Segments with 13 permits	1.9	0.5%	98.3%	28	45%	4-5
Segments with 14 permits	1.0	0.2%	98.5%	26	43%	4-5
Segments with 15 permits	2.4	0.6%	99.1%	28	45%	4-5
Segments with 16 permits	0.7	0.2%	99.3%	33	54%	4-5
Segments with 17 permits	0.7	0.2%	99.4%	30	49%	4-5
Segments with 18 permits	0.5	0.1%	99.5%	31	51%	4-5
Segments with 19 permits	0.6	0.1%	99.7%	34	56%	5-6
Segments with 20 permits	0.3	0.1%	99.8%	38	62%	5-6
Segments with 21 permits	0.1	0.0%	99.8%	36	58%	5-6
Segments with 22 permits	0.5	0.1%	99.9%	41	67%	5-6
Segments with 23 permits	0.3	0.1%	100.0%	36	58%	6-7
Segments with 24 permits	0.2	0.0%	100.0%	42	68%	6-7
Segments with 1-24 permits (TOTAL)	**415.1**	**100%**				

* Note: The total duration of the study period was from 7/22/2011 to 8/11/2016.

INDUSTRY PRACTICES

This section describes temporary pipeline materials, design, construction, operations, and maintenance practices. The information was gathered through conversations with temporary pipeline operators and TxDOT officials as well as field visits.

Temporary Pipeline Materials

When the shale energy boom started, water operators first began using aluminum pipelines (also known as irrigation pipelines because they are commonly used in agriculture) to transport water to well sites. Figure 13 shows a temporary pipeline installation using aluminum pipelines in the Barnett Shale Region. Aluminum temporary pipelines are rigid, which makes them difficult to install and repair. These pipelines are commonly manufactured in 30-foot segments, resulting in many joints. Water leaks are common with aluminum pipelines, especially at the joints. Construction crews often place extra segments of aluminum pipeline along a route in case a section is damaged or needs to be replaced during operation, as shown in Figure 13.

Figure 13. Temporary Aluminum Pipeline in the Barnett Shale Region.

Because of the difficulty in installing and repairing temporary aluminum pipelines, operators began to use other types of pipelines such as high-density polyethylene (HDPE) and lay-flat pipelines (Figure 14). Polyethylene pipelines are made of a polymer material, while lay-flat pipelines are made of polyurethane or woven synthetic yarns and collapse when not in use (*22*, *23*). Polyethylene pipelines and lay-flat temporary pipelines generally serve different purposes. Polyethylene temporary pipelines are usually 3 or 4 inches in diameter and are used during the drilling phase of well development. Lay-flat temporary pipelines are 8 or 10 inches in diameter and are used during hydraulic fracturing or well completion activities.

(a) Polyethylene pipeline

(b) Lay-flat pipeline

Figure 14. Polyethylene and Lay-Flat Temporary Pipelines.

Polyethylene and lay-flat pipelines are lighter, more durable, and have longer segments than aluminum temporary pipelines. According to operators, when polyethylene and lay-flat pipelines are installed and maintained properly, leaks occur infrequently and are easy to repair. Pinhole leaks are the most common type of leak and can easily be patched. If a rupture occurs, the pipeline is clamped on either side of the break and a new segment is cut and inserted.

Temporary Pipeline Design and Construction

According to water pipeline operators, pipeline routes are usually dictated by oil company's land men. Land men secure agreements with landowners for leasing mineral rights and using surface lands for well development including but not limited to access roads, equipment storage, oil and gas pipelines, and temporary pipelines. Land departments determine where temporary pipelines enter and leave private property based on where they have secured agreements with landowners. Installing temporary pipelines using the shortest physical path from a water source to a drilling location is not always feasible due to culvert locations and landowner lease agreements. Pumps are used to maintain the pressure in the pipeline to keep water flowing. The need for pumps varies depending on factors such as the length of temporary pipeline and terrain conditions. In general, TxDOT does not allow pumps to be placed within state right of way.

A large number of manufacturers produce polyethylene and lay-flat pipelines. The researchers evaluated data from some 30 vendors of pipelines for water transfer. Little information was available regarding recommended maintenance and inspection schedules or expected pipeline lifespans. Most of the information available was related to sizes, materials, pressures, and flow rates, as shown in Table 8.

Table 8. Temporary Pipeline Specifications for Polyethylene and Lay-Flat Pipelines.

Material	Diameter (inches)	Operating Pressure (psi)	Burst Pressure (psi)	Flow Rate (bpm*)	Deployment Rate	Retrieval Rate
Polyethylene	2–12	100–300	220–600	40–140	10 miles/day	10 miles/day
Lay-Flat	1–12	100–400	220–1200	40–140	2–5 mph	0.5 mph

* bpm = barrels per minute.

Pipeline installation practices vary depending on the pipeline material. Aluminum temporary pipelines must be unloaded and positioned by hand to ensure they are not damaged. Although many types of clamps can be used to join aluminum pipeline segments, clamping usually must be done by hand. Ease of construction is one the reasons the industry now predominately uses polyethylene and lay-flat temporary pipelines. These temporary pipelines usually come on a spool which is towed behind a truck. The spool may be mechanically operated to easily install and retrieve pipelines. Polyethylene and lay-flat temporary pipeline segments must be joined by hand, but the segments are much longer, resulting in fewer joints than aluminum pipelines.

Temporary pipelines that are installed longitudinally within the right of way often cross driveways and other property entrances. To prevent blocking driveway culverts and flooding roads, TxDOT does not allow temporary pipelines to be placed in culverts under driveways. Temporary pipelines range in size from 3 to 10 inches, which could make access driveways impassable. As a result, several types of driveway crossing structures are commercially available, including driveway ramps and manifolds, as shown in Figure 15.

Typically, driveway ramps are used for drilling pipelines (3- and 4-inch), and manifolds are used for fracking pipelines (8- and 10-inch). Driveway ramps and manifolds provide a method for vehicles to cross over temporary pipelines without damaging the vehicle or pipeline and have the added benefit of anchoring the temporary pipeline in place. Some landowners prefer operators to build ramps using caliche or dirt to provide a gradual transition over temporary pipelines.

Roadside terrain affects where temporary pipelines are installed and whether they need to be anchored. TxDOT requires temporary pipelines to be installed against the right-of-way fence if possible, and suggests using wooden stakes to anchor temporary pipelines in place if they are installed on a slope. Lay-flat temporary pipelines move when filling up with water and often break the wooden stakes used to secure the temporary pipeline in place. For this reason, operators began using metal fence posts to anchor temporary pipelines.

(a) Crossing ramp

(b) Manifold

Figure 15. Temporary Pipeline Driveway Crossing Ramp and Manifold.

Particularly at low elevation points such as ditches, pipelines could wash out during rain storms. Figure 16 shows one operator's solution to securing a temporary pipeline at a low elevation point near a culvert. Notice that posts were placed on both sides of the temporary pipelines to keep the pipelines in place during rain storms. Sleeves (the black tubes at the bottom of the fence posts in Figure 16) are used to reduce friction when temporary pipelines come into contact with the edge of the posts. Sleeves need to be secured to the bottom of the posts; otherwise the friction between the pipeline and the sleeve sometimes pushes the sleeve up the post, causing the pipeline to rub against the metal post. While metal fence posts could secure a pipeline in place during rain events, the crash worthiness of these posts has not been tested and could be problematic depending on their location and size. In addition, if metal stakes are driven too deep into the ground, they could interfere with underground utilities.

Figure 16. Metal Fence Posts Used to Anchor a Temporary Pipeline in a Drainage Location.

Temporary Pipeline Operations and Maintenance

When temporary pipelines are installed, they are commonly pressure tested to locate leaks and weak spots. These locations may be repaired by patching small holes or replacing damaged sections of the temporary pipeline. The environmental impact of leaks and spills in temporary pipelines transporting water is a function of the amount of TDS in the water. Both TxDOT officials and pipeline operators use terms such as saltwater and fresh water to describe the water transported in temporary pipelines. At this time, TxDOT has not developed limits for what are deemed acceptable TDS ranges for the water being transported in temporary pipelines.

Inspection strategies for temporary pipelines in operation vary depending on the operator. Some operators indicated that they walk the extent of the pipeline when they initially begin pumping water, while other operators indicated that they only drive along the road and look for leaks. Another operator stated that they conduct inspections throughout the day and maintain a maintenance log during shift changes. All operators indicated that they inspect temporary pipelines to some degree while water is being pumped. This inspection is to ensure that water arrives at its intended location as quickly as possible.

Drainage Issues

As noted, TxDOT does not allow temporary pipelines to be placed in culverts under driveways. Despite this prohibition, some operators install temporary pipelines through driveway culverts, as shown in Figure 17. Typically, driveway culverts have smaller diameters than roadway culverts. A temporary pipeline occupying a small-diameter driveway culvert has a significant impact on the hydraulic conveyance of these culverts, dramatically increasing the risk of flooding during heavy rain events. For this reason, TxDOT requires the use of driveway ramps, manifolds, or some other method approved by the landowner when temporary pipelines cross driveways.

Figure 17. Temporary Pipeline Installed in Driveway Culvert.

A similar drainage issue is one in which a temporary pipeline crosses a driveway at the lowest point (usually where the roadside ditch is located), with ramps added on either side of the pipeline. In the example shown in Figure 18, the ramps apparently were built with a mix of pavement aggregate and asphalt, further limiting the hydraulic conveyance of the roadside ditch. In this instance, the asphalt transition makes drainage worse by raising the elevation at the location where water would be flowing.

Figure 18. Temporary Pipeline Ramp Installed at Low Point of Right of Way with Asphalt Transition.

Instances when temporary pipelines burst and leak large amounts of water are relatively uncommon, although reliable statistics do not exist. Some TxDOT officials expressed concern about finding large roadside patches where salt crystals were visible on the surface of the ground and roadside vegetation had died. These locations were often along routes where temporary pipelines had been permitted in the past, but the pipelines had long been removed from the right of way.

According to operators, pinhole leaks are more common than large bursts. Figure 19 shows a small pinhole leak on a polyethylene pipeline. Pinhole leaks do not discharge large amounts of water quickly, but some flooding is possible depending on how long the pipeline is left unrepaired and the terrain of the location.

Pipeline leaks over water bodies are particularly problematic. In the example shown in Figure 20, the temporary pipeline leak occurred at the joint between two pipeline segments, which was located directly above the water body. There was no information about the TDS of the water being transported, and specific environmental issues were not documented formally. However, TxDOT personnel noted anecdotally that vegetation downstream from where this leak occurred appeared to be dead.

Figure 19. Temporary Pipeline Small Pinhole Leak.

(Courtesy of TxDOT)

Figure 20. Temporary Pipeline Water Leak on a Water Stream in the Eagle Ford Shale Region.

When temporary pipelines are installed through culverts, operators occasionally have difficulty removing pipeline sections from the culverts. When this happens, some operators end up damaging the safety end treatment in their effort to remove the pipeline or simply decide to leave the temporary pipeline in place. In other instances, some operators remove safety end treatments to install temporary pipelines. This practice is more common with rigid aluminum temporary pipelines but is still observed occasionally with polyethylene and lay-flat temporary pipelines.

Figure 21 shows a polyethylene pipeline that was cut and abandoned in a culvert. In this particular instance, the pipeline was small and, therefore, it would be tempting to assume that the impact on the hydraulic conveyance of the culvert would be negligible. However, notice that even a small pipeline is an obstruction to water flow and, as such, can increase the amount of sediments in the culvert, reducing the effective cross-sectional area of the culvert structure. Obviously, as the size of the temporary pipeline that was left in place within a culvert increases, the negative impact on drainage and hydraulic conveyance also increases.

Figure 21. Temporary Pipeline Cut and Left in Place in a Culvert.

Roadside Safety Issues

Temporary pipelines are frequently located close to the edge of the pavement within the clear zone. TxDOT requires operators to install temporary pipelines away from the clear zone and as close to the right-of-way line as possible. However, there is often vegetation that must be cleared to install pipelines against the right-of-way line. As a result, operators install temporary pipelines close to the edge of vegetation rather than against the right-of-way line. In the example shown in Figure 22, because of vegetation growth close to the right-of-way line, the temporary pipeline was placed close to the edge of the pavement, at times within the clear zone.

Figure 22. Temporary Pipeline Installation around Vegetation.

Temporary pipelines tend to move downward when located on sloped surfaces. They also tend to drift because of pressure changes when water is being pumped. For this reason, TxDOT recommends that operators use wooden stakes to keep temporary pipelines in place. However, several operators noted that wooden stakes are not strong enough to keep temporary pipelines in place and frequently break when temporary pipelines move. As a result, operators began using metal fence posts to anchor temporary pipelines, as shown in Figure 23. Notice the close proximity of the posts to the edge of pavement. As mentioned, the crash worthiness of these posts has not been tested and could be problematic depending on their location and size.

Miscellaneous Temporary Pipeline Issues

Most TxDOT districts require signage to be placed where temporary pipelines cross the right-of-way line. However, district officials have noted that operators very rarely install signs. These signs are meant to provide contact information in case of an emergency. Several districts noted that the information on signs was outdated or did not provide a local contact who could respond in an emergency. Figure 24 shows a pipeline crossing the right-of-way line without a sign in a TxDOT district that requires signage.

Figure 23. Metal Fence Posts Used to Anchor a Temporary Pipeline.

Figure 24. Temporary Pipelines Crossing Right-of-Way Line without Signage.

LEASE FEE COMPARISON ANALYSIS

As authorized by the Texas Legislature, TxDOT began using lease agreements in 2016 for the placement of saltwater pipelines within the right of way. Under the lease program, operators pay a lease fee of $2,500 for each temporary pipeline up to seven miles in length. The fee structure is such that $2,500 is charged for every seven miles of temporary pipeline (i.e., 0–7 miles is $2,500, 7–14 miles is $5,000, and so on). The purpose of the fee is to recoup the costs associated with reviewing and monitoring leases. However, the law also establishes that the lease amount may not be less than the fair market value.

The scope of the research did not include conducting a comprehensive review of lease fee structures (for among other reasons, because the research started when temporary permits were the regular instrument to authorize the installation of temporary saltwater pipelines within the right of way). Nevertheless, during interviews with other agencies, the researchers learned about instances where fees were in place to authorize the occupation of the right of way. For example, Reeves County in the Permian Basin Region charges $14 per rod (1 rod = 16.5 feet) or $4,480 per mile in addition to a $500 application fee.

Using the spatial database of temporary pipelines described earlier, the researchers conducted a preliminary analysis of the revenue that would have been generated if the lease program had been in place since 2011. The purpose of the analysis was to provide an estimate of the typical revenue that might realistically be generated in the future as a function of the number of leases and their length in any given year (rather than to demonstrate a case of missed opportunities because the lease program was not in place). For the 1091 permits analyzed, which involved 1426 temporary pipelines and 1846 miles of temporary pipelines (see Table 3 and Table 7), the equivalent revenue using TxDOT's current lease fee structure would be $3.5 million. By comparison, using a lease fee structure similar to that used in Reeves County, the equivalent revenue would be $9.1 million.

CHAPTER 3. CURRENT PRACTICES AT OTHER AGENCIES

INTRODUCTION

This chapter summarizes existing standards, specifications, and technical literature related to the design, construction, and operation of temporary pipelines at other agencies. The researchers searched for available literature and contacted federal and state agencies to determine how temporary pipelines are accommodated in other parts of the country. In particular, the researchers reviewed practices at the Bureau of Land Management (BLM), the U.S. Army Corps of Engineers (USACE), and various state agencies.

FEDERAL AGENCIES

Bureau of Land Management

The BLM is currently developing formal standards for the installation of temporary pipelines. In the meantime, the BLM conveys the following requirements to operators seeking to install temporary pipelines:

- Water being transported must contain TDS that does not exceed 10,000 mg/L. At this level, the BLM's assumption is that contamination from leaks or spills is relatively minor.
- Water being transported cannot contain any petroleum sheen.
- Temporary pipelines can have a maximum size of 4 inches and be operated at a maximum pressure of 325 psi. Multiple temporary pipelines can be permitted parallel to one another.
- The BLM allows temporary pipelines to be in place for up to one year.

The BLM allows exceptions to the 4-inch maximum size rule when transferring water a short distance for drilling and hydraulic fracturing. Operators transport water in 4-inch temporary pipelines from the water source to the well site and fill a temporary pond or water tanks prior to drilling and completion. Larger temporary pipelines are allowed for up to ten days for drilling and completion.

Initially when operators approached the BLM to install temporary pipelines, they were told to apply for a right-of-way lease that required a National Environmental Policy Act (NEPA) review and environmental assessment. At the time, the BLM estimated it would take approximately four to five months to review and approve temporary pipeline applications using this process. Due to the length of time required for approval, very few operators applied for right-of-way leases. To speed up the process, the BLM identified a categorical exclusion under NEPA rules on which the agency could base approval of temporary pipeline installations quickly. It now takes about a week to approve a temporary pipeline request, and operators are sent a letter of approval once the review is completed. It is worth noting that a categorical exclusion classification implies that the impact on the human environment is not significant. It was not clear whether the BLM conducted field evaluations to verify that this was indeed the case for prior installations or whether this was based on preliminary high-level assessments.

Because of the use of a category exclusion to expedite the approval process, the BLM introduced several additional requirements, including the following:

- Temporary pipelines must be routed around any environmentally sensitive areas.
- Temporary pipelines cannot impede access to any driveways or entrances. Operators must bury pipelines or use temporary driveway crossings such as driveway ramps or manifolds.
- Operators must install temporary pipelines along existing roads. Temporary pipelines are not allowed on lands that are not adjacent to a roadway, including within electric or pipeline rights of way.

These requirements can increase the cost to install and operate temporary pipelines because of the potential need for longer temporary pipelines and more pumps. Operators can still apply for a conventional right-of-way lease that may allow temporary pipelines to be installed on land not directly adjacent to roadways, but due to the difference in review and approval times, very few operators apply for those leases.

U.S. Military

The U.S. military has long used temporary pipelines for a wide range of applications. The U.S. Army's Inland Petroleum Distribution System (IPDS) consists of 19-foot-long aluminum pipe sections having a diameter of 6 inches and an operating pressure of 740 psi (*24*). The Army is currently developing a replacement for IPDS known as Rapidly Installed Fluid Transfer System (RIFTS) based on flexible lay-flat 6-inch pipeline segments (*24*). The Marine Corps' Hose Reel System (HRS) is a flexible 6-inch pipeline that operates at low pressures (*24*). The Navy developed the Offshore Petroleum Distribution System (OPDS) to transport fuel from tanker ships to shore and to work with IPDS to transport fuel inland (*25*).

For construction and maintenance, the military recommends cleaning and proper storage of temporary pipelines and related components to reduce the potential for leaks (*26*). The conditions that apply to military temporary pipelines are quite different from those that apply to temporary pipelines for energy developments. However, some relevant requirements used by the military might be applicable, including clearing the minimum amount of land possible to maintain natural vegetation and securing temporary pipelines near culverts so that they are not swept away when contacting drainage water.

OTHER STATE AGENCIES

Colorado

The Oil and Gas Conservation Commission is responsible for regulating oil and gas operations in Colorado. Regarding temporary pipelines, the Oil and Gas Location Assessment form submitted with each well includes a requirement to describe any pipelines used at the energy development location. The commission has also developed best management practices for temporary pipelines, including a required pressure test prior to putting a pipeline into service (*27*). The commission has additional rules for permanent pipelines, but additional information pertaining to temporary pipelines was not available.

North Dakota

In North Dakota, all water is owned by the state and managed by the State Water Commission. The North Dakota Century Code requires a permit for any use of water other than domestic, livestock, fish, wildlife, and recreational uses unless the water need for these uses is greater than 12.5 acre-feet per year (*28*). Oil and gas operations are classified as industrial uses under the state's permitting system. North Dakota does not have any standards regarding the accommodation of temporary pipelines within the state right of way.

Ohio

The Ohio Administrative Code has definitions for various types of pipelines, including pipelines used for drilling of oil and/or natural gas wells. This includes any pipeline used solely for the temporary supply of fuel to drilling or service rigs and their auxiliary equipment during the process of drilling, completing, or servicing an oil or gas well (*29*). This definition does not explicitly apply to temporary water pipelines. However, aspects of the function of temporary water pipelines are similar to those of temporary fuel lines. A relevant Ohio Administrative Code rule is that all pipelines and fittings must be designed for at least the greatest operating pressure or the maximum regulated relief pressure in accordance with the current recognized practices of the industry (*29*).

Oklahoma

The Oklahoma Corporation Commission is responsible for regulating oil and gas drilling, production, and environmental protection. The agency currently does not have guidelines on temporary water pipelines. Permits for water use are handled by the Oklahoma Water Resource Board, which requires permits for all water use other than domestic. When applying for a fresh water permit, operators are required to provide leases from surface right owners granting permission to use their property, an estimated schedule showing the amount of water to be used, an economic study showing the value of fresh water and commodity to be extracted, additional expenses if saltwater were to be used, information about all wells within two miles, and subsurface information about the geological formations. The Oklahoma Water Resource Board monitors the amount of water used, not how the water will be transported to the energy development site.

The Oklahoma Department of Wildlife Conservation owns and manages lands that might be leased for mineral exploration and production, including oil and gas. The Oklahoma Administrative Code includes guidelines for mineral exploration and production, including damage and use charges of $1,000 per mile for temporary fresh water pipelines on Oklahoma Department of Wildlife Conservation lands. The length of time is not stipulated other than being "temporary" (*30*).

Pennsylvania

A recently enacted section of the Pennsylvania Code addressed the use of temporary pipelines for oil and gas energy developments (*31*). The Pennsylvania Code updated the term "temporary pipelines" used in previous versions to "well development pipelines." These pipelines are defined as pipelines used for oil and gas operations that transport (a) materials used for the drilling or hydraulic fracture stimulation, or both, of a well and (b) the residual waste generated as a result of the activities and that lose functionality after the well site they serviced has been restored. Relevant provisions in Section 78a.68b of the Pennsylvania Code include the following (*31*):

- Well development pipelines must meet applicable requirements of erosion and sediment control as well as dam safety and waterway management.
- Well development pipelines must be installed aboveground except when crossing roads, railways, or a body of water where the pipeline may be installed below ground surface.
- Well development pipelines may not be installed through existing culverts or under bridges without approval by the department.
- A well development pipeline crossing over a body of water may not have joints unless secondary containment is provided. Well development pipelines crossing over wetlands must use a single section of pipe to the extent possible. Shut-off valves must be installed on both sides of the temporary crossing.
- Well development pipelines used to transport fluids other than fresh water must have shut-off valves placed at intervals that prevent the discharge of more than 1000 barrels of fluid.
- Highly visible flags must be placed every 75 feet or less along the entire length of the well development pipeline.
- Well development pipelines must be pressure tested prior to first use and after the pipeline is moved, repaired, or altered. A passing test is holding 125 percent of the anticipated maximum pressure for two hours. Leaks or other defects discovered during pressure testing must be repaired prior to use. Pressure test results and any defects and repairs to the well development pipeline must be documented and made available to the department upon request.
- Water used for hydrostatic pressure testing may not be discharged into state water unless approved by the department in writing.
- Well development pipelines must be inspected prior to each use and daily while the pipeline is in use. Inspection dates and any defects and repairs to the well development pipeline must be documented and made available to the department upon request.

- Well development pipelines not in use for more than seven days must be emptied and depressurized. Well development pipelines may not be used for more than 12 months without approval from the department.

- Well development pipelines may not carry flammable materials.

- Well development pipelines must be removed in accordance with the required restoration timeline of the well site it serviced.

- Operators must keep records of the location of all well development pipelines, the type of fluids transported through those pipelines, and the approximate period of time that the pipeline was installed. The records must be made available to the department upon request.

- Operators must keep records for one year after the temporary pipeline is removed.

Pennsylvania has enacted more specific requirements for temporary pipelines than most other states with significant energy production sites. The information found for other states was generally informal or related to fees that could be collected for the use of public lands.

OTHER AGENCIES

Alberta Energy Regulator

The Alberta Energy Regulator allows temporary surface pipelines to be installed without a pipeline license if they are temporary in nature and the water poses minimal hazards. Temporary pipeline restrictions include but are not limited to the following (*32*):

- The water has a TDS up to 640 mg/L, an electric conductivity (EC) of two deciSiemens per meter or less, a pH between 6.5 and 9, no hydrocarbon sheen, no municipal water, no industrial use water, and no produced water. Water that does not meet these requirements cannot be transported in temporary pipelines.

- The pipeline must have a pressure relief device if there is a possibility that pressure might exceed the maximum operating pressure due to temperature changes. The pipeline must also have a system to allow for expansion and contraction, temperature monitoring equipment if the material has temperature limitations, and restraints to control lateral and vertical movement.

- The pipeline must be buried at all road and trail crossings and must have warning signs at both ends of the crossing.

- Additional precautions are required when equipment is working in the vicinity of the pipeline and if any conditions may obscure or endanger the pipeline, including off-road vehicular traffic.

- Operators must take reasonable measures to resolve any noise complaints associated with temporary pipelines or related facilities (*33*).

- The pipeline may not be connected to any equipment other than equipment needed to transport the water.

- The pipeline and related equipment should be removed within 10 days of the termination of operations.

- Operators must receive consent from landowners on private property and from occupants on public land, as well as other approvals as necessary (e.g., from municipalities for road crossings) (*34*).

Encana Oil and Gas

Encana Oil and Gas (USA) has a temporary pipeline installation guide, mostly for flow control equipment applications (*35*). Relevant requirements for flexible pipelines, which might be applicable to temporary water pipelines, include the following:

- The working pressure and test pressure of the end connections must be consistent with the working pressure rating of the pipeline.

- The external protection cover for the hose must be inspected for damage (such as scuffing, kinks, and bulges) and action taken to replace the hose.

- The internal portion of the hose must be checked for wear, corrosion, and erosion as prescribed by the manufacturer.

- Non-destructive examination should be conducted as specified by the manufacturer or at least every five years.

- Flexible pipelines used to transport fluids must have their connections restrained with suitably rated restraints.

CHAPTER 4. FIELD DATA COLLECTION

INTRODUCTION

This chapter summarizes activities completed in the field to gather sample data about the characteristics and operation of temporary pipelines within the state right of way. The data collected provided a basis for recommendations and potential improvements for accommodating temporary pipelines in the state right of way.

METHODOLOGY

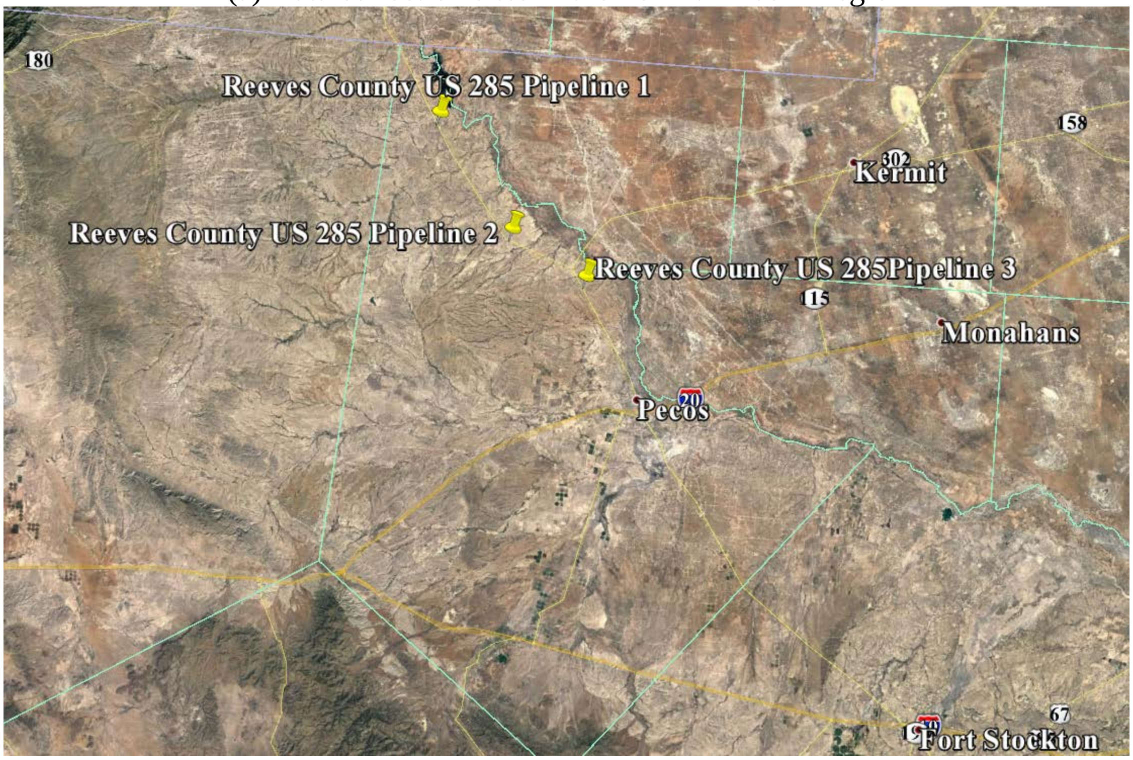
Data Collection Locations

The researchers identified suitable locations with the assistance of officials from the Odessa and Corpus Christi Districts. Field data collection took place at three locations in the Permian Basin Region and five locations in the Eagle Ford Shale Region. The researchers did not collect field data in the Barnett Shale Region because of decreased gas well development activity in that region. Table 9 and Figure 25 show the locations where field data collection took place.

Table 9. Field Data Collection Locations.

Region	County	Route	From Reference Marker	To Reference Marker	Length (miles)
Permian	Reeves	US 285	328 – 0.38	328 + 0.38	0.76
Permian	Reeves	US 285	354 + 0.86	354 + 0.86	Crossing
Permian	Reeves	US 285	344 – 0.55	344 + 0.51	1.06
Eagle Ford	Karnes	FM 1353	538 – 0.23	540 – 0.48	1.75
Eagle Ford	Karnes	FM 626	544 + 0.47	546 – 0.68	0.85
Eagle Ford	Karnes	FM 626	546 – 0.19	546 + 1.23	1.42
Eagle Ford	DeWitt	FM 240	518 + 1.03	520 – 0.23	0.74
Eagle Ford	DeWitt	FM 2816	518 + 0.51	518 + 0.95	0.44

(a) Data collection sites in the Permian Basin Region



(b) Data collection sites in the Eagle Ford Shale Region

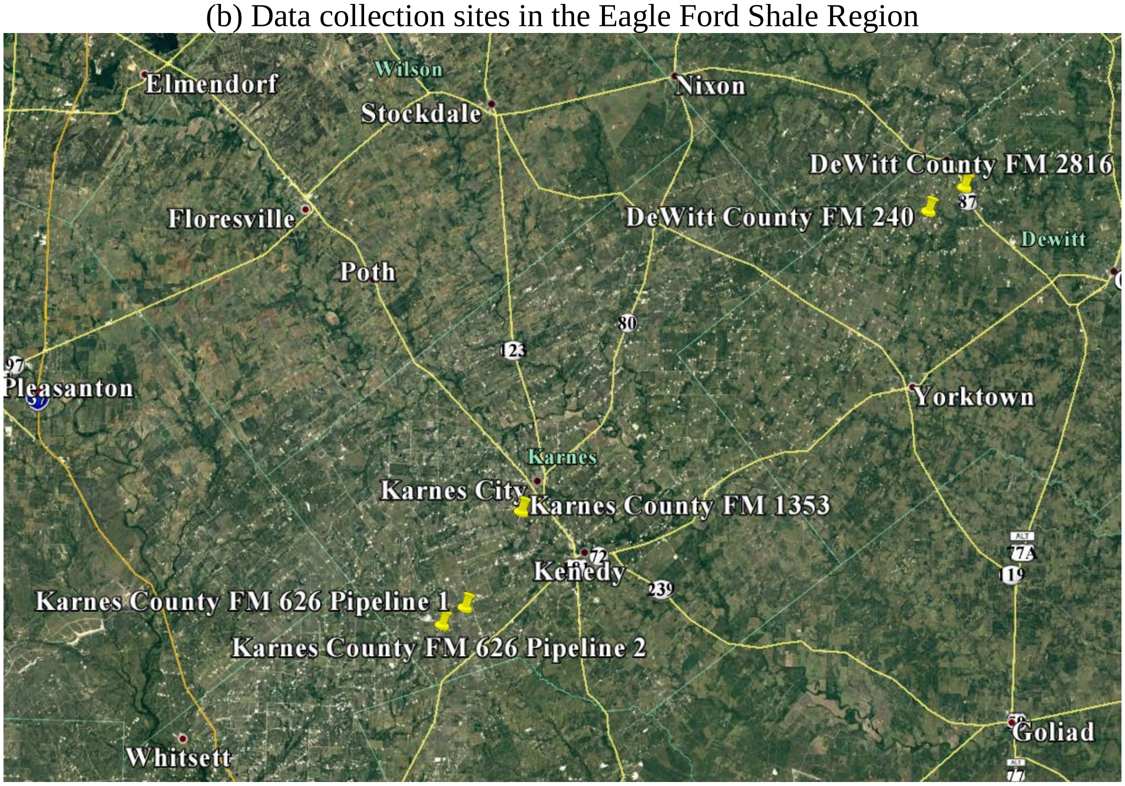


Figure 25. Field Data Collection Locations in the Permian Basin and Eagle Ford Shale Regions.

Data Collection Equipment and Methodology

The researchers collected data about temporary pipeline locations and other roadside features using a global positioning system (GPS) receiver and a level. The GPS equipment used for data collection included a Trimble® R8 GPS receiver and a handheld Trimble Survey Controller® (Figure 26). The researchers used Trimble Business Center® (TBC) software to post-process the GPS data collected in the field. Using the TxDOT real-time network (RTN) for GPS data corrections was not feasible because cellular service was not reliable in the areas where data collection took place. As a result, the researchers used a post-processing kinematic (PPK) data correction procedure by relying on TxDOT reference station data downloaded using the TBC software. In the field, each GPS data point was occupied for at least 15 seconds.

Figure 26. GPS Data Collection Equipment.

Using only GPS data for capturing Z data resulted in problems, such as temporary pipeline elevations being documented as being below ground (even though they were obviously on the surface of the ground). It would have been possible to obtain an acceptable vertical positional accuracy, but it would have been necessary to occupy each location for extended periods of time. This was impractical given that the nature and purpose of the data collection campaign was to conduct a preliminary assessment of temporary pipeline locations and characteristics, with a focus on cross-sectional data to document the relationship between temporary pipelines and transportation infrastructure features. For this reason, the researchers used a standard optical level and a leveling rod to augment the collection of Z data at measurement locations.

Figure 27 describes the elevation data collection process. In the figure, Points 1 through 8 represent points along a temporary pipeline. Points A through E represent points where the level is placed. Point 1 and Point A (which may be several hundred feet apart) have elevation data measured with the GPS receiver. The level is initially at Point A, and Point 1 is a back sight point. The elevation of the level at Point A is as follows:

$$HI = BE + BS \quad \text{(Eq. 4-1)}$$

where

HI = elevation of the level at Point A.
BE = elevation of Point 1 (at ground level) recorded using the GPS receiver.
BS = reading on the leveling rod when placed at Point 1.

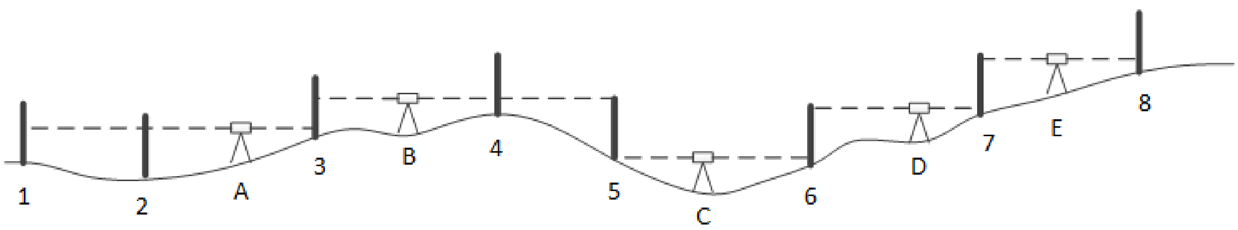


Figure 27. Elevation Data Collection Procedure.

After determining the elevation of the level at Point A, the elevation at Point 2 is as follows:

$$FE = HI - FS \quad \text{(Eq. 4-2)}$$

where

FE = elevation of Point 2.
FS = reading on the leveling rod when placed at Point 2.

The process for determining the elevation at Point 3 is similar. For Point 4, the level is moved to Point B, and the process is repeated using Point 3 as a back sight point. This process is followed for the entire length of a pipeline installation, until elevation data are collected for the temporary pipeline and all other roadside features. To close the loop, the same procedure is performed back from Point 8 to Point 1 to ensure that elevations at each point match in both directions.

For the collection of location and attribute data in the field, the researchers prepared a data dictionary that used TxDOT feature codes to the extent possible. Table 10 lists the feature codes used for the data collection effort. Notice the use of line control codes to differentiate multiple line features of the same type. For example, driveways use a line feature, but there should not be a line connecting one driveway to another. In this instance, line control codes provided a mechanism to distinguish the start of a driveway line from the end of a previous driveway line. In addition to feature codes, the data dictionary included basic feature attributes such as material, owner, and diameter.

Table 10. Data Collection Feature Codes.

Feature Class	Feature Code	Feature Logical Name	Feature Type
Line Control Codes	BC*	Begin Curve	Line Control Code
	BL*	Begin Line	Line Control Code
	EC*	End Curve	Line Control Code
	EL*	End Line	Line Control Code
Drainage	SET	Safety End Treatment	Point
	CLV_DRV	Driveway Culvert	Line
	CLV_RD	Road Culvert	Line
	DC	Ditch Centerline	Line
	DTT	Ditch Top	Line
	MES	Mitered End Section	Line
	WNG	Wing Wall	Line
Land	PE	Property Entrance	Point
	SHRB	Shrub	Point
	SE	Spot Elevation	Point
	T	Tree	Point
	EW	Edge of Water	Line
	ROWE	Right of Way—Existing	Line
Miscellaneous	MIS_PT	Miscellaneous Point	Point
	MIS_LNE	Miscellaneous Line	Line
Pipeline	PIP_OCS	Pipeline Operator Contact Sign	Point
	PIP_STK	Pipeline Stake	Point
	WPU	Water Pump	Point
	RMP_DRV	Driveway Ramp	Line
	TMP_WTLN	Temporary Waterline	Line
Road	TS	Traffic Sign	Point
	ABUT	Bridge Abutment	Line
	DECK	Bridge Deck	Line
	DRV	Driveway	Line
	EP	Edge of Pavement	Line
	GR	Guardrail	Line
Utilities	FH	Fire Hydrant	Point
	GV	Gas Valve	Point
	VG	Gas Vent	Point
	LP	Light Pole	Point
	MH	Manhole	Point
	PP	Power Pole	Point
	TP	Telephone Pole	Point
	TRNS	Transformer	Point
	GL	Gas Line	Line

Note: BC*, BL*, EC*, and EL* use the same format that TxDOT uses for line control codes.

DATA COLLECTION RESULTS

The researchers conducted several analyses using the data collected in the field. The first analysis focused on the offset of temporary pipelines with respect to the right-of-way line. When the data collection took place, TxDOT used temporary permits, and the permit form specified that pipelines had to be located within 3 feet of the right-of-way line. Figure 28 shows the distribution of lateral distances between temporary pipelines and the right-of-way line for the eight sections where there were measurements in the field in the Eagle Ford Shale and Permian Basin Regions.

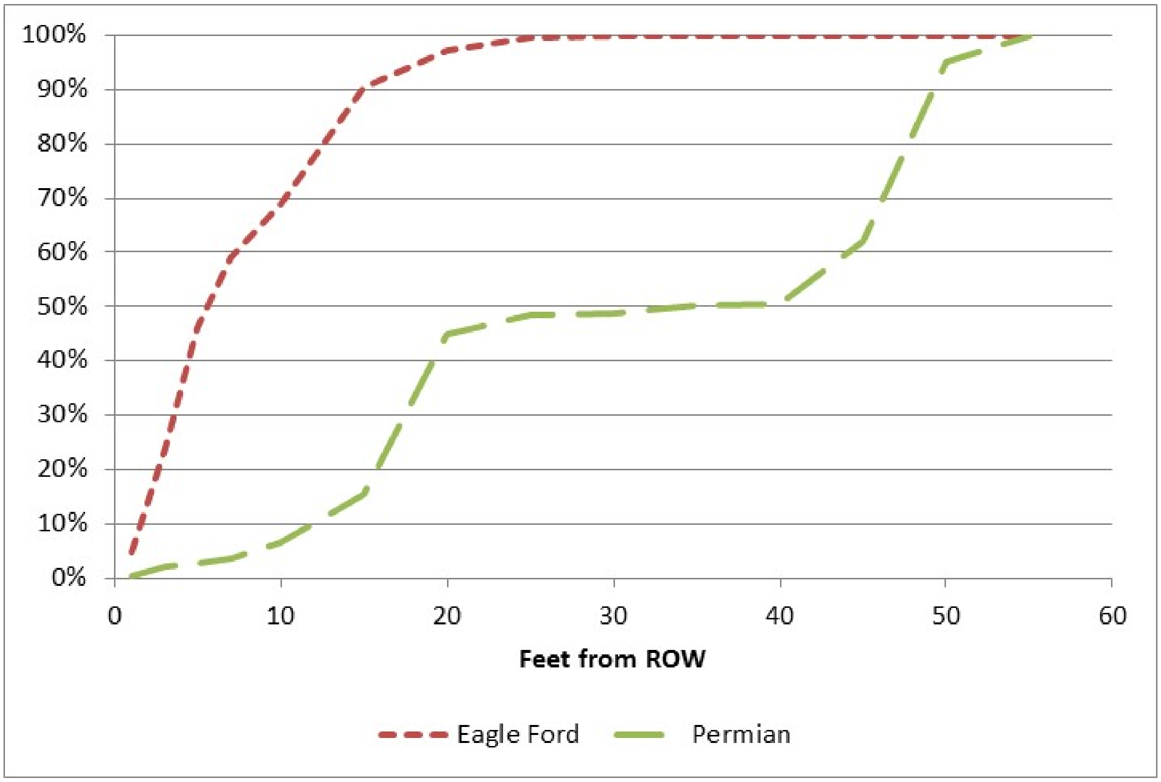


Figure 28. Distribution of Distances from Temporary Pipelines to the Right-of-Way Line.

For the five locations in the Eagle Ford Shale Region, the average lateral distance from the temporary pipelines to the right of way was 7 feet. For the three locations in the Permian Basin Region, the average lateral distance was 31 feet. Only 24 percent of the length of pipelines measured in the Eagle Ford Shale Region and two percent of the length of pipelines measured in the Permian Basin Region were installed within 3 feet of the right-of-way line. The figure also shows that 90 percent of pipelines were installed within 15 feet of the right-of-way line in the Eagle Ford Shale Region and within 48 feet in the Permian Basin Region.

It is worth noting that the roadway segments in the two regions were quite different: relatively narrow FM roads in the Eagle Ford Shale Region versus a considerably wider U.S. route in the Permian Basin Region. Because of the additional roadside space on US 285, it is probably not surprising that operators took advantage of that availability.

Clear zones are critical for traffic safety purposes. A clear zone should be relatively flat and free of obstructions. The recommended width of clear zones varies based on volume, speed, and grade (*36*). Based on the posted speed limit of the roads where data were collected, the clear zones should be at least 30 feet along the highway segments measured in the Eagle Ford Shale Region, except FM 2816, where it should be at least 16 feet. On US 285 in the Permian Basin Region, the clear zone should be at least 30 feet. These distances are measured from the edge of the traveled way, not the edge of pavement. Shoulder widths on the roads measured varied from 1.5–4 feet in the Eagle Ford Shale Region and 8–10 feet in the Permian Basin Region.

Figure 29 shows the distribution of distances from the temporary pipelines to the edge of pavement for the eight sections where there were measurements in the field in the Eagle Ford Shale and Permian Basin Regions. For the five locations in the Eagle Ford Shale Region, the average lateral distance from the temporary pipelines to the edge of pavement was 25 feet. For the three locations in the Permian Basin Region, the average lateral distance was 36 feet. The median distance in both regions was about 25 feet. Figure 29 also shows that 90 percent of the length of the temporary pipelines was installed within 30 feet of the edge of pavement in the Eagle Ford Shale Region and within 55 feet in the Permian Basin Region. Overall, these results show that a significant percentage (probably 20–40 percent) of the road segments measured had temporary pipelines that were likely placed within the clear zone.

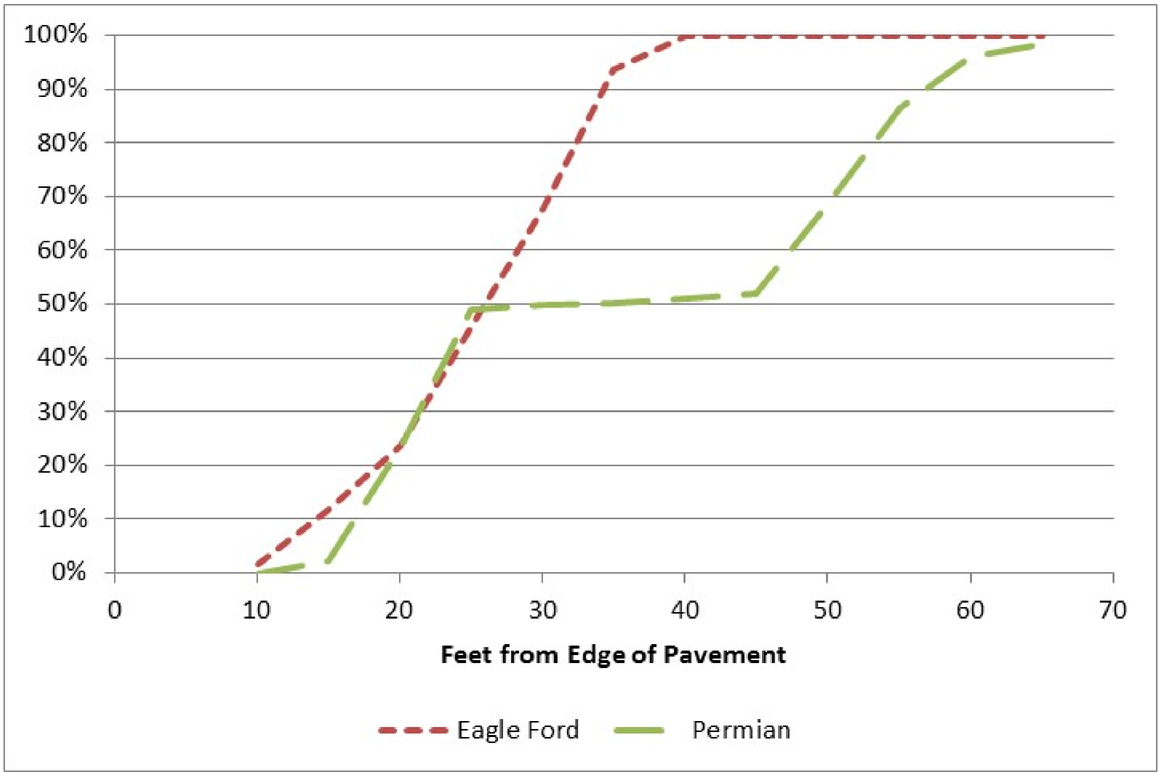


Figure 29. Distribution of Distances from Temporary Pipelines to the Edge of Pavement.

To help visualize the impacts of temporary pipeline installations on specific roadside design features, the researchers prepared a number of cross sections. General trends and observations include the following:

- When slopes are present, many operators install temporary pipelines at the toe of the slope rather than using stakes to anchor the temporary pipeline near the right-of-way line. Figure 30 shows an example of this practice. In this particular instance, the temporary pipeline was installed at the toe of the slope even though this resulted in the pipeline being placed 46 feet from the right-of-way line.

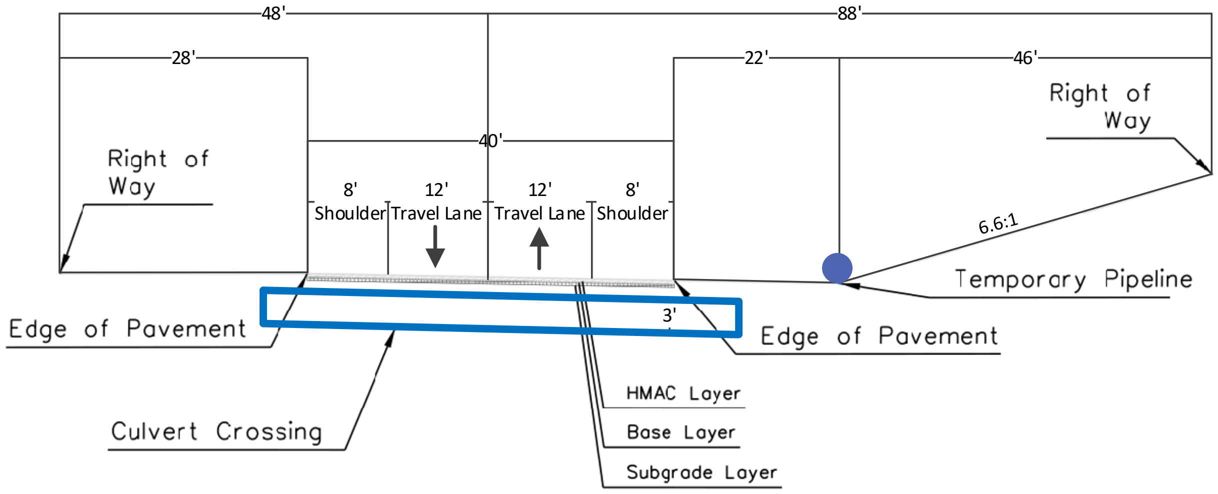


Figure 30. Sample Cross Section on US 285 in Reeves County.

- Temporary pipelines are rarely installed at uniform distances from the edge of pavement or the right-of-way line. In some cases, the pipelines might be installed parallel to the road, but the pipelines shift over time because they are not anchored properly. This practice is detrimental to roadside maintenance activities, particularly vegetation management. One of the risks of installing temporary pipelines at varying distances from the edge of pavement and the right-of-way line is that the temporary pipelines could be damaged if maintenance personnel do not notice the pipelines. Figure 31 and Figure 32 show typical examples of this situation.

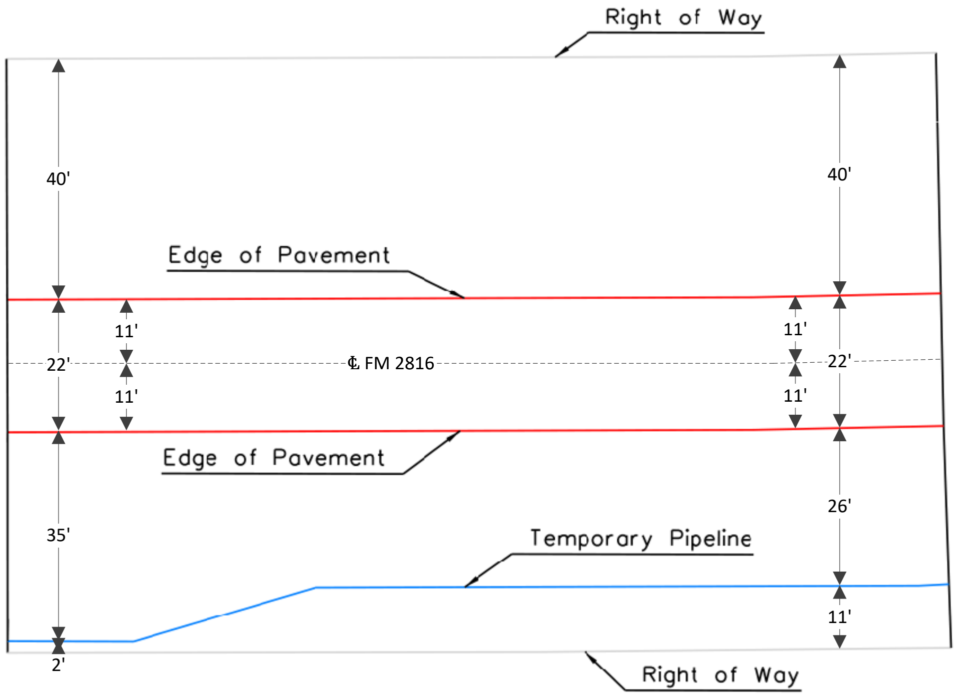


Figure 31. Plan View of Temporary Pipeline Installed on FM 2816 in De Witt County.

Figure 32. Temporary Pipeline Installation on FM 2816 in De Witt County.

CHAPTER 5. HYDRAULIC CAPACITY IMPACT ANALYSIS

INTRODUCTION

This chapter describes the results of a hydraulic analysis the researchers conducted to determine the impact of temporary pipelines on the hydraulic capacity of box and pipe culverts. Feedback from TxDOT officials highlighted the need for guidelines on the maximum number and size of temporary pipelines to allow inside culverts. The results of the analysis provide a basis for recommendations and guidance on how to proceed for future installations.

To conduct the hydraulic analysis, the researchers combined field geometric data about culverts and roadways with estimated flow data in a simulation software environment to arrive at typical discharge flow rates through various types and sizes of culverts. The researchers made comparisons between the output flow rate with and without temporary pipelines occupying culverts to estimate potential reductions in capacity.

This approach was high level and preliminary. It does not replace the thorough analysis that would be necessary to assess the hydraulic conveyance of individual culverts in the field. Nevertheless, the analysis discussed here provided useful information about typical situations and general trends as well as a basis for implementation recommendations and guidance.

INPUT DATA

Several geometric data elements are necessary to estimate the hydraulic capacity of culverts, including culvert size, culvert inlet and outlet elevations, roadway elevation, and drainage channel invert elevation. One important criterion for hydraulic analysis is the overtopping flow rate, which is based partly on the difference in elevation between the top of the culvert and the crest of the road.

The researchers captured these data elements for several culverts as part of the field data collection campaign, as described in Chapter 4. For those culverts, the researchers found that the average difference in elevation between the top of the culvert and the edge of pavement was about 10 inches. When accounting for a typical cross slope of two percent to the centerline of the road and an average combined shoulder and lane width of 13.9 feet, the elevation at the road crest would be 13 inches higher than the top of the culvert. The researchers used this difference in elevation to determine the overtopping flow rate in the hydraulic analysis.

The researchers analyzed the hydraulic conveyance of pipe culverts and box culverts. Table 11 shows the various pipe and box culvert sizes analyzed. For simplicity, the researchers assumed all culverts to be straight, single-barrel concrete culverts.

Table 11. Sizes of Culverts Considered in Hydraulic Analysis.

Culvert Type	Culvert Size (inches)		
Pipe Culvert (diameter)	24	36	48
	30	42	60
Box Culvert (span × rise)	**Culvert Size (feet)**		
	2 × 2	4 × 3	5 × 5
	2 × 3	4 × 4	5 × 6
	3 × 2	4 × 5	6 × 3
	3 × 3	5 × 2	6 × 4
	3 × 4	5 × 3	6 × 5
	4 × 2	5 × 4	6 × 6

Typical inputs for designing culverts include minimum, maximum, and design flow rates. These values can be measured from discharge data collected in the field or calculated using conceptual methods such as the rational method or the unit hydrograph method. For this analysis, the researchers are not designing culverts but quantifying the effects of installing temporary pipelines in existing culverts. To this end, the researchers compared the overtopping flow rate of culverts without temporary pipelines to the overtopping flow rate of culverts of the same size with temporary pipelines. The overtopping flow rate is calculated as part of the hydraulic analysis; therefore, it was not necessary to determine exact minimum, maximum, and design flow rates. The researchers used reasonable estimates for flow rate inputs and compared the resulting overtopping flow rates of culverts without temporary pipelines to culverts with temporary pipelines.

HYDRAULIC CAPACITY IMPACT ANALYSIS

The researchers used FHWA's hydraulic analysis software HY-8, version 7.50, for the hydraulic analysis (*37*, *38*). This software is a culvert analysis tool, not a water surface computation program, which made it suitable for the needs of the analysis. Figure 33 shows the HY-8 culvert crossing data input screen, which includes flow data, roadway data, and culvert data.

The HY-8 software does not account directly for flow obstructions such as temporary pipelines inside of culverts. To model culverts with temporary pipelines, the researchers reduced the effective cross section of the culvert. In the field, the researchers noticed several cases where a single temporary pipeline caused additional sedimentation that essentially raised the bottom of the cross section inside the culvert to roughly match the top of the pipeline. For example, as shown in Figure 34a, a 3 × 3-foot culvert with a 12-inch temporary pipeline would be reduced to a 2 × 3-foot cross section with its bottom raised by 12 inches. Similarly, as shown in Figure 34b, inserting a 12-inch pipeline in a 36-inch pipe culvert would raise the effective invert by 12 inches and reduce the effective cross section accordingly.

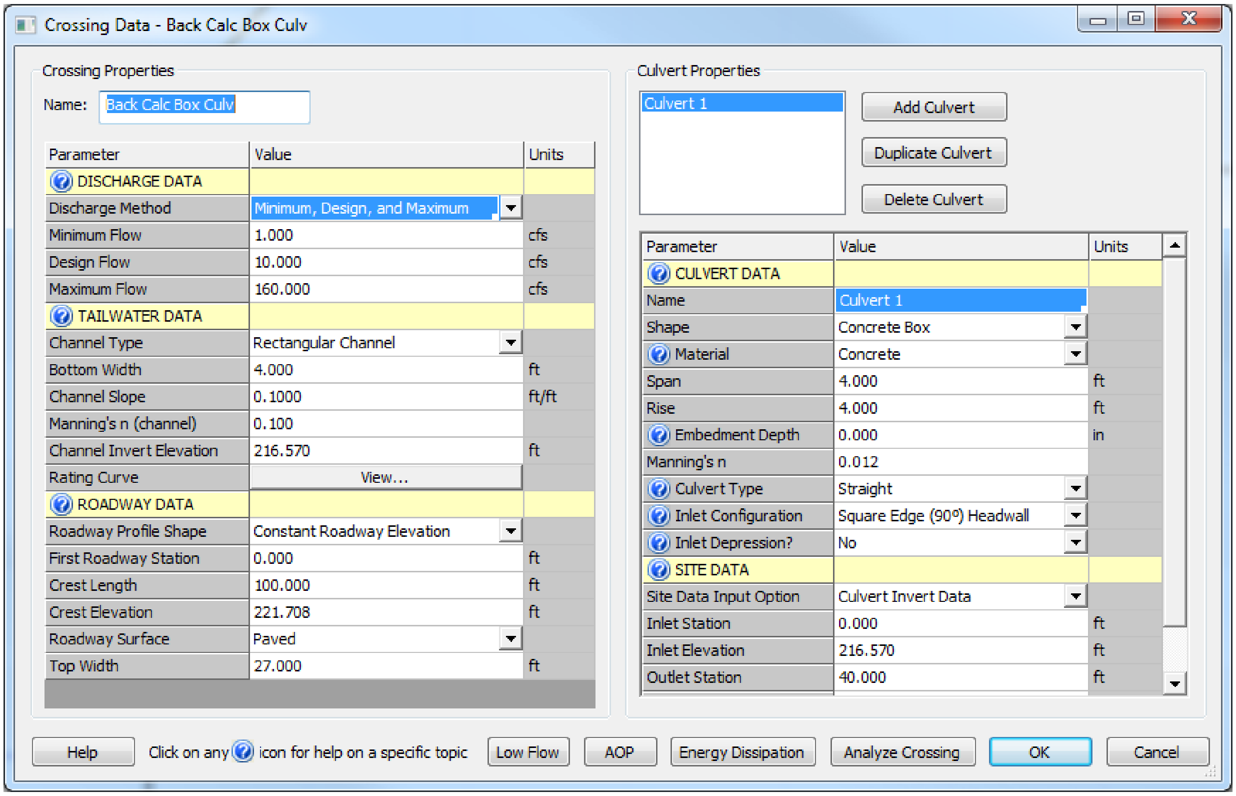


Figure 33. HY-8 Data Input Screen.

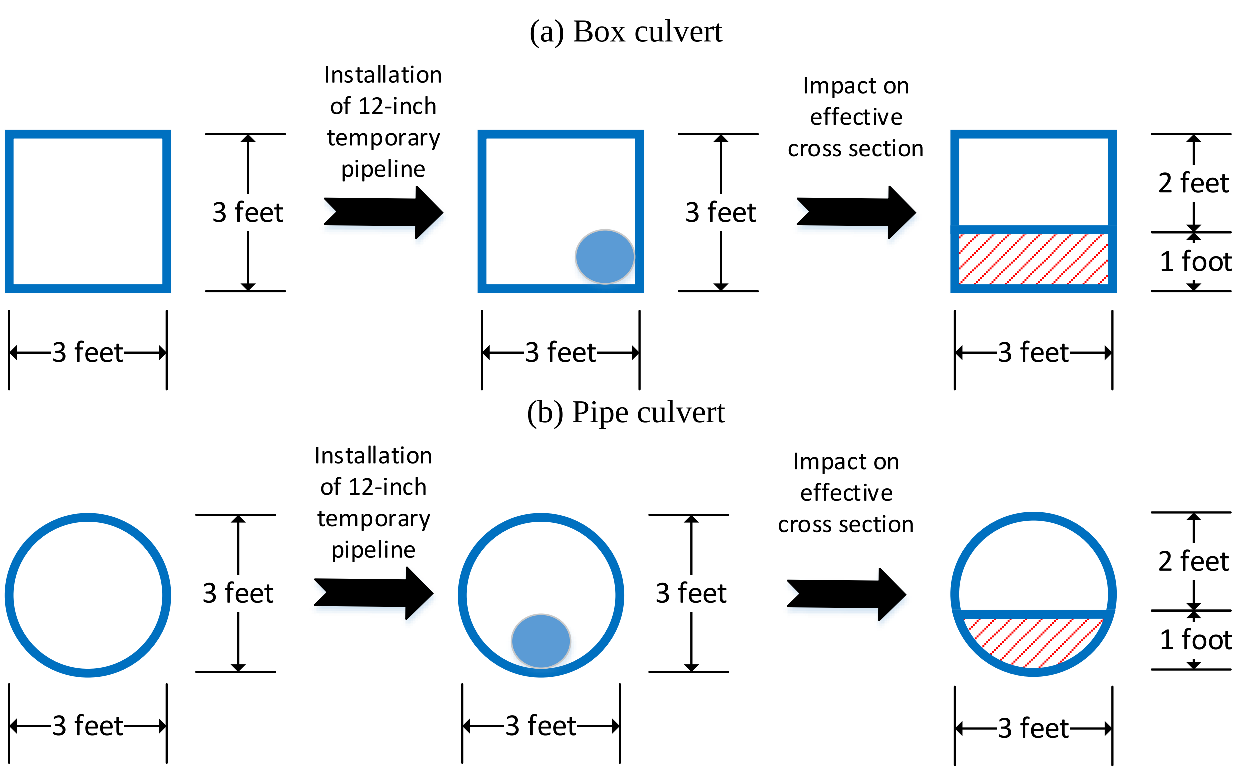


Figure 34. Reduction of Effective Cross Section after Inserting Pipeline in Culvert.

RESULTS

The researchers calculated the relative reduction in overtopping flow rate for the various combinations of temporary pipeline sizes and culvert sizes described previously. Table 12 shows the corresponding results for box culverts. For example, the impact of inserting a 6-inch pipeline in a 3 × 3-foot box culvert is a 20 percent reduction in the overtopping flow rate of the box culvert. As the size of the temporary pipeline increases, the reduction in overtopping flow rate increases. For example, the impact of inserting a 10-inch pipeline would be a 39 percent reduction in the overtopping flow rate of the box culvert. Notice that the impact of inserting two temporary pipelines of equal diameter is the same as the impact associated with a single pipeline.

Table 12. Reduction in Overtopping Flow Rate with Temporary Pipelines in Box Culverts.

Box Culvert Span × Rise (feet)	Temporary Pipeline Diameter (inches)—Single and Double Pipeline Occupancy											
	3"	4"	6"	8"	10"	12"	3" + 3"	4" + 4"	6" + 6"	8" + 8"	10" + 10"	12" + 12"
	Percent Reduction in Overtopping Flow Rate											
2 × 2	14	19	28	37	46	55	14	19	28	37	46	55
2 × 3	10	13	20	26	33	39	10	13	20	26	33	39
3 × 2	14	19	28	38	47	56	14	19	28	38	47	56
3 × 3	10	13	20	26	33	39	10	13	20	26	33	39
3 × 4	7	10	14	20	25	29	7	10	14	20	25	29
4 × 2	4	18	32	36	45	58	4	18	32	36	45	58
4 × 3	12	13	19	25	31	38	12	13	19	25	31	38
4 × 4	6	8	15	18	25	28	6	8	15	18	25	28
4 × 5	9	9	12	15	23	24	9	9	12	15	23	24
5 × 2	7	12	22	38	41	50	7	12	22	38	41	50
5 × 3	16	18	20	24	30	41	16	18	20	24	30	41
5 × 4	9	11	14	24	25	27	9	11	14	24	25	27
5 × 5	2	4	12	13	15	19	2	4	12	13	15	19
5 × 6	4	5	10	11	14	20	4	5	10	11	14	20
6 × 3	9	12	23	24	30	42	9	12	23	24	30	42
6 × 4	12	13	14	18	19	27	12	13	14	18	19	27
6 × 5	5	7	11	18	18	21	5	7	11	18	18	21
6 × 6	1	3	6	9	12	15	1	3	6	9	12	15

The results for pipe culverts are similar, as shown in Table 13. For example, the impact of inserting a 6-inch pipeline in a 30-inch pipe culvert is a 16 percent reduction in the overtopping flow rate of the pipe culvert. Similarly, the impact of inserting a 10-inch pipeline in a 30-inch pipe culvert would be a 32 percent reduction in the overtopping flow rate of the pipe culvert. As opposed to box culverts, the impact of inserting two temporary pipelines of equal diameter is greater than the impact associated with a single pipeline. The reason is that two pipelines inserted in a circular pipeline are displaced sideways and upward compared to the situation with a single pipeline.

Table 13. Reduction in Overtopping Flow Rate with Temporary Pipelines in Pipe Culverts.

Pipe Culvert Diameter (inches)	Temporary Pipeline Diameter (inches)—Single and Double Pipeline Occupancy											
	3"	4"	6"	8"	10"	12"	3" + 3"	4" + 4"	6" + 6"	8" + 8"	10" + 10"	12" + 12"
	Percent Reduction in Overtopping Flow Rate											
24	8	12	21	31	42	53	10	15	27	40	53	65
30	6	9	16	23	32	40	7	11	20	30	40	51
36	1	3	9	15	22	29	2	4	12	19	28	37
42	2	3	7	15	18	24	3	4	9	17	22	27
48	1	2	3	6	9	16	2	2	4	8	12	18
60	1	1	2	3	6	11	1	1	2	4	10	11

The researchers then compared the results to existing district guidelines. Examples of requirements from several districts include the following:

- Districts typically do not allow more than two temporary pipelines in any culvert.
- The Corpus Christi District allows 3-inch to 6-inch temporary pipelines in 24-inch culverts, as well as temporary pipelines greater than 6 inches in culverts 36 inches and larger.
- The Lubbock District developed guidelines for pipe culverts and box culverts showing allowable temporary pipelines based on culvert size.
- Several districts allow temporary pipelines as long as they do not occupy more than 25 percent of the cross-sectional area of the culvert.

An inherent assumption behind these policies is that there is a risk that TxDOT absorbs when an obstruction is artificially inserted into a culvert, which reduces the effective cross-sectional area and hydraulic capacity of the culvert. TxDOT typically designs culverts for a 25-year return period for principal arterials (e.g., US 285 in the Permian Basin Region) and checks the potential flooding for a 100-year rainfall event. Similarly, TxDOT designs culverts on minor arterials and collectors (e.g., the FM roads measured in the Eagle Ford Shale Region) for a 10-year return period and checks the potential flooding for a 100-year rainfall event.

A reduction in hydraulic capacity has the effect of reducing the effective return period. Using design rainfall intensities (*39*) for each county in oil and gas producing regions in Texas, the researchers calculated the percent reduction in flow rate for corresponding reductions in storm return periods. Appendix A includes the complete list of percent reductions in flow rate for counties in the Barnett Shale, Eagle Ford Shale, and Permian Basin Regions.

With this information, the researchers calculated average percent reductions in flow rates for corresponding reductions in return periods for each of these regions. Table 14 shows the aggregated results. In general:

- For a design return period of 25 years, a 15 percent reduction in capacity would reduce the return period to 10 years, a 28 percent reduction in capacity would reduce the return period to 5 years, and a 35 percent reduction in capacity would reduce the return period to 2 years.
- For a design return period of 10 years, a 15 percent reduction in capacity would reduce the return period to 5 years, and a 35 percent reduction in capacity would reduce the return period to 2 years.
- When analyzing overtopping flow for a return period of 100 years, a 12 percent reduction in capacity would reduce the return period to 50 years, a 23 percent reduction in capacity would reduce the return period to 25 years, and a 35 percent reduction in capacity would reduce the return period to 10 years.

Table 14. Percent Reduction in Flow Rate in Oil and Gas Producing Regions of Texas.

Reduction in Return Period (Years)	Region		
	Barnett Shale	Eagle Ford Shale	Permian Basin
	% Reduction in Flow Rate for Corresponding Reduction in Return Period		
100 to 50	12	12	12
100 to 25	23	23	23
100 to 10	35	35	36
100 to 5	44	44	45
100 to 2	57	57	59
50 to 25	13	13	13
50 to 10	26	26	27
50 to 5	37	37	38
50 to 2	52	52	54
25 to 10	15	15	16
25 to 5	28	28	29
25 to 2	45	45	47
10 to 5	15	15	15
10 to 2	35	35	37

Although districts typically do not quantify the increase in the level of risk, they nevertheless deal with it in a variety of ways. For example, in the Permian Basin Region, district officials may allow operators to install more temporary pipelines in culverts during the summer months because the probability of a rain event is lower. In other cases, a district does not allow any temporary pipelines to be installed in a culvert that is particularly prone to flooding during rain events.

Based on the hydraulic analysis and district stakeholder feedback, the researchers used a 25 percent maximum reduction in capacity as the basic criteria for whether or not a certain sized temporary pipeline should be allowed in a culvert. The maximum allowable reduction in capacity (i.e., 25 percent) is a policy decision. There is nothing intrinsically wrong with selecting a different threshold (e.g., a more stringent 10 percent). However, because several districts already use 25 percent, the researchers decided to keep it.

The researchers then combined this requirement with the requirement of not accepting more than two temporary pipelines in any culvert to arrive at a tabulation of the maximum of temporary pipelines (and their size) to allow inside culverts of any size. Table 15 shows the results for box culverts and Table 16 shows the results for pipe culverts. Exceptions to these values could be made at the district level on a case-by-case basis.

Table 15. Recommended Maximum Number of Temporary Pipelines That Can Be Installed in a Box Culvert.

Box Culvert Span × Rise (feet)	Temporary Pipeline Diameter (inches)					
	3	4	6	8	10	12
	Maximum Number of Temporary Pipelines in Culvert					
2 × 2	2	2	2	1	0	0
2 × 3	2	2	2	1	1	0
3 × 2	2	2	2	2	1	0
3 × 3	2	2	2	2	1	0
3 × 4	2	2	2	2	2	1
4 × 2	2	2	2	2	2	1
4 × 3	2	2	2	2	2	1
≥ 4 × 4	2	2	2	2	2	2

Table 16. Recommended Maximum Number of Temporary Pipelines That Can Be Installed in a Pipe Culvert.

Pipe Culvert Diameter (inches)	Temporary Pipeline Diameter (inches)					
	3	4	6	8	10	12
	Maximum Number of Temporary Pipelines in Culvert					
24	2	2	1	0	0	0
30	2	2	2	1	0	0
36	2	2	2	2	1	0
42	2	2	2	2	2	1
≥ 48	2	2	2	2	2	2

CHAPTER 6. CHARACTERISTICS AND IMPACTS OF SALTWATER

INTRODUCTION

This chapter includes an overview of relevant Texas water laws and regulations, a review of relevant information obtained from state and regional water agencies, and a discussion of impacts from saltwater leaks and spills.

WATER IN TEXAS

Water laws and regulations in Texas are different for surface water and groundwater. As mentioned, the state of Texas owns and regulates the use of surface water. The use of surface water must be permitted by the state through TCEQ. Groundwater in Texas belongs to landowners once captured. According to feedback provided by TWDB officials, groundwater production and use is managed and regulated differently under the following situations:

- Domestic use. A water well drilled on a landowner's property for domestic use does not need a license. Instead, the landowner must submit a well report to TDLR for registration within 60 days of drilling completion. In practice, many owners do not comply with this requirement.

- Non-domestic use. A license is required from TDLR if a landowner drills a water well for non-domestic use (e.g., irrigation, livestock, or industrial) or a well operator drills a water well on someone else's property. The well owner or operator must submit a license application within 60 days of drilling completion.

Groundwater production and use may also be subject to the rules outlined by local or regional groundwater conservation districts. As of November 2015, there were 101 GCDs in Texas, as shown in Figure 35 (*40*). The blank areas in Figure 35 are currently not within any GCDs and are thus only subject to the rule of capture.

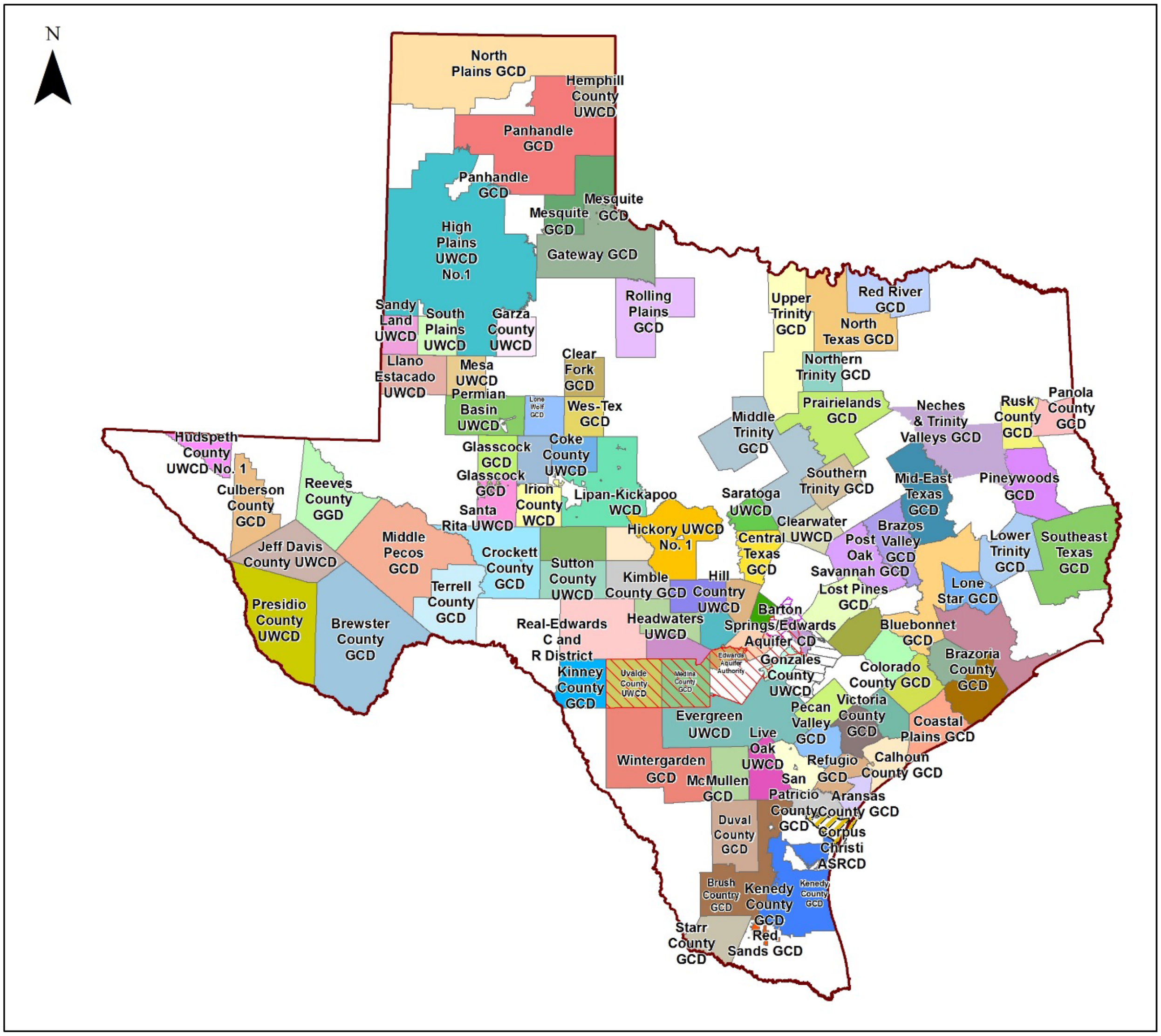


Figure 35. Texas Groundwater Conservation Districts (as of November 2015) (*40*).

WATER QUALITY

A measure of water quality is TDS (*41*). TDS can be measured directly by evaporating liquid solvent, measuring the mass of residues left (also known as gravimetric analysis), and reporting the result in mg/L or parts per million (ppm) (*42*). An indirect, less accurate, measure of TDS is by measuring electric conductivity in water, expressed in deciSiemens per meter (dS/m) or millimho per centimeter (mmhos/cm), and by applying a multiplier to estimate TDS (*41*).

The accuracy of EC readings depends on the calibration of the EC meter. When properly calibrated, EC readings can be within 10 percent of the actual EC value. The multiplier to convert EC to TDS can vary from 550 to 880 depending on the EC value and measuring conditions (*43*). According to the U.S. Department of Agriculture (*44*):

$$TDS\ (\text{mg/L}) = 640EC\ (\text{dS/m or mmhos/cm}), \text{ for EC between 0.1 and 5.0 dS/m}$$

$$TDS\ (\text{mg/L}) = 800EC\ (\text{dS/m or mmhos/cm}), \text{ for EC} > 5.0 \text{ dS/m}$$

TDS is normally used to classify water according to the amount of salt in the water. As mentioned, there is no universal consistency in the definition of different types of water (e.g., fresh, brackish, saline, or brine). For example, according to Section 27.0516 of the Texas Water Code, fresh water is "surface water or groundwater, without regard to whether the water has been physically, chemically, or biologically altered, that (a) contains a total dissolved solids concentration of not more than 1,000 milligrams per liter; and (b) is otherwise suitable as a source of drinking water supply" (*16*). In contrast, in 1996 the Railroad Commission conducted a survey of fresh and brackish water usage in enhanced oil recovery projects and used 3,000 mg/L TDS as the threshold for fresh water (*19*). Based on typical values found in the literature, the researchers prepared a diagram to depict water quality classification ranges (Figure 36).

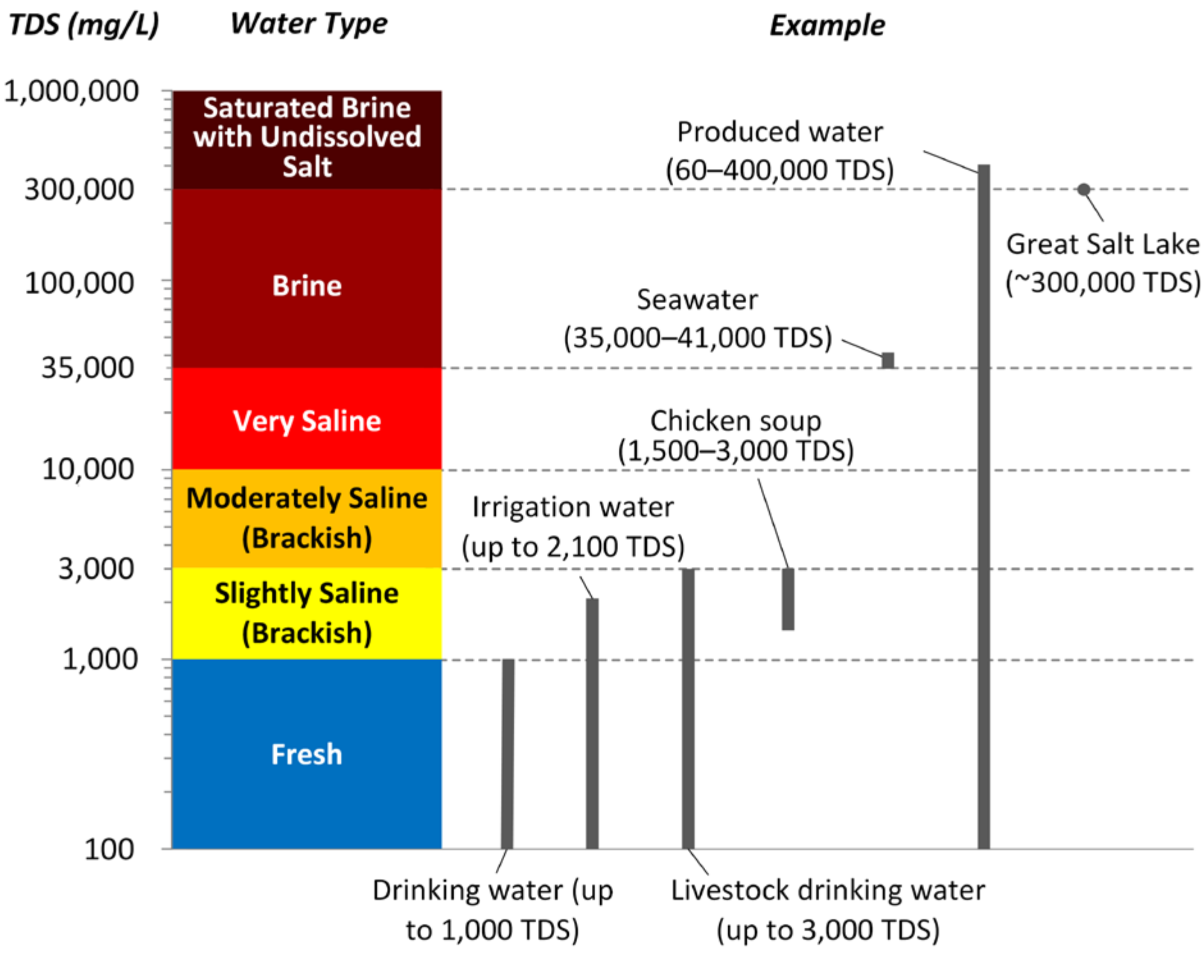


Figure 36. Water Quality Classifications and Examples (*18, 19*).

For consistency with the Texas Water Code, Figure 36 shows fresh water as water with TDS up to 1,000 mg/L (*16*). Saline water is water with TDS greater than 1,000 and up to 35,000 mg/L.

Brine is water with TDS greater than 35,000 mg/L (*19*). The TDS in a fully saturated brine is around 300,000 mg/L, beyond which the result is saturated brine with undissolved salt. For consistency with the TWDB classification scheme, brackish water is water with TDS greater than 1,000 and up to 10,000 mg/L (*18*). Brackish water is classified into slightly saline water (i.e., water with TDS greater than 1,000 and up to 3,000 mg/L) and moderately saline water (i.e., water with TDS greater than 3,000 and up to 10,000 mg/L).

Figure 36 also provides a few examples of types of water commonly found in everyday life to help put the amount of salt in water in proper perspective. For example, the upper limit for drinking water for humans is a TDS of 1,000 mg/L. Water suitable for irrigation normally contains TDS up to 2,100 mg/L. TDS in chicken soup normally ranges from 1,500–3,000 mg/L, TDS in seawater ranges from 35,000–41,000 mg/L, and Great Salt Lake contains saturated brine with TDS at about 300,000 mg/L.

Figure 37 provides a distribution of TDS values for 19,491 produced-water samples compiled and processed by the U.S. Geological Survey (USGS) based on data collected in Texas from 1925 to 2013 (*45*). It is not clear to what degree the samples are an accurate representation of all the produced water in Texas. Nevertheless, some of the reported values are interesting. For example, the reported TDS median was about 70,000 mg/L. Only 10 percent of the reported values showed produced water with TDS less than 10,000 mg/L.

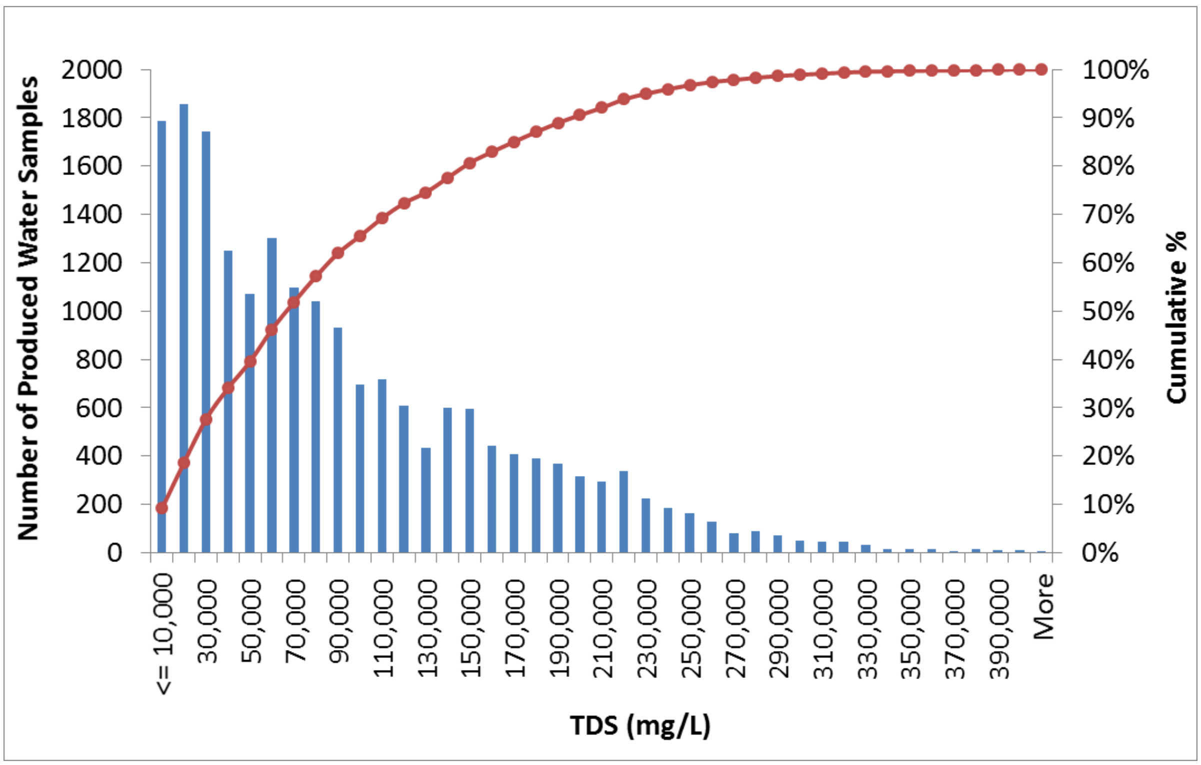


Figure 37. TDS Range of Produced Water in Texas (*45*).

WATER USE IN THE OIL AND GAS INDUSTRY IN TEXAS

Type of Water Used in the Oil and Gas Industry

In 2011, TWDB completed a study on the type and amount of water used in the mining and oil and gas industries in Texas (*19*). Based on a review of a survey that the Railroad Commission completed in 1996, the TWDB study estimated that the proportion of water used for developing and operating oil and gas wells was 75 percent fresh water and 25 percent brackish water. Readers should note that the Railroad Commission survey defined fresh water as having TDS up to 3,000 mg/L. If the threshold had been 1,000 mg/L, the result would have been a lower percentage for fresh water. A 2010 Permian Basin operator survey reviewed by the TWDB study indicated that the oil and gas industry had begun to use more brackish water in recent years, and the proportion of water used had changed to 20 percent fresh water and 80 percent brackish water (*19*). Although not clarified explicitly, the definition of fresh water in the Permian Basin operator survey was water with TDS probably up to 1,000 mg/L.

As part of a follow-up study completed in 2012, TWDB gathered information from industry operators and estimated percentages of different types of water used in different energy producing regions in the state (*46*). As Table 17 shows, the use of fresh water was as low as 20 percent in the western part of the Permian Basin Region but as high as nearly 100 percent in East Texas. The use of recycled water was only significant in the Anadarko Basin Region.

Table 17. Estimated Percentages of Water Use for Hydraulic Fracturing in 2011 (*46*).

Play/Region	Data Coverage*	Type of Water	Percentage of Use
Permian Far West	11%	Recycled/reused	0%
		Brackish	80%
		Fresh	20%
Permian Midland	23%	Recycled/reused	2%
		Brackish	30%
		Fresh	68%
Anadarko Basin	11%	Recycled/reused	20%
		Brackish	30%
		Fresh	50%
Barnett Shale	40%	Recycled/reused	5%
		Brackish	3%
		Fresh	92%
Eagle Ford Shale	31%	Recycled/reused	0%
		Brackish	20%
		Fresh	80%
East Texas Basin	15%	Recycled/reused	5%
		Brackish	0%
		Fresh	95%

*Data coverage is the total number of wells completed by well operators who were contacted divided by the total number of wells completed by all operators.
**Fresh water was water with TDS up to 1,000 mg/L.

The 2012 TWDB study included an assessment of the use of groundwater versus surface water for hydraulic fracturing operations. As Table 18 shows, groundwater is more heavily used than surface water in most energy producing regions of the state except in the Barnett Shale region. The 2012 TWDB study also collected information about drilling water use. Table 19 shows the summary results based on interviews with 20 operators.

Table 18. Estimated Groundwater vs. Surface Water Use for Hydraulic Fracturing (*46*).

Play/Region	Water Used for Hydraulic Fracturing	
	Groundwater	Surface Water
Permian Basin	100%	0%
Anadarko Basin	80%	20%
Barnett Shale	20%	80%
Eagle Ford Shale	90%	10%
East Texas Basin	70%	30%

Table 19. Reported Drilling Water Use in 2011 (*46*).

Play/Region	Operator	Reported Water Use for Drilling (gal/well)	Comment
Midland Basin (Permian Basin)	1	84,000	~Fresh*
	2	100,000	—
	3	210,000	~Fresh
	4	210,000–420,000	~Fresh
Delaware Basin (Permian Basin)	5	100,000	—
	6	210,000–420,000	Brackish
Anadarko Basin	7	200,000	—
	8	420,000	~Fresh
Barnett Shale	9	250,000	—
	10	210,000–420,000	~Fresh
	11	168,000	~Fresh
	12	500,000	~Fresh
Eagle Ford Shale	13	125,000	—
	14	420,000	—
	15	160,000	~Fresh
	16	126,000	~Fresh
	17	252,000–420,000	~Fresh
East Texas Basin	18	600,000	—
	19	840,000–1,100,000	~Fresh
	20	420,000	~Fresh

*Fresh water was assumed to be water with TDS up to 3,000 mg/L.

Water Well Data Analysis

The researchers analyzed groundwater data downloaded from the TWDB website, including the Submitted Drillers Reports Database (SDRDB) (*47*) and the TWDB Groundwater Database (GWDB) (*48*). SDRDB is an inventory of all registered water wells in the state. This database is not a complete inventory because many private water wells are not registered, and the database does not include water quality information. By comparison, GWDB is used to identify natural chemical components of groundwater and monitor water levels and water quality of some 137,000 water wells and 2,000 springs. Theoretically, GWDB should be a subset of SDRDB. However, this is not the case because SDRDB began to collect driller's reports in 2002, but GWDB includes older historical records going back to 1929. In addition, although all water well owners are required to submit reports to SDRDB, there are many unpermitted wells in the state, some of which might be recorded in GWDB.

Only SDRDB contains information on proposed well use. Table 20 lists 14 predefined categories that are available for water well drillers to specify the proposed use of a well. If the proposed use of a well does not meet the predefined categories, drillers may select Other and describe the use in a separate attribute named Proposed Use Other.

With this information, the researchers extracted well records from SDRDB to identify water wells that were drilled in relation to oil and gas developments. The result was 186,478 records from 2010 to 2015. As shown in Table 21, most water wells drilled from 2010 to 2015 were for domestic use. Wells drilled for fracking supply and rig supply accounted for 0.9 percent and 6.6 percent of the total number of water wells drilled, respectively. A closer review of the wells with user-defined proposed uses revealed that 25 of 194 wells were drilled for drilling supply in 2015.

Next, the researchers reviewed and analyzed GWDB data. This database stores water quality data in three separate tables based on the source water: major aquifers, minor aquifers, and combination aquifers. Each record from these data tables represents the concentration of a certain constituent in a water sample collected from a groundwater well. TDS is one of 647 constituents that were tested for water samples. The researchers extracted records of water samples that were tested for TDS between 2010 and 2015. Some wells were tested more than once during the six-year period, in which case the researchers calculated the average TDS value for the well. Figure 38 shows the location of all 2,430 wells that had at least one reported TDS value between 2010 and 2015. Some 81 percent of these wells contained fresh water with TDS up to 1,000 mg/L.

Finally, the researchers linked the data extracted from both SDRDB and GWDB. Currently, TWDB is in the early stages of linking the two databases by adding the well report tracking number from SDRDB to corresponding wells included in GWDB. Thus, only a small number of wells could be located in both databases at this time.

The researchers found 84 water wells that were drilled between 2010 and 2015 and were tested for TDS, where 11 wells were specified for rig supply. Most of these 11 wells were located in the Eagle Ford Shale Region, with average TDS ranging from 122 to 1,472 mg/L. One well was located in the Permian Basin, with an average TDS of 1,781 mg/L. Although the data analysis results are consistent with the findings from existing studies that water used in West Texas was more brackish than in East Texas, the sample size is not sufficiently representative to summarize the typical water used for oil and gas developments statewide.

Table 20. Proposed Use for Drilled Water Wells (*47*).

Proposed Use	Description
Predefined Uses	
Closed-Loop Geothermal	A vertical closed system well used to circulate water and other fluids or gases through the earth as a heat source or heat sink
De-watering	A well used to remove water from the water table close to the surface for construction purposes
Domestic	Private household use (only) well
Environmental Soil Boring	An artificial excavation constructed to measure or monitor the quality and quantity or movement of substances, elements, chemicals, or fluids beneath the surface of the ground (not including any well that is used in conjunction with the production of oil, gas, or any other minerals)
Extraction (since 2015)	A well that is used for extraction of chemicals, vapors, and groundwater in a remedial process to remove contaminated groundwater
Fracking Supply (since 2012)	A well that is drilled to supply water for fracking oil and gas wells that is mixed with additives to break up the oil or gas formations
Industrial	A well that is drilled to supply water for industrial or manufacturing and is not used for drinking unless it meets the requirements of a public water system approved by TCEQ
Injection	• An air-conditioning return flow well • A cooling water return flow well • A drainage well • A recharge well • A saltwater intrusion barrier well • A sand backfill well • A subsidence control well • A closed system geothermal well
Irrigation	A well drilled solely for agricultural purposes to water crops
Monitor	An artificial excavation that is constructed to measure or monitor the quantity or movement of substances below the surface of the ground (not used in conjunction with the production of oil, gas, or other minerals)
Public Supply	A well that has 15 or more service connections or serves 25 or more individuals 60 days out of a year
Rig Supply	A well drilled to supply water to an oil or gas rig at a drilling site
Stock	A well used to fill a stock tank or to provide water for livestock
Test Well	A well drilled to explore for groundwater or other substances below ground surface
User-Defined Uses	
Other (since 2014)	User-specified use may include: • ISCO (in-situ chemical oxidation) installation well • Drilling Supply • BDI installation well • Piezometer • Commercial

Table 21. Number of Water Wells by Year and Their Proposed Use (2010–2015) (*47*).

	2010	2011	2012	2013	2014	2015	Total	Annual Average
Closed-Loop Geothermal	212	266	219	227	223	131	**1,278**	**213**
De-watering	138	43	20	17	31	48	**297**	**50**
Domestic	8,721	10,822	11,215	11,444	12,351	10,373	**64,926**	**10,821**
Environmental Soil Boring	4,748	4,633	4,554	3,959	3,937	3,383	**25,214**	**4,202**
Extraction	0	0	0	0	0	3	**3**	**1**
Fracking Supply	1	206	208	402	550	220	**1,587**	**265**
Industrial	443	710	706	385	308	215	**2,767**	**461**
Injection	275	104	353	282	308	650	**1,972**	**329**
Irrigation	2,216	4,803	5,413	4,711	4,115	2,361	**23,619**	**3,937**
Monitor	5,809	5,682	5,643	5,227	5,565	5,101	**33,027**	**5,505**
Other	0	0	0	0	1	193	**194**	**32**
Public Supply	232	191	305	271	303	240	**1,542**	**257**
Rig Supply	2,365	2,631	2,321	2,054	2,113	853	**12,337**	**2,056**
Stock	1,133	2,118	1,662	2,023	2,109	1,818	**10,863**	**1,811**
Test Well	887	1,241	1,349	1,370	1,186	802	**6,835**	**1,139**
Unknown	0	6	0	4	1	6	**17**	**3**
Total	**27,180**	**33,456**	**33,968**	**32,376**	**33,101**	**26,397**	**186,478**	**31,080**

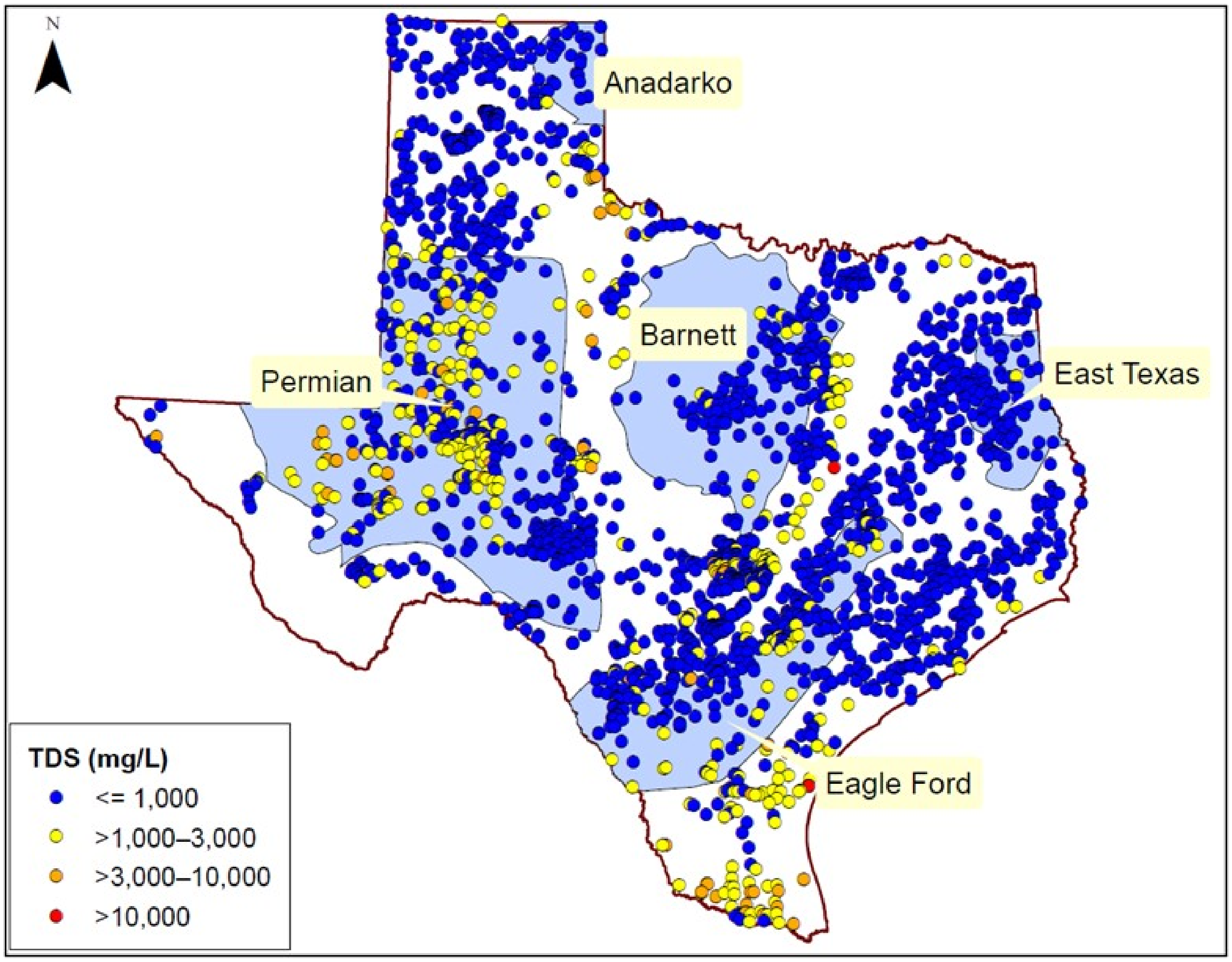


Figure 38. Average TDS of Water Collected from Groundwater Wells (Sampled between 2010 and 2015) (*48*).

In addition to the groundwater well data analysis, the researchers reached out to several GCDs in energy producing regions to gather information about types of water used to develop oil and gas wells. The GCDs contacted did not have official water quality data in relation to oil and gas developments. However, these agencies provided narrative descriptions of water used by the oil and gas industry based on their experience, as summarized in Table 22. These descriptions are generally consistent with the findings in the 2012 TWDB study, as shown in Table 17.

Table 22. Water Quality Information from Selected Groundwater Conservation Districts.

GCD	Shale/Basin Area	Groundwater Quality for Oil and Gas Industry
Rusk County	East Texas Basin	• Oil and gas companies normally use fresh water because water wells are generally not deep.
Permian Basin	Permian Basin	• Oil and gas companies use both fresh water and brackish water. • The district has seen an increasing amount of brackish water being used.
Middle Pecos	Permian Basin	• Oil and gas companies use fresh to slightly saline (TDS up to 3,000 mg/L) water depending on the area.
Panhandle	Anadarko Basin	• Oil and gas companies generally use fresh water. • Some companies may use produced or recycled water that is processed on site and does not need to be transported.
Evergreen	Eagle Ford Shale	• In recent years, oil and gas companies have used water with TDS ranging from 200–10,000 mg/L. Most of the water used is fresh water with TDS up to 1,000 mg/L and/or water with TDS greater than 1,000 and up to 2,000 mg/L.

SALTWATER IMPACTS

Based on the high-level analysis in the previous section, the amount of brackish water for developing and completing oil and gas wells appears to be increasing in the state. Because of the possibility that water with relatively high TDS values is transported in temporary pipelines and some of that water might be leaked or spilled, it is of particular interest to assess the potential impacts if the leaks or spills occur within the state right of way.

General Impacts to Vegetation and Animal Life

Based on Food and Agriculture Organization (FAO) guidelines and other reports, the Texas A&M AgriLife Extension Service published guidelines in 2003 for determining whether water is suitable for irrigation in Texas (*49, 50*). Table 23 includes permissible limits for various classes of irrigation water based on TDS. In general, tolerance levels to salt in soil and irrigation water varies widely depending on the type of crop.

Table 23. Permissible Limits for Classes of Irrigation Water (*50*).

Class of Water	TDS (mg/L)
Class 1, Excellent	< 175
Class 2, Good	175–525
Class 3, Permissible	525–1,400
Class 4, Doubtful	1,400–2,100
Class 5, Unsuitable	> 2,100

In 2014, the Texas A&M AgriLife Extension Service published another guideline that provides soil and irrigation water salinity thresholds for a number of native and introduced plant species in Texas (*51*). Table 24 summarizes irrigation water TDS threshold ranges for various plant categories. Notice that most irrigation water TDS thresholds were estimated from soil salinity, assuming that soil salinity was at least twice the irrigation water salinity due to evaporation and transpiration. Because the speed of accumulation of salt depends on soil type, the estimated irrigation water salinity thresholds should only be used as a general guide (*51*).

Table 24. Irrigation Water TDS Thresholds for Common Native and Introduced Plant Species in Texas (Adapted from [*51*]).

Species	Level of Sensitivity	TDS Thresholds (mg/L)
Trees and Shrubs	Very Sensitive	640
	Moderately Sensitive	640–1,280
	Moderately Tolerant	960–1,920
	Tolerant	1,920–2,560
	Very Tolerant	2,560–3,200
Turf Grasses, Flower, and Ornamental Ground Covers	Sensitive	640–960
	Moderately Tolerant	960–1,280
	Tolerant	1,920–2,950
	Very Tolerant	2,560–3,200
Vegetables and Herbaceous Crops	Very Sensitive	0–1,280
	Sensitive	640–1,280
	Moderately Tolerant	1,280–5,600
Fruit and Nut Crops	Very Sensitive	640–1,280
	Sensitive	640–1,280
	Moderately Tolerant	640–1,920
	Tolerant	1,920–4,800
Field Grasses, forages, and Field Crops	Very Sensitive	0–1,280
	Sensitive	640–1,280
	Moderately Tolerant	960–2,560
	Tolerant	1,920–3,200
	Very Tolerant	3,200

The FAO guidelines mentioned previously also included water quality criteria for livestock and poultry uses adapted from the 1972 National Academy of Sciences (NAS) water quality criteria (*52*). As shown in Table 25, water with TDS less than 3,000 mg/L is generally considered satisfactory for livestock and poultry.

Table 25. Water Quality Guide for Livestock and Poultry Uses (*49*).

Water Salinity		Rating
EC (ds/m)	TDS (mg/L)	
< 1.5	Less 1,000	Excellent
1.5–5.0	1,000–3,000	Very satisfactory
5.0–8.0	3,000–5,000	Satisfactory for livestock
		Unfit for poultry
8.0–11.0	5,000–7,000	Limited use for livestock
		Unfit for poultry
11.0–16.0	7,000–10,000	Very limited use
> 16.0	Over 10,000	Not recommended

Roadside Vegetation Management

The TxDOT *Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges* includes specifications for seed mix selections for erosion control in all 25 TxDOT districts (*53*). The 2014 Texas A&M AgriLife Extension Service's guideline includes the salinity tolerance for 14 of the 44 species included in the standard TxDOT specifications (*51*). In addition, the researchers found the soil salinity tolerance for western wheatgrass, but not for the remaining 29 species (*54*). The 14 species with corresponding TDS thresholds are listed in Table 26, Table 27, and Table 28 depending on the specific seed mix application.

The TxDOT *Roadside Vegetation Management Manual* provides a list of wildflower seeds for roadside soil stabilization and environmental protection (*55*). The choice of wildflowers for each TxDOT district varies by natural region. As shown in Figure 39, of the 12 natural regions in Texas, 11 regions are onshore. The manual includes 17 wildflower species for these onshore regions. Table 29 lists four wildflowers with TDS thresholds that were found in the 2014 Texas A&M AgriLife Extension Service's guideline (*51*).

Table 26. Selected Plant Species for Permanent Rural Seeding with Irrigation Water and Soil TDS Thresholds (*51*, *53*).

		Plant Species									
		Alkali Sacaton	**Bahia Grass**	**Bermuda Grass**	**Blue Grama**	**Buffalo Grass**	**Little Bluestem**	**Plains Bristle Grass**	**Sand Dropseed**	**Sideoats Grama**	**Western Wheatgrass**
TDS threshold (mg/L)	**Water**	3,200	960–1,280	2,950	960–1,280	960–1,280	1,920–2,240	960–1,280	960–1,280	640–1,280	—*
	Soil	> 8,000	1,920–4,800	4,800–6,400	1,920–4,800	1,920–4,800	4,800–5,600	1,920–4,800	1,920–4,800	1,280–2,560	4,800–12,800**
TxDOT District											
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							√	√		√	

* No information was found for the TDS threshold.
** The soil salinity thresholds of western wheatgrass were obtained from a separate reference (*54*).

Table 27. Selected Plant Species for Permanent Urban Seeding with Irrigation Water and Soil TDS Thresholds (*51*, *53*).

		Plant Species				
		Bermuda Grass	**Blue Grama**	**Buffalo Grass**	**Sand Dropseed**	**Sideoats Grama**
TDS threshold (mg/L)	**Water**	2,950	960–1,280	960–1,280	960–1,280	640–1,280
	Soil	4,800–6,400	1,920–4,800	1,920–4,800	1,920–4,800	1,280–2,560
TxDOT District						
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		√				√

Table 28. Selected Plant Species for Temporary Seasonal Seeding with Irrigation Water and Soil TDS Thresholds (*51*, *53*).

		Plant Species				
		Cereal Rye	**Oats**	**Tall Fescue**	**Wheat**	**Western Wheatgrass**
TDS threshold (mg/L)	**Water**	960–1,280	640–1,280	640	2,560	—*
	Soil	1,920–2,560	1,280–2,560	640–1,280	2,560–3,200	4,800–12,800**
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			√			

* No information found for TDS threshold of water for Western Wheatgrass.
** The soil salinity thresholds of western wheatgrass were obtained from a separate reference (*54*).

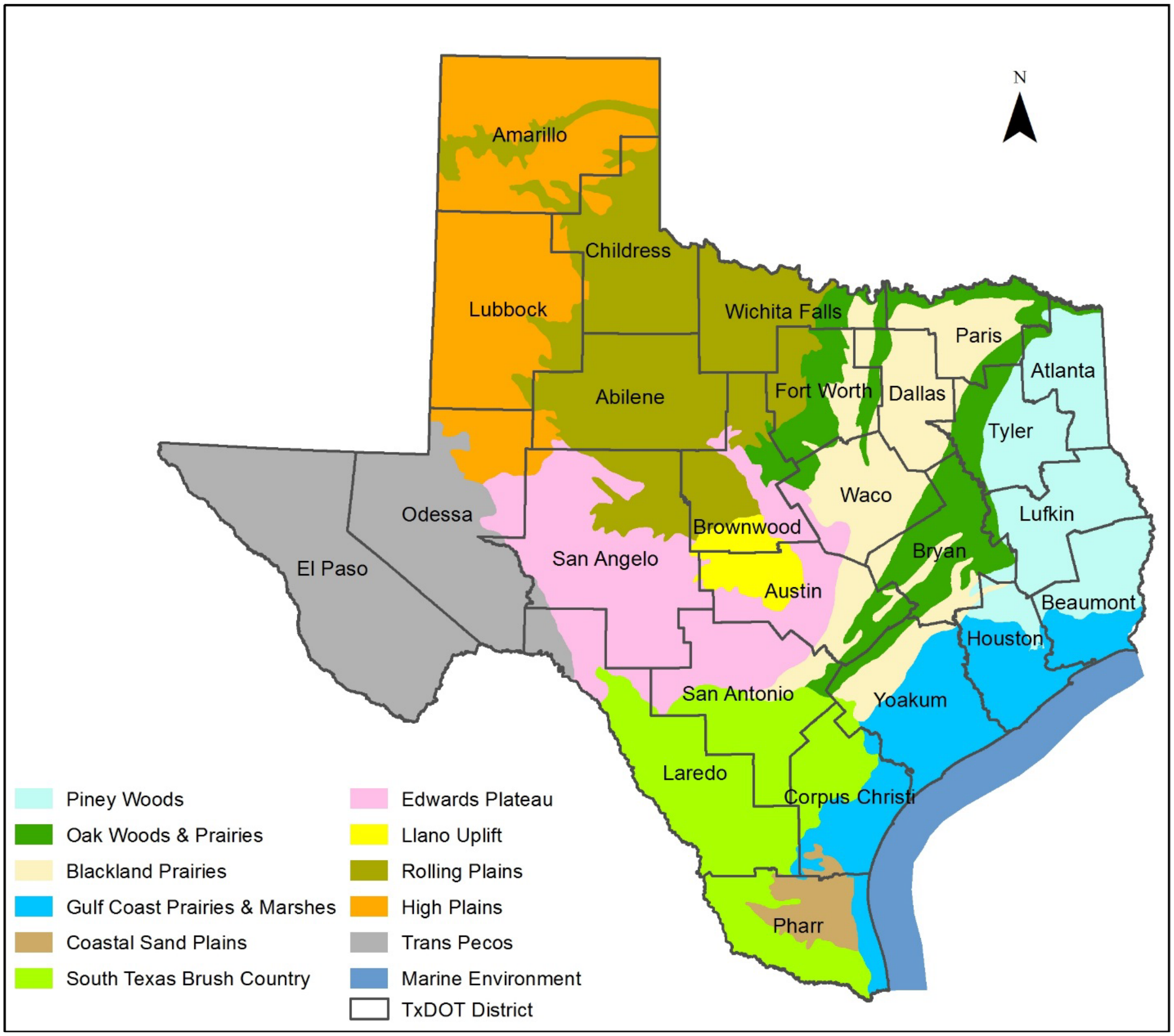


Figure 39. Natural Regions of Texas in Relation to TxDOT Districts (*56*).

Table 29. Selected Wildflowers for Roadside Vegetation with Irrigation Water and Soil TDS Thresholds (*51*, *55*).

		Plant Species			
		Bluebonnet	**Missouri Primrose**	**Pink Evening Primrose**	**Mexican Hat**
TDS threshold (mg/L)	**Water**	3,200–4,800	960	2,560–3,200	3,200–5,600
	Soil	—*	< 1,920	3,200–5,600	—*
Natural Region	**TxDOT District**				
Piney Woods	Atlanta, Beaumont, Bryan, Houston, Lufkin, Paris, Tyler			√	√
Oak Woods and Prairies	Atlanta, Austin, Brownwood, Bryan, Dallas, Fort Worth, Houston, Lufkin, Paris, San Antonio, Tyler, Waco, Wichita Falls, Yoakum	√		√	
Blackland Prairies	Atlanta, Austin, Bryan, Dallas, Fort Worth, Houston, Paris, San Antonio, Tyler, Waco, Wichita Falls, Yoakum	√	√	√	√
Gulf Coast Prairies and Marshes	Beaumont, Corpus Christi, Houston, Laredo, Pharr, Yoakum	√		√	
Coastal Sand Plains	Corpus Christi, Laredo, Pharr	√		√	
South Texas Brush Country	Corpus Christi, Laredo, Pharr, San Antonio, Yoakum	√		√	
Edwards Plateau	Austin, Brownwood, Laredo, Odessa, San Angelo, San Antonio, Waco	√	√	√	
Llano Uplift	Austin, Brownwood, San Angelo	√	√	√	
Rolling Plains	Abilene, Amarillo, Brownwood, Childress, Fort Worth, Lubbock, Odessa, San Angelo, Wichita Falls		√		√
High Plains	Abilene, Amarillo, Childress, Lubbock, Odessa, San Angelo			√	√
Trans Pecos	El Paso, Laredo, Odessa, San Angelo				√

* No information found for the TDS threshold.

Response to Leaks and Spills

In Texas, if a discharge or spill of a certain substance occurs and reaches a pre-established threshold, the responsible party must notify the state. The threshold quantity is called the reportable quantity (RQ), which depends on the type of substance released and where the release occurred (e.g., into water or on land). Different types of discharges or spills are subject to different state or federal rules, and corresponding responsible agencies need to be involved. Table 30 lists reportable quantities for various types of spills and related rules, statutes, or responsible agencies.

Table 30. Reportable Quantities of Spills by Spill Type (*57*).

Spill Type	Where Discharged	Reportable Quantity	Rule, Statute, or Responsible Agency
Hazardous substance	onto land	Final RQ in 40 Code of Federal Regulations (CFR) 302.4	30 TAC 327
	into water	Final RQ or 100 lb, whichever is less	
Any oil	coastal waters	As required by the Texas General Land Office	Texas General Land Office
Crude oil, oil that is neither a petroleum product nor used oil	onto land	210 gallons (five barrels)	30 TAC 327
	directly into water	Enough to create a sheen	
Petroleum product, used oil	onto land, from an exempt petroleum storage tank (PST)	210 gallons (five barrels)	30 TAC 327
	onto land, or onto land from a non-exempt PST	25 gallons	
	directly into water	Enough to create a sheen	
Associated with the exploration, development and production of oil, gas, or geothermal resources	under the jurisdiction of the Railroad Commission	As required by the Railroad Commission	Railroad Commission
Industrial solid waste or other substances	into water	100 lb	30 TAC 327
From petroleum storage tanks, underground or aboveground	into water	Enough to create a sheen on water	30 TAC 334.75-81
From petroleum storage tanks, underground or aboveground	onto land	25 gallons or equal to the RQ under 40 CFR 302	30 TAC 327
Other substances that may be useful or valuable and are not ordinarily considered to be waste, but will cause pollution if discharged into water in the state	into water	100 lb	30 TAC 327

The spill categories listed in Table 30 do not specifically address saltwater leaks or spills from temporary pipelines. Presumably, this type of event could be associated with (a) the exploration, development, and production of oil, gas, or geothermal resources or (b) other substances that are valuable or are not considered waste but can cause pollution if discharged into water in the state. The researchers contacted officials at the Railroad Commission and TCEQ for clarification on this topic, but no specific feedback was received concerning how to handle saltwater leaks or spills from temporary pipelines or concerning what state agency would have regulatory responsibility. This is an outstanding policy issue.

The potential impact of produced-water releases is well documented and can include pollution of surface and underground water sources, damage to plant growth and soil structure, and other adverse impacts on ecosystems (*58*). As an illustration, Figure 40 shows the effect on trees and vegetation that resulted from a produced-water spill that occurred near a well location in Alto, Texas, in 2008 (*59*, *60*).

(a) Produced-water spill (b) Resulting death of trees and vegetation

Figure 40. Impact of Produced-Water Spill on Trees and Vegetation (*59*, *60*).

There is a two-year statute of limitation for seeking compensation for surface damages resulting from produced-water spills even if the damages were undetectable initially. Obtaining compensation for surface damages is particularly difficult for landowners that only have surface rights. The two-year statute of limitation does not affect local, county, and state jurisdictions that own surface rights.

In 2004, the Railroad Commission prepared a draft field guide for the assessment and cleanup of produced-water releases. The commission updated the document in 2011. The field guide remains a draft and therefore is not an official policy document. Nevertheless, Railroad Commission site remediation staff use the guide when evaluating response actions to produced-water releases. The commission also shares copies of the draft guide with energy stakeholders. Steps included in the draft guide are as follows:

- **Notification**. If a produced-water release exceeds 25 barrels or any volume that enters water sources (both surface and underground), the responsible operator is encouraged to notify the Railroad Commission immediately.

- **Initial response**. Initial response includes removing the source of the release and recoverable fluids; flushing soils if produced water percolates through soils; identifying receptors such as surface water supply intakes and agricultural areas; and estimating the duration and volume of the release, type of soil, and whether immediate environmental threat exists.

- **Soil assessment and remediation**. If the impact of produced-water release on soils becomes apparent over time, the operator should conduct a soil assessment to identify impacts (including taking samples from adjacent unaffected areas to determine background soil conditions) and implement applicable soil remediation strategies such as amendments, flushing, and removal of saline soils.

- **Groundwater assessment and remediation**. If evidence points to produced-water release as causing groundwater contamination or recurring produced-water releases occur, the operator should conduct a groundwater assessment and implement applicable groundwater remediation strategies, which could include hydraulic control and removal as well as closure in place with institutional controls.

- **Surface water assessment and remediation**. If impact on surface water bodies has occurred, the operator should conduct a surface water assessment and identify environmental receptors that are sensitive to the produced water released. The operator should also implement applicable surface water remediation strategies, which could include removal of source and free-standing fluids, hydraulic control of groundwater if it affects surface water, removal of affected soils if they are contributing salinity to nearby water bodies, and removal of affected standing water if the volume is small.

A critical factor to keep in mind is the amount of water that could be discharged if there is a leak or spill. Typical flow rates for temporary pipelines appear to range from 40–140 bpm, which is equivalent to 1680–5880 gallons per minute (gpm) for 8- to 10-inch temporary pipelines (*61*, *62*). For context, water trucks that transport water to well sites have a capacity between 130 and 150 barrels. If a temporary pipeline operating at 100 bpm were to burst but the event is not detected for one hour, the resulting discharge would be 6000 barrels or 252,000 gallons of water (i.e., the equivalent of 43 water trucks). Even five minutes could be significant. In this case, the discharge would be 500 barrels or 6000 gallons (i.e., the equivalent of 3.5 water trucks).

Pinhole leaks are more common than burst ruptures. However, if undetected or unrepaired, a relatively minor leak could still discharge a significant amount of water. For example, a leak discharging 1 gpm would discharge 1440 gallons (or 34 barrels) over 24 hours (i.e., almost the equivalent of one-fourth of a water truck).

CHAPTER 7. STAKEHOLDER MEETINGS

INTRODUCTION

This chapter documents and summarizes lessons learned from various stakeholder meetings. At the beginning of the project, the researchers conducted several meetings with TxDOT officials, county officials, and temporary pipeline operators to review existing practices and identify issues. Near the end of the project, the researchers conducted two stakeholder meetings to discuss the draft guidebook and receive feedback on recommendations for temporary pipeline installation, operation, and maintenance practices.

STAKEHOLDER MEETINGS TO GATHER BACKGROUND INFORMATION

The researchers conducted meetings with stakeholders in the Barnett Shale, Eagle Ford Shale, and Permian Basin Regions. Stakeholders included TxDOT officials, county officials, and temporary pipeline operators. TxDOT officials typically included district permit coordinators, district maintenance engineers, district transportation planning and development directors, district maintenance directors, utility inspectors, area engineers, maintenance supervisors, and maintenance staff.

The researchers conducted meetings with officials from Tarrant, Wise, Dimmit, McMullen, Glasscock, Martin, Yoakum, and Reeves Counties. All these counties have a permitting process in place, except McMullen County, which does not require permits for temporary pipelines. The only requirement at McMullen County is for operators to install temporary pipelines at the edge of the right-of-way line, remove pipelines when work is complete, and repair any damage caused. County officials included county engineers, county judges, county road and bridge administrators, county maintenance personnel, and county commissioners.

With respect to pipeline operators, the researchers requested copies of temporary 1082-T permits issued by districts, identified a sample of operators, and then contacted those operators to schedule meetings.

The stakeholder meetings involved discussions about the following topics:

- Accommodation practices.
- Interaction with existing utility installations.
- Temporary pipeline design practices, standards, and specifications.
- Materials and construction methods and procedures.
- Temporary pipeline operation and maintenance procedures and requirements.
- Roadside maintenance impacts.
- Highway drainage impacts.

- Safety to the traveling public.
- Environmental issues and emergency response practices.
- Outreach, communication, coordination, and training.

In preparation for the stakeholder meetings, the researchers prepared an interview guide, which is included in Appendix B.

Feedback from stakeholders was heavily influenced by the fact that, when the stakeholder meetings took place, Form 1082-T was the main instrument that TxDOT used to authorize the placement of temporary pipelines within the state right of way. Although leases are now used, many of the lessons learned from the initial stakeholder meetings are still relevant.

Stakeholder Feedback—TxDOT

Accommodation Practices

A typical practice at the districts is to send installation requests to area office and maintenance sections to verify the feasibility of installation. Over time, districts have developed provisions that they attach to the approval forms. In many cases, the provisions are paraphrased versions of requirements already included in the approval forms or in the TAC, but in other instances, districts add provisions that were not part of the standard forms. Examples of additional provisions include the following:

- Call the area utility inspector and give a 48-hour notice before beginning work.
- Use driveway manifolds at all driveway locations and coordinate their placement with property owners.
- Place the temporary pipeline as close to the right of way or fence line as possible.
- In the event of heavy rain, check with the TxDOT utility inspector concerning the possibility of flooding due to blockage.

Special provisions are typically prepared at the district office level, but it is not clear to what degree area offices and maintenance sections are involved in the preparation or update of those provisions. Although area offices have the opportunity to review individual installation requests, they have little control on how approvals are handled or what kinds of provisions are attached to approvals. Some area offices complained that, because the approvals are handled at the district office, the area offices are stuck with how the approvals are written.

One of the districts wondered if 90 days was too long to accommodate a temporary pipeline within the right of way, considering that most operators only have temporary pipelines in place for 7–10 days. Shorter allowed durations (e.g., 30–60 days) would enable districts to track temporary pipelines more closely.

Districts identified a need for guidance on the maximum size of pipelines that should be accommodated in the state right of way. To minimize the impact on culverts, districts compare the size of the proposed temporary pipeline to the size of the culverts and determine if the culvert is sufficiently large. Frequently, area offices verify the size of culverts in the field. In general, districts identified a need for standards regarding sizes of pipelines occupying culverts. Districts also identified a need for a driveway ramp design standard. One of the reasons is that area offices frequently receive calls from landowners complaining that driveway pipeline crossings are inadequate and block access to their property.

District officials noted a need for better signage showing a local contact who is in a position of responsibility in case there are maintenance issues that need to be addressed right away.

All the districts highlighted the need for increased inspection of temporary pipelines in the field but acknowledged that this is a challenge given the current limitation on hiring additional maintenance inspectors. A common complaint is that operators do things that are not approved or allowed. For example, some districts complain of operators placing pumps in the right of way even though this practice is not allowed, or that temporary pipelines are not placed close to the right-of-way line.

Another complaint is that operators sometimes install temporary pipelines illegally. This issue seems to vary by district. For example, in the Lubbock District, the number of approved installations is relatively low, but the district's concern is that the number of authorized temporary pipelines is probably less than 10 percent of the actual number of pipelines in the field. At the beginning of the energy boom, the San Angelo District had issues with operators not applying for permits and then moving onto private property without permission when told by TxDOT that they needed to apply for permits to use the state right of way. The district had to involve county sheriff officials multiple times to keep operators from installing temporary pipelines without permits. At the Odessa District, it is common for area offices to discover unauthorized temporary pipelines when conducting highway maintenance activities. In practice, because of the high level of energy development activity in the region and the insufficient number of maintenance inspectors, area offices frequently have to realign their inspection priorities (e.g., by focusing on temporary pipelines that are near highway construction projects). Because of the more limited inspection and enforcement along other highway corridors, one of the results is that unauthorized temporary pipelines may be identified, but the district's decision is to leave those pipelines alone.

Interaction with Existing Utility Installations

Temporary pipeline operators have little interaction with existing utilities, even though they occupy some of the same space within the right of way. An area of concern is whether existing provisions for stakes or other devices to anchor temporary pipelines account for the possibility that driving these devices into the ground might hit underground utility installations. With rare exceptions, districts do not require or encourage temporary pipeline operators to coordinate with utility owners or even place One Call requests to identify and mark the location of existing utility facilities on the ground.

In the Fort Worth District, operators are encouraged to use steel stakes to anchor temporary pipelines. The officials' perception is that these stakes are driven deeper on slopes. In the Corpus Christi District, the existing requirement is to use wooden stakes. In practice, area offices allow operators to use metal posts to anchor temporary pipelines because wooden stakes break easily. When installing metal posts, area offices frequently recommend that operators place One Call requests, but the degree to which this actually happens is unknown. In the Lubbock District, operators are required to use stakes to keep temporary pipelines in place, but operators rarely comply with this requirement.

Although temporary pipeline operators rarely interact with utilities, pipeline interaction with utility lines does happen. For example, officials at the Live Oak Area Office indicated that a fiber optic line was being installed at a location that had several temporary pipelines. This conflict required the district to instruct the pipeline operators to move their temporary pipelines.

Districts do not use databases to track temporary pipeline permits. Some districts keep digital copies of permits and leases. The Corpus Christi District uses a file-naming convention that includes road, operator, and approval date. The Laredo District uses a spreadsheet to track request and approval dates. Several districts indicated that adding temporary pipeline records to a system such as the Utility Installation Review (UIR) system would give inspectors the capability to manage those installations more effectively, know who to contact if maintenance issues arise, determine whether a temporary pipeline on the ground is legal, and know when permits are expiring so that they can verify that the temporary pipelines are removed.

Temporary Pipeline Design Practices, Standards, and Specifications

The Corpus Christi and Laredo Districts require operators to place temporary pipelines near right-of-way fences and mow if required prior to installing the temporary pipeline. District officials indicated that operators rarely mow. The Corpus Christi District requires operators to coordinate with landowners as to the landowners' preferred method to cross driveways. The Corpus Christi District does not allow driveway crossings to exceed 4 inches in height. As a result, three- and 4-inch temporary pipelines are typically used with driveway ramps that extend the entire width of the driveway. For larger pipelines, operators use driveway manifolds that do not exceed 4 inches in height. The district does not allow the operator to trench a driveway unless the landowner specifically approves this.

Districts do not require surveying or as-built drawings for temporary pipelines. Most districts only require operators to submit a high-level map showing the approximate location of their proposed temporary pipeline. However, several district officials indicated that operators should be required to stake out temporary pipeline locations prior to installation and to submit as-built drawings.

The Lubbock District requires that temporary pipelines occupy no more than 10 percent of the cross-sectional area of a culvert, while the Odessa District allows temporary pipelines to occupy no more than 33 percent of the cross-sectional area of a culvert.

Materials and Construction Methods and Procedures

With some exceptions, districts do not specify materials or construction methods. Corpus Christi District officials noted that operators used aluminum pipelines at the beginning of the shale energy boom. These pipelines leaked more than the polyethylene and lay-flat temporary pipelines currently used. However, aluminum temporary pipelines stayed in place, whereas polyethylene and lay-flat temporary pipelines require stakes. The Laredo District requires the use of lay-flat temporary pipelines in culverts so that when not in use they restrict less culvert capacity. The district has received requests to install 10-inch aluminum temporary pipelines, but the district is concerned that these pipelines are too large and could cause serious damage and harm to a vehicle and its occupants if the pipeline is struck by a car. The San Angelo District does not allow operators to use aluminum temporary pipelines.

Several area offices indicated that a traffic control plan (TCP) should be required when operators are installing or removing temporary pipelines in the right of way. In addition, although the approval forms include a requirement to notify TxDOT prior to installing temporary pipelines, operators rarely comply with this requirement.

Temporary Pipeline Operation and Maintenance Procedures and Requirements

District maintenance inspectors are responsible for verifying that temporary pipelines are installed properly within the right of way. Maintenance inspectors also check temporary pipelines for anomalies, mainly leaks. Maintenance practices vary by district. For example, Lubbock and Odessa District inspectors do not specifically inspect maintenance issues with temporary pipelines, but do inspect them as a part of routine maintenance inspections. Odessa District inspectors have a specific focus on the inspection of temporary pipelines near construction projects. The San Angelo District inspects temporary pipelines once a week. However, during the energy boom, temporary pipelines were inspected two or three times per week.

When maintenance issues arise, inspectors attempt to contact temporary pipeline operators to resolve the issues. However, districts do not have a formal process for tracking temporary pipeline operator responses to these requests. A common issue is the difficulty to identify and therefore contact the operator who is responsible for a specific pipeline. One of the reasons is that pipeline operators rarely use markers or signs displaying contact information in case of an emergency. Several districts noted that the information on signs was outdated or did not provide a local contact who could respond in an emergency.

District officials lack adequate knowledge about the type of water transported in temporary pipelines. Beyond the requirement for temporary pipelines to carry non-produced water, it is common for district officials to assume that the water being transported is fresh water. In some cases, they assume it is fresh water but do not know for certain whether that is always the case.

Roadside Maintenance Impacts

District officials highlighted a number of roadside maintenance issues related to the use of the right of way by temporary pipelines. Frequently, the issue is temporary pipelines negatively affecting roadside mowing operations either because temporary pipelines occupy the right of way for long periods of time or because multiple temporary pipelines are placed at the same location simultaneously or one after the other. Maintenance crews often contact the district office to notify operators to move their temporary pipelines to avoid damage to the pipelines while mowing. Most operators are responsive to the districts' requests, but when conflicts arise, districts have to remind operators that the operators are responsible for the cost of maintenance activities if they are hesitant to work around maintenance crews.

Districts also noted that most operators mow prior to installing temporary pipelines but not while temporary pipelines are in the field. This can be an issue because mowing contractors often leave a section un-mowed when temporary pipelines are in the way. The challenge for area offices is whether to try to recoup money from the mowing contractors for the unfinished strips because, at the same time, the district does not want mowers accidentally damaging the temporary pipelines. Damaging temporary pipelines can have serious repercussions, particularly in situations where the operator cannot be reached easily. For example, the San Angelo District has had issues with mowers hitting temporary pipelines, causing water (of unknown TDS) to run for several hours and causing temporary pipelines to interfere with ditch maintenance.

Roadside maintenance impacts by temporary pipelines are exacerbated in situations where temporary pipelines occupy the right of way illegally. For example, in the Lubbock District, one of the issues is trying to identify the operators because pipelines do not have signs or markers. District officials often move the pipelines themselves so they can conduct roadside maintenance activities. The district does not have an exact dollar amount but knows that temporary pipelines have at least indirectly increased maintenance expenditures due to lost productivity.

The Odessa District has had a similar experience. If a temporary pipeline is occupying the right of way illegally, maintenance crews might move the pipelines themselves or cover them with dirt to move equipment during maintenance operations. In some cases, pipeline operators have asked the area office to delay maintenance activities until drilling is complete and temporary pipelines can be removed, but this action is not a desirable outcome for the area office.

Highway Drainage Impacts

Districts manage the risk of flooding on a case-by-case basis. Generally, districts have been able to avoid major issues by asking operators to remove temporary pipelines from culverts before major rain events. To facilitate this process, some districts have required the use of quick connectors or shut-off valves on either side of the culvert. As opposed to roadway culverts, temporary pipelines inside driveway culverts are not allowed. However, districts find temporary pipelines inside driveway culverts all the time.

Sometimes districts require operators to clean out culverts before installing temporary pipelines, particularly in the case of smaller culverts. Another strategy districts have used is to limit the amount of time a temporary pipeline is allowed to occupy a culvert. For example, at the Fort Worth District, sometimes area offices have requested shorter time frames and, consequently, a special provision was added stating that the temporary pipeline could be in place for a period of time shorter than 90 days (e.g., two weeks).

An issue for districts is to determine the maximum number and size of pipelines that can be allowed inside culverts. Districts have developed informal guidelines, but all of them expressed a need for more formal guidelines moving forward. In some situations, districts might not allow temporary pipelines inside culverts at certain locations that are particularly prone to flooding.

Occasionally there are situations that require immediate attention. For example, the Karnes Area Office found a temporary pipeline that floated across a road during a rain event that caused localized flooding and had to be removed by the pipeline operator.

Safety to the Traveling Public

Districts expressed concern about several traffic-related issues. One of the issues is when operators attempt to tamper with culvert safety end treatments. For example, at the Fort Worth District, when an operator proposes to use a culvert that has a safety end treatment, inspectors determine if the temporary pipeline fits through the safety end treatment. If the temporary pipeline does not fit, the district works with the operator to identify an alternative location. In some instances, operators have removed part or all of a safety end treatment and cannot reinstall it back in place.

The Corpus Christi District restricts the number of temporary pipelines that may be installed side-by-side to two unless the district determines that the right of way would not be affected from a traffic safety standpoint by allowing more than two temporary pipelines. The Laredo District has concerns about allowing 10-inch temporary pipelines because of the risk that these pipes might cause serious damage to vehicles and harm occupants if a crash occurs. The district has observed several instances in which vehicles have hit temporary pipelines, thus their concern about allowing larger diameter pipelines within the right of way.

Another traffic safety issue is related to TCPs and signage. Districts highlighted the need for more effective traffic control when installing and removing temporary pipelines. Although operators have largely shifted from rigid aluminum pipes to other types of pipelines such as polyethylene and lay-flat pipelines, it still takes time to install and remove the pipelines in the field. Districts have observed problems such as operators using incorrect signs and leaving signs by the roadside after finishing the fieldwork. Districts have also observed pumps within the right of way (which are not allowed because they are not crashworthy and create a serious traffic safety hazard) and have had to ask operators to remove those devices.

Environmental Issues and Emergency Response Practices

Many district officials indicated that they have not observed major environmental issues with temporary pipelines. However, this observation is probably because of a common assumption that temporary pipelines only carry fresh water, and, consequently, procedures for responding to and cleaning up saltwater leaks and spills are not considered necessary and have not been implemented. Several area offices noted that they are not certain whether temporary pipelines only carry fresh water and that the only way to truly know what is being transported is if a leak occurs.

TxDOT inspectors notify the pipeline operator after detecting a leak. In situations where the operator cannot be identified (e.g., the pipeline is occupying the right of way illegally or the pipeline does not have any signs showing contact information), the inspectors notify the district office to proceed with the search at that level.

Anecdotal evidence indicates that there are environmental issues related to the operation of temporary pipelines. In the Eagle Ford Shale Region, a TxDOT official noticed a temporary pipeline leaking from a joint connection into a river (Figure 20). A visual inspection of the area showed vegetation that appeared to be contaminated. In the Permian Basin Region, a TxDOT official discovered a temporary pipeline transporting what appeared to be crude oil. It took several months of coordination between TxDOT, the Railroad Commission, the property owner, and the energy company to get the pipeline removed. A TxDOT official from the Permian Basin Region indicated that operators are allowed to transport brine and brackish water in temporary pipelines. Operators are held responsible for leaks and any resulting environmental issues that may occur. However, in practice, TxDOT coordinates with the fire marshal's office when leaks occur to ensure that the appropriate agencies are involved.

Outreach, Communication, Coordination, and Training

Districts and area offices typically do not conduct formal training or public outreach regarding temporary pipelines. One district indicated that they include information about temporary pipelines when providing utility training to inspectors. In most cases, the interaction between TxDOT and the public occurs when citizens contact TxDOT when driveway crossings are inadequate and block access to their property or when they discover leaks in temporary pipelines. Because of the number of complaints from the public related to driveway-crossing issues, districts began to require operators to work with landowners to determine an acceptable driveway-crossing method and obtain their concurrence when submitting a request to install a temporary pipeline within the right of way.

Many TxDOT officials expressed a need for better coordination practices with operators. Most coordination occurs only when a specific issue arises, such as a temporary pipeline interfering with maintenance or construction activities. Some area offices noted that conducting a marketing campaign or awareness outreach would help to educate operators on the need to apply for leases and comply with all installation requirements.

Stakeholder Feedback—Counties

Accommodation Practices

Most counties developed a permitting process out of necessity when they noticed operators installing temporary pipelines in the right of way. The permitting process for many counties is similar to TxDOT's process in that operators submit permit applications with maps showing the location of temporary pipelines. The permitting process ranges from having a verbal agreement about where the temporary pipelines will be installed to having guidelines describing temporary pipeline accommodation policies and requirements.

Several counties have fees associated with temporary pipelines, including Dimmit County, Martin County, and Reeves County. Dimmit County charges a fee based on the size and length of temporary pipelines. Martin County allows temporary pipelines to occupy culverts, but there are very few in the county. Martin County charges a fee of $200 to bore under a road (open cuts are not allowed). Reeves County charges a fee of $14 per rod (16.5 feet) for a permit that is valid for six months.

Interaction with Existing Utility Installations

Counties reported very few interactions between temporary pipelines and existing utilities. In the Barnett Shale Region, there were a few instances where operators discovered telephone cables running through culverts. In these cases, the operators coordinated with the telephone companies to ensure that the telephone lines were removed so that the temporary pipelines could be installed through the culverts. Several counties require operators to use One Call before digging or boring, but bores are not conducted often, so the degree of compliance with this requirement is unknown.

Temporary Pipeline Design Practices, Standards, and Specifications

Counties typically do not have specific design practices, standards, or specifications for temporary pipelines. Several counties ask operators to install temporary pipelines as close to the right-of-way line as possible. Tarrant County allows temporary pipelines to occupy no more than 25 percent of the cross-sectional area of a culvert based on the diameter of temporary pipelines and culverts. Counties do not require surveys or as-built records of temporary pipelines.

Materials and Construction Methods and Procedures

Counties do not have specific material requirements for temporary pipelines but noted that operators use mostly polyethylene or lay-flat pipelines in lieu of aluminum pipelines, which were more common several years ago. Several counties require operators to notify the county at least 24 hours in advance before starting any work in the right of way. Many counties require traffic control in accordance with the *Texas Manual on Uniform Traffic Control Devices* (TMUTCD) when operators are working in the right of way.

Several counties indicated that they allow over-the-road crossings for temporary pipelines. Requirements for over-the-road crossings include signage before the crossing warning drivers of the obstruction ahead, use of a low-profile ramp or manifold, the presence of a flagger 24 hours a day, flashing lights to alert motorists, and light towers to illuminate the area after dark.

Temporary Pipeline Operation and Maintenance Procedures and Requirements

Counties inspect for leaks, proper installation practices, and unpermitted temporary pipelines. When issues are discovered, counties contact the permit holder to resolve the issues. Several counties stated that they have not found leaks in temporary pipelines. Counties do not have standardized systems to track temporary pipeline maintenance activities.

Roadside Maintenance Impacts

Counties noted a few instances where temporary pipelines have interfered with roadside maintenance activities. In several counties, roadside maintenance such as mowing has been rescheduled to accommodate temporary pipelines. However, some counties are concerned about the impact and limit the accommodation of temporary pipelines within the right of way.

Wise County officials recalled one instance where an operator cut and filled a road to install a temporary pipeline crossing without a permit. The county does not allow open cuts of roads for temporary pipelines. Resolving the issue involved meetings with the operator, the oil company, and the sheriff. The operator was required to remove the pipeline and repair the road. Reeves County officials indicated that temporary pipelines do interfere with roadside maintenance activities, but because the county charges fees to install temporary pipelines, the county is willing to alter its own maintenance schedules to accommodate temporary pipelines. The county considers that altering its maintenance schedules is a minor cost in light of the additional revenue they receive from pipeline operators.

Highway Drainage Impacts

Two counties in the Permian Basin Region noted that they have few culverts or their culverts are undersized, so they require operators to bore under the road. Tarrant County contacts operators to remove temporary pipelines from culverts prior to rain events. Several counties in the Eagle Ford and Permian Basin Regions noted that temporary pipelines have not caused major flooding or drainage issues, including one county that allows temporary pipelines to be installed in ditches.

Safety to the Traveling Public

All counties require traffic control in accordance with the TMUTCD when operators are working in the right of way. Although counties did not report specific instances of crashes or other major traffic safety issues related to temporary pipelines, the counties are concerned about issues such as adequate space within the clear zone and nighttime visibility. One of the concerns is that most county roads have narrow rights of way. In some instances, there is virtually no roadside, and temporary pipelines are tied to right-of-way fences. It is also common for temporary pipelines to roll into ditches. Of specific concern is nighttime visibility because of the lack of signs or markers alerting motorists to the presence of temporary pipelines. As a result, at least one county does not allow longitudinal pipeline installations.

Multiple counties indicated that they allow operators to install pumps in the right of way as long as they are installed in areas where the counties determine the risk to be lower (e.g., away from the road and intersections). However, the counties do not have specific distances or clear zone requirements. At least one county requires operators to place barricades and cones around pumps. In practice, most operators place pumps on private property to avoid theft.

Environmental Issues and Emergency Response Practices

Most counties indicated that they inspect temporary pipelines for leaks and have found only a few instances where leaks have occurred. Several counties stated that if leaks do occur, they are not a concern because temporary pipelines transport fresh water. However, Reeves County officials indicated that probably 90 percent of temporary pipelines transport fresh water and 10 percent transport produced water. In this county, when leaks do occur, the inspector stays on site until the responsible operator begins repairing the pipeline. In addition, operators are responsible for repairing any associated damage the leaks may have caused. Several counties indicated that their only response to a leaking temporary pipeline is to notify the responsible operator.

Outreach, Communication, Coordination, and Training

Counties have not conducted community outreach regarding temporary pipelines. In the Barnett Shale Region, counties indicated that landowners own the land up to the centerline of the roadways, and therefore the counties notify landowners when temporary pipelines will be installed.

Counties did not recall receiving complaints from the public about driveway crossings being inadequate. However, counties do receive other complaints. For example, one county receives complaints from landowners when operators use the public right of way to install a temporary pipeline instead of leasing private land from the landowner. Reeves County receives complaints about damaged roads and sometimes asks operators to repair the damage they have caused. In this county, inspectors use pictures as training material during internal safety meetings.

Stakeholder Feedback—Temporary Pipeline Operators

Accommodation Practices

Operators stated that TxDOT requirements for temporary pipelines are reasonable, including information about the location, culvert locations, and maps or images from Google Earth. When occupying a culvert, some operators send a picture of the culvert along with the application package. Operators highlighted that the review process works well depending on who they contact first. One operator indicated that the review process works better when there is coordination with a TxDOT area office prior to submitting the application package at the district office. Operators also indicated that approval times vary from district to district, with some districts approving the application within a day or two and other districts taking weeks to respond. Operators did note that when it takes longer than a week to receive a response, it is usually because there are extenuating circumstances for TxDOT (e.g., ice on roads or a large project).

Operators reported that major issues with TxDOT's accommodation policy are inconsistent practices and requirements among districts and TxDOT not having the same sense of urgency when an operator needs a temporary pipeline installed quickly.

Interaction with Existing Utility Installations

Operators indicated that they normally do not interact with utilities. One operator reported that they had only one instance in the last three years in which coordination with utility owners was necessary. The reason was that the FM road where they proposed to install a temporary pipeline was to be reconstructed. Coordination involved several meetings with all the parties involved to ensure that the temporary pipeline would not be in the way of the highway construction.

Temporary Pipeline Design Practices, Standards, and Specifications

Operators indicated that they have little control over the routes that temporary pipelines must follow. Typically, the process that oil company land men follow involves securing approvals from landowners, which dictates where pipelines can be installed. Using the shortest path is not always feasible because of culvert locations and having to avoid certain properties due to disagreements. One operator stated that operators can install temporary pipelines on the property where the well drilling is taking place at no cost, but when crossing other properties, surveys must be conducted in order to accurately pay that landowner. This operator does not conduct surveys when using public right of way.

One operator indicated that there are no industry design guidelines or manuals for temporary pipelines. The operator maintains a pressure that does not exceed the manufacturer's maximum operating pressure while delivering the required amount of water to the end user. The operating pressure for this operator's temporary pipelines is at least 150 psi.

One operator did not place signs or labels on temporary pipelines, while another operator places signs and labels with contact information on temporary pipelines about every mile. One operator reported using t-posts to keep temporary pipelines in place but feels One Call is unnecessary because the stakes are only a couple feet deep.

Materials and Construction Methods and Procedures

Operators typically use polyethylene and lay-flat temporary pipelines because they are easier to store, require less labor to install and remove, and do not leak compared to aluminum temporary pipelines. Operators indicated that they install temporary pipelines as close to the right-of-way line as possible, mow the right of way when needed, and place signs with local contact information. Regarding requirements to notify TxDOT prior to beginning any work, one operator did not recall such a requirement, other operators stated that they notify the district permit coordinator, and other operators stated that they notify the local area office.

One operator employs safety personnel who make sure that when installing temporary pipelines they are using appropriate safety equipment and gear as well as ensuring that they are not blocking traffic. The operator uses flaggers if there is a need to cross or drive alongside roadways.

During spring 2015, South Texas received considerable amounts of rainfall. One of the operators contacted recalled seeing temporary pipelines float over roads as a result of flooding. To address this situation, the operator began using steel pipelines instead of lay-flat pipelines in low elevation areas. Another operator installs quick connects at culverts so that temporary pipelines can be removed easily in the event of rain or construction.

Temporary Pipeline Operation and Maintenance Procedures and Requirements

Operators indicated that they inspect temporary pipelines prior to beginning pumping and while they are actively transporting water. The number of inspections that operators reported varied but included two to three inspections before water is pumped, daily general inspections, and multiple times per day while water is being pumped.

Operators indicated that pinhole leaks are the most common type of leak and only leak a small amount of water. These leaks can be easily patched. When larger leaks occur, clamps are placed on either side of the leak, and the damaged section is repaired or replaced.

Roadside Maintenance Impacts

Operators reported that they are responsible for mowing before installing temporary pipelines. One operator claimed to have never mown because temporary pipelines are not in place long enough to require mowing. Another operator stated that if mowing were needed, a contractor would be hired to mow. Operators reported having no issues with interfering with TxDOT's maintenance or construction operations. One operator claimed to have never received a call from TxDOT for maintenance requests or coordination issues.

Highway Drainage Impacts

Operators indicated that they have not experienced damage to roadways or structures due to temporary pipeline leaks, and they were not aware of any drainage impacts from temporary pipelines.

Safety to the Traveling Public

Operators indicated that they have not experienced traffic safety issues with the general public, specifically drivers of small vehicles hitting temporary pipelines. However, operators did recall sand truck drivers striking temporary pipelines in the past.

Environmental Issues and Emergency Response Practices

Most operators reported only transporting fresh water through their temporary pipelines, not produced water. However, it is not clear whether fresh water to those operators meant water with TDS no more than 1,000 mg/L or whether it included water with a higher TDS. One operator indicated that some of the source wells produced brackish water that would be suitable for livestock to drink but people would not like the taste. One operator had internal discussions about transporting produced water in temporary pipelines along county roads but has never done so. Another operator is evaluating whether it is possible to transport recycled water in temporary pipelines for upcoming jobs.

Outreach, Communication, Coordination, and Training

Operators indicated that they normally meet with landowners to determine an approved driveway crossing method. These agreements are frequently verbal, but written agreements are also commonplace. When landowners have an agreement with an energy developer that stipulates a certain driveway crossing method as part of an oil and gas lease or surface use agreement, pipeline operators use the crossing method included in that agreement. One operator in the Permian Basin Region noted that the public in West Texas is familiar with the oil and gas industry, and, consequently, there is no need to conduct public outreach activities.

Prior to the establishment of leases, installing temporary pipelines longitudinally within the state right of way was not always possible. For this reason, operators had to negotiate with landowners to use their property. One operator indicated that negotiating with TxDOT to use the state right of way would be preferable because this right of way is clear and maintained regularly. This operator would not mind paying a reasonable fee to install longitudinal temporary pipelines within the state right of way.

GUIDEBOOK STAKEHOLDER MEETINGS

As part of the project, the researchers developed a guidebook to provide guidance on the installation, operation, and maintenance of temporary pipelines in the state right of way. The researchers conducted two stakeholder meetings to discuss the draft guidebook and receive feedback on recommendations for temporary pipeline installation, operation, and maintenance practices.

The first stakeholder meeting took place in Odessa for stakeholders in the Permian Basin Region. The second stakeholder meeting took place in San Antonio for stakeholders in the Eagle Ford Shale Region. The researchers sent out invitations to a wide range of stakeholders, including TxDOT Right of Way and Maintenance Division officials; officials at district offices, area offices, and maintenance sections; and temporary pipeline operators. Of 92 people invited, including 61 from TxDOT and 31 operators, 49 people attended the two meetings (Table 31).

Table 31. Stakeholders that Attended the Workshops.

Meeting Location	TxDOT Officials	Operators	Total
Odessa	17	10	27
San Antonio	9	13	22
Total	**26**	**23**	**49**

In addition to obtaining feedback from participants about the draft guidebook, the stakeholder meetings provided an opportunity for Right of Way Division officials to gather information from districts and operators regarding the development of a framework that will guide the management of the temporary pipeline lease program at the department over the next few years. A summary of the feedback received from participants at the stakeholder meetings follows, with a focus on feedback that involved considerable discussion among participants.

Lease Applications

The current lease term is 90 days with an optional one-time extension of 90 days. An operator in the Permian Basin Region asked if the extended lease period could be prorated or partially refunded if the occupation is not needed for the full 90 days. TxDOT officials explained that the fee structure covers administrative costs and some of the costs of managing the right of way. The current fee does not cover all of the costs that TxDOT incurs and cannot be refunded. Another operator in the Permian Basin Region asked what to do if there is a situation where a third lease term is needed. The current practice is to remove the existing temporary pipeline and then apply for a new lease.

Exhibit A of the temporary pipeline lease form (i.e., Form ROW-L-TWL) includes blank text boxes for permit numbers for the water production source and the end disposal source. However, several operators indicated that permit numbers are frequently not available. In other cases, multiple permit numbers might apply. TxDOT officials will look into the feasibility of updating Exhibit A to include multiple permit numbers and coordinates, making permit numbers optional in case these numbers are not available. The discussion then extended to whether the terms water production source and end disposal source were appropriate. The consensus was that these two terms were confusing, and therefore TxDOT will replace them with the terms origins and destinations, respectively. Additionally, TxDOT has added textboxes for latitude and longitude of origin source, beginning of right of way, end of right of way, and destination source to the lease application.

There was considerable discussion about the feasibility of requiring operators to submit files in Keyhole markup language (KML) format to document the location of their proposed temporary pipelines, considering that most operators already provide printouts of Google Earth maps. Most operators considered this requirement feasible. Some operators indicated that their companies do not allow employees to use Google Earth but might have licenses for ArcGIS™ software. A recommendation was to look into the feasibility of developing a simple-to-use data standard for pipeline operators to submit the alignment of their proposed temporary pipelines as part of the lease application process. Having this information in digital format would enable TxDOT to conduct a more effective review of the proposed installation.

Water Transported in Temporary Pipelines

An operator in the Permian Basin Region confirmed transporting recycled water with extremely high TDS (of the order of 100,000 mg/L) using temporary pipelines. In this operator's experience, recycled water involves the removal of components such as fracking chemicals and other additives, but not salt. Operators asked if they could use temporary pipelines to transport high TDS water if they take precautions to prevent leaks and spills. TxDOT's concern is the risk of the impact on the roadside if saltwater discharges occur (and who is liable for these events) and suggested having a registered professional engineer sign and seal documents showing proposed temporary pipeline installations if the water has more than a pre-specified TDS threshold (e.g., 10,000 mg/L).

A suggestion was made for operators to indicate the TDS of the water as part of the documentation submitted with the lease application. In general, operators indicated that they already have the capability to know what kind of water they are transporting, so providing this information in the application form would not be an additional burden. Some operators did indicate that TDS of water can vary over time, even from the same water source. A potential solution would be for the operators to provide a range of TDS values instead of a single number, which might not represent exactly the actual TDS of the water on a given day.

Temporary Pipeline Operations and Maintenance

Pipeline operators from both the Permian Basin and Eagle Ford Shale Regions indicated that the requirement in the TAC for a maximum operating pressure of 60 psi was low and unrealistic. In practice, the types of pipelines that operators use nowadays already allow for operating pressures that are considerably higher than 60 psi. At the Corpus Christi District, the current practice is to require operators to provide the specifications of the temporary pipeline they will use, including the operating pressure ratings of the material, and then operate the pipeline safely within the parameters indicated in the specifications.

The current lease agreement form requires signs to be placed every 500 feet. Both TxDOT and the operators in the Permian Basin and Eagle Ford Shale Regions indicated that placing signs at such short intervals is not necessary. As a minimum, operators should place signs where temporary pipelines cross the right-of-way line and every mile or two along the pipeline installation. Because some signs that are currently used are bulky, TxDOT officials would like to see smaller signs or stencils attached directly to the pipelines.

One of the recommendations in the guidebook is to use driveway ramps and manifolds that do not exceed 4 inches in height to minimize traffic safety risks, including the risk of an errant vehicle striking one of these devices. The requirement not to exceed 4 inches in height is already included in the current regulations. Operators in the Permian Basin Region indicated that they do not use driveway ramps or manifolds for crossing temporary pipelines over driveways and property entrances. Instead, they typically build caliche pads over temporary pipelines. Operators in the Eagle Ford Shale Region stated that the methods used to cross temporary pipelines over driveways and property entrances often exceed 4 inches in height. What they frequently do is to add material on either side of the temporary pipeline and gradually grade the ramp back to the existing surface.

The guidebook includes guidance for the maximum number of temporary pipelines that should be allowed in culverts in order to avoid an excessive degradation of the hydraulic conveyance of a culvert. Chapter 5 provides additional information on the methodology the researchers used to develop the guideline. Odessa District officials indicated that, under certain circumstances, it might be appropriate to accept a higher level of risk by allowing larger temporary pipeline sizes or more temporary pipelines in culverts. For example, in West Texas it rarely rains from July to September. Under this scenario, allowing larger or more temporary pipelines to be placed in culverts during the summer would not necessarily result in a higher level of risk for the department.

CHAPTER 8. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The water transfer industry has evolved over time as the oil and gas industry has increased its use of temporary pipelines to transport water needed for drilling and completing oil and gas wells. From initially using rigid aluminum pipelines, temporary pipeline operators have largely migrated to polyethylene and lay-flat pipelines. These newer temporary pipelines are lighter and more durable than aluminum temporary pipelines, making them more economical to install, operate, and maintain.

TxDOT uses two types of lease agreements for the installation of saltwater pipelines on the right of way: short-term leases (up to 180 days) for aboveground temporary saltwater pipelines, mainly intended to carry non-produced water; and long-term leases (for periods less than two years, between two and five years, or greater than five years) for underground saltwater pipelines, mainly to carry produced water. Prior to temporary leases becoming operational in summer 2016, TxDOT used temporary permits for aboveground temporary pipelines.

The purpose of Research Project 0-6886 was to review temporary pipeline installation practices, develop a guidebook to install and operate temporary pipelines, and recommend potential changes to policies and regulations based on field data collection and stakeholder feedback. The research included a review of standards, specifications, and practices in Texas and other states; data collection in the field to extract information about typical installation trends; a hydraulic analysis to estimate the impact of temporary pipelines on the hydraulic capacity of culverts; a review of the characteristics and impact of saltwater on the roadside; and stakeholder meetings to discuss trends and the draft guidebook.

The review of standards, specifications, and practices in Texas and other states revealed similarities as well as differences. For example, Pennsylvania recently enacted a section of the Pennsylvania Code to address the use of temporary pipelines for oil and gas energy developments. Some of the requirements are similar to those in Texas. There are also requirements that are more specific to Pennsylvania (e.g., where joints may be located and how markers should be used to identify temporary pipeline locations when covered with snow). Many other states with significant energy development activity do not have standards or specifications for temporary pipelines.

The researchers requested copies of temporary pipeline permits from TxDOT districts to develop a GIS-based database of temporary pipeline locations in ArcGIS format. The database includes data attributes such as district, county, road, temporary pipeline location, size, length, and number of pipelines included in the permit. The researchers received 1091 permits that corresponded to 1426 temporary pipelines that were installed from 2011 to 2016. The GIS database facilitated the completion of a variety of analyses. General trends indicate the following:

- Temporary pipelines installed in Texas vary from 2–12 inches in diameter. Because of the difficulty in installing and repairing temporary aluminum pipelines, operators began to use other types of pipelines such as polyethylene and lay-flat pipelines. Polyethylene temporary pipelines are usually 3 or 4 inches in diameter and are used during the drilling phase of well development. Lay-flat temporary pipelines are 8 or 10 inches in diameter and are used during hydraulic fracturing or well completion activities.

- The average length of a pipeline is 1.3 miles. The median length is 0.94 miles. The longest temporary pipeline in the database was 11 miles long.
- Operators tend to favor certain highway segments to install temporary pipelines within the right of way. The range in the number of temporary pipeline permits per segment in the database was 1 through 24. Highway segments that involved only one permit covered slightly more than 50 percent of the roadways covered. Segments that involved up to five permits covered close to 90 percent of the roadways covered. Only 10 percent of the roadways covered involved more than five permits.
- Highway segments that had one permit were occupied for three months on average. Segments that had two permits were occupied by pipelines for 5.6 months on average. With a few exceptions, the average duration of pipeline occupancy increased with the number of permits.

The data collection campaign focused on gathering sample data about the characteristics and operation of temporary pipelines within the state right of way. The researchers identified suitable locations with the assistance of officials from the Odessa and Corpus Christi Districts. Field data collection took place at three locations in the Permian Basin Region and five locations in the Eagle Ford Shale Region. The researchers did not collect field data in the Barnett Shale Region because of decreased gas well development activity in that region. In general, the data collected provided a basis for recommendations and potential improvements for accommodating temporary pipelines in the state right of way.

Trends observed from the data collection campaign included the following:

- Temporary pipelines that are installed longitudinally within the right of way often cross driveways and other property entrances. To prevent blocking culverts and flooding roads, TxDOT does not allow temporary pipelines to be placed in culverts under driveways. Several types of driveway crossing structures are commercially available, including driveway ramps and manifolds. Typically, driveway ramps are used for drilling pipelines and manifolds are used for fracking pipelines. Some landowners prefer operators to build ramps using caliche or dirt to provide a gradual transition over temporary pipelines.
- Temporary pipelines in driveway culverts are a common phenomenon despite not being allowed. Driveway culverts are typically smaller than roadway culverts, making the issue of using small-diameter driveway culverts for temporary pipelines particularly critical.
- Operators place temporary pipelines farther away from the right-of-way line than what is recommended or required. For the five locations in the Eagle Ford Shale Region, the average lateral distance from the temporary pipelines to the right of way was 7 feet. For the three locations in the Permian Basin Region, the average lateral distance was 31 feet. Only 24 percent of the length of pipelines measured in the Eagle Ford Shale Region and

2 percent of the length of pipelines measured in the Permian Basin Region were installed within 3 feet of the right-of-way line.

- Placing temporary pipelines away from the right-of-way line means that they were placed closer to the edge of pavement. For the five locations in the Eagle Ford Shale Region, the average lateral distance from the temporary pipelines to the edge of pavement was 25 feet. For the three locations in the Permian Basin Region, the average lateral distance was 36 feet. The median distance in both regions was about 25 feet. Overall, results show that a significant percentage (probably 20–40 percent) of the road segments measured had temporary pipelines that were likely placed within the clear zone.

- Many operators install temporary pipelines at the bottom of the ditch or toe of the slope rather than using stakes to anchor the temporary pipeline near the right-of-way line. Temporary pipelines are also rarely installed at uniform distances from the edge of pavement or the right-of-way line. In other cases, the pipelines might be installed parallel to the road, but the pipelines shift over time because they are not anchored properly. This practice is detrimental to roadside maintenance activities, particularly vegetation management.

- Instances where temporary pipelines burst and leak large amounts of water are relatively uncommon, although reliable statistics do not exist. Pinhole leaks are more common than large bursts. Pinhole leaks do not discharge large amounts of water quickly, but some flooding is possible depending on how long the pipeline is left unrepaired and the terrain of the location. TxDOT officials reported cases of large roadside patches where salt crystals were visible on the surface of the ground and grass had died.

- When temporary pipelines are installed through culverts, operators occasionally have difficulty removing pipeline sections from the culverts. When this happens, some operators end up damaging the safety end treatment in their effort to remove the pipeline or simply decide to leave the temporary pipeline in place.

- TxDOT typically requires signage to be placed where temporary pipelines cross the right-of-way line. However, operators very rarely install signs. Frequently, information on signs is outdated or does not provide a local contact who could respond in an emergency.

The researchers conducted a hydraulic analysis to determine the impact of temporary pipelines on the hydraulic capacity of box and pipe culverts. Feedback from TxDOT officials highlighted the need for guidelines on the maximum number and size of temporary pipelines to allow inside culverts. The results of the analysis provide a basis for recommendations and guidance on how to proceed for future installations.

To conduct the hydraulic analysis, the researchers combined field geometric data about culverts and roadways with estimated flow data in a simulation software environment to arrive at typical discharge flow rates through various types and sizes of culverts. The researchers made comparisons between the output flow rate with and without temporary pipelines occupying culverts to estimate potential reductions in capacity. Based on the hydraulic analysis and district stakeholder feedback, the researchers used a 25 percent maximum reduction in capacity as the basic criteria for whether or not a certain sized temporary pipeline should be allowed in a culvert. The researchers then combined this requirement with the requirement of not accepting more than two temporary pipelines in any culvert to arrive at a tabulation of the maximum number of temporary pipelines (and their size) to allow inside culverts of any size.

TxDOT typically designs culverts for a 25-year return period for principal arterials (e.g., US 285 in the Permian Basin Region) and checks the potential flooding for a 100-year rainfall event. Similarly, TxDOT designs culverts on minor arterials and collectors (e.g., the roads measured in the Eagle Ford Shale Region) for a 10-year return period and checks the potential flooding for a 100-year rainfall event. A reduction in capacity would have the effect of reducing the effective return period. For a design return period of 25 years, a 15 percent reduction in capacity would reduce the return period to 10 years, a 25 percent reduction in capacity would reduce the return period to 5 years, and a 40 percent reduction in capacity would reduce the return period to 2 years. Similarly, for a design return period of 10 years, a 15 percent reduction in capacity would reduce the return period to 5 years, and a 35 percent reduction in capacity would reduce the return period to 2 years. For a return period of 100 years, which is used for overtopping flow calculations, a 10 percent reduction in capacity would reduce the return period to 50 years, a 20 percent reduction in capacity would reduce the return period to 25 years, and a 25 percent reduction in capacity would reduce the return period to 10 years.

As mentioned, TxDOT uses short-term leases for aboveground temporary saltwater pipelines, mainly intended to carry non-produced water, and long-term leases for underground saltwater pipelines, mainly to carry produced water. Based on feedback from TxDOT officials, a common assumption is that aboveground temporary pipelines carry fresh water. This prompted a review of current laws, regulations, and industry practices to document the degree to which this assumption is correct. Lessons learned from this effort included the following:

- Although the Texas Water Code provides a clear definition for what fresh water is (including that it should contain TDS no more than 1,000 mg/L), it is common for some energy industry stakeholders to consider that fresh water includes water with a considerably higher TDS.

- Although a significant percentage of temporary pipelines carry water with a relatively low TDS, it appears that TDS in the water varies widely across the state. Some operators indicated that they transport brackish water with extremely high TDS (of the order of 100,000 mg/L).

- The oil and gas industry is increasing the use of brackish water to develop and complete wells. This means that the use of temporary pipelines to carry brackish water to satisfy these needs is also likely to increase.

- Roadside vegetation, including grass mixes and wildflowers that TxDOT has planted on the roadside over the years, is vulnerable to high TDS in the soil. Most of the vegetation on the roadside can only tolerate TDS up to 4,800 mg/L in the soil. This situation increases the level of risk to TxDOT significantly because temporary pipeline operators do not currently report the TDS of the water they transport, and the current TxDOT requirements for dealing with leaks and spills essentially assume that the water being transported is fresh water.

- There are currently no clear guidelines at the state level for how to deal with leaks and spills from temporary saltwater pipelines. The Railroad Commission and TCEQ have guidelines for how to deal with a wide range of liquid discharges, but these guidelines do not specifically address saltwater pipelines. This is an outstanding policy issue.

The researchers conducted meetings with stakeholders in the Barnett Shale, Eagle Ford Shale, and Permian Basin Regions. At the beginning of the project, the researchers conducted several meetings with TxDOT officials, county officials, and temporary pipeline operators to review existing practices and identify issues. Near the end of the project, the researchers conducted two stakeholder meetings to discuss the draft guidebook and receive feedback on recommendations for temporary pipeline installation, operation, and maintenance practices.

In general, stakeholders agreed on the strategic advantage of developing effective communication channels and working relationships between TxDOT officials and temporary pipeline operators. Effective communications facilitate the review of applications and the resolution of issues that might emerge in the field during the installation and operation of the temporary pipelines.

However, there were significant differences in the feedback received from TxDOT and county officials with respect to the feedback received from operators. Although TxDOT officials highlighted positive aspects related to the accommodation of temporary pipelines within the right of way, they mentioned a myriad of issues, most of which were related to poor practices by operators regarding the way they install and operate temporary pipelines. Those issues clearly warrant the implementation of guidelines to clarify roles and responsibilities, improve pipeline installation and operation practices, and minimize the level of risk and exposure to TxDOT and the citizens of the state.

By comparison, operators typically considered TxDOT's accommodation policies and guidelines for temporary pipelines to be reasonable and easy to follow. Operators did not recall instances where their installation or operation practices interfered with TxDOT roadside maintenance activities. They also did not recall causing any damage to roadways or culvert safety end treatments or increasing the level of risk to motorists. They also considered the impact of leaks and spills to be minimal. Operators did have a few comments about their working relationship with TxDOT officials and emphasized the need to standardize procedures and requirements across the state. They also expressed a desire for the TxDOT review process to be expedited.

RECOMMENDATIONS FOR GUIDELINES

The researchers developed a standalone guidebook that contains recommended guidelines for installing, operating, and maintaining temporary pipelines within the state right of way (*64*). The guidebook addresses practices concerning temporary pipeline accommodation, installation, operation, and maintenance for three main user groups, as follows:

- TxDOT division and district personnel responsible for leasing the right of way.

- Oil and gas operators and their subcontractors.
- TxDOT district personnel responsible for inspecting and managing temporary pipelines in the field.

The topics covered in the guidebook follow the lifecycle of a temporary pipeline and range from applying for a lease, water characteristics, constructing pipelines, pipeline crossings, maintaining the right of way, maintaining temporary pipelines, and removing temporary pipelines. The guidelines focus on critical information for TxDOT and operators but not prescriptive mandates about how things are to be done.

A few guidelines from the guidebook that warrant some discussion include the following:

- Pipeline operators should submit temporary pipeline lease requests as early as possible to give TxDOT ample opportunity to review the technical feasibility of the proposed installation. Pipeline operators are understandably pressed for time and would like to execute the temporary pipeline lease as quickly as possible. However, drilling and developing a well involves a great deal of planning by an energy developer as well as coordination with all of its subcontractors. This process usually takes place over several months. There should be no reason why energy developers cannot provide pipeline operators with ample advance time so that these operators can submit their own lease applications to TxDOT in a timely fashion. There may be circumstances where schedules change at the last minute, but these instances should be an exception rather than the rule. To deal with last-minute requests, TxDOT might consider implementing a dual lease fee structure, where rush requests are accepted for review, but the lease fee upon approval would be much higher than the standard lease fee.
- Pipeline operators should use a standard TxDOT TCP or submit a TCP for review and approval prior to beginning any field work. TxDOT has a wide range of TCPs for different types of work within the right of way, and pipeline operators are strongly encouraged to use one of the standard TCPs (*65*). Additional details about TCPs can be found in the TMUTCD and the TxDOT *Project Development Process Manual* (*66, 67*). Operators should include the proposed TCP with their lease application to ensure district officials have an opportunity to review and approve it before TxDOT executes the lease agreement.
- TxDOT should work with TCEQ and the Railroad Commission to develop spill and leak response measures based on the level of TDS in the water being transported. Until these measures are developed, the researchers recommend adopting the following guidelines and spill response protocols:
    - **Water with TDS up to 3,000 mg/L.** Repair temporary pipeline within 24 hours. No environmental impact evaluation or reporting needs to be conducted because the environmental impacts are expected to be minimal.
    - **Water with TDS greater than 3,000 and up to 10,000 mg/L.** Repair temporary pipeline within 24 hours. Estimate the amount of water spilled and the potential

environmental impacts. Report the incident to TxDOT within 24 hours so that TxDOT can document and monitor the location for evidence of long-term environmental damage. If the spill has a negative impact on vegetation, the operators must assess the soil and remediate the soil and vegetation.

- Current lease provisions require operators to place signs every 500 feet along temporary pipelines. This requirement should be changed to instruct pipeline operators to place signs at the locations where temporary pipelines cross the right-of-way line and use stencils or attach smaller signs to the pipelines along the longitudinal installation.

- Pipeline operators should not use metal temporary pipelines. These pipelines are more likely to leak or cause damage to vehicles and harm to occupants in the event the pipelines are struck by an errant vehicle.

- To anchor temporary pipelines, pipeline operators should use devices such as stakes or pipes that do not exceed four feet in length and do not exceed 4.5 inches in diameter or width. The height of the device aboveground should not exceed three feet, and the depth of the device below ground should not exceed 16 inches. To improve roadside safety and visibility, operators should place bright caps on top of the devices.

- Boring is the recommended method for road crossings. If boring is not feasible, operators should use the sizing guidelines listed in Table 15 and Table 16 for the maximum number and size of pipelines to allow inside culverts.

- When temporary pipelines cross driveways or property entrances, pipeline operators should use crossing structures that maximize their crash worthiness properties. This includes ensuring that no component of the crossing structure, including the end connectors, is higher than 4 inches from the ground level.

RECOMMENDATIONS FOR CHANGES TO POLICIES

Texas Administrative Code

A review of the TAC indicated there is a need to update a few provisions. Areas where updates may be in order include the following:

- Define clearly the type of water that temporary pipelines can transport. There is considerable ambiguity in the definitions of terms such as fresh water, salt water, produced water, and brackish water. Chapter 2 provides a summary of several definitions that could be included in the TAC.

- Clarify the maximum operating pressure for temporary pipelines. This includes using the correct units (e.g., pounds per square inch instead of pounds per inch). It also includes using maximum operating pressure values that are more reflective of current industry practices rather than 60 psi, which the industry considers to be too low for practical purposes. Another possibility is to remove the maximum operating pressure requirement from the TAC and include it in other documents, such as manuals and SOPs.

TxDOT Manuals and Procedures

The standalone guidebook provides specific guidelines for the installation, operation, and maintenance of temporary pipelines. A few additional recommendations at the policy level to improve the management of the temporary pipeline lifecycle and the lease program follow.

General Recommendations

- Add references to temporary pipelines in relevant TxDOT manuals. Potential manuals include but are not limited to the following: *ROW Utility Manual*, *Use of Right of Way by Others Manual*, *Maintenance Management Manual*, *Maintenance Operations Manual*, and *Hydraulic Design Manual*. The *ROW Utility Manual* will likely require updates in several chapters, specifically Chapter 3, Section 3; Chapter 12, Section 5; and Chapter 12, Section 13. The other manuals could be updated by simply providing references to these sections at the beginning of the manuals.

- Clarify the type of water that can be transported in temporary pipelines. Currently, the lease application refers to saltwater pipelines, but the lease agreement refers to non-produced-water pipelines. There is also no formal agreed upon definition for different classifications of water or what constitutes saltwater versus non-produced water. In addition, this clarification should keep in mind that some operators are transporting recycled water in temporary pipelines. Recycled water is essentially produced water that has been treated to some degree. As mentioned, Chapter 2 provides a summary of several definitions that could be included in relevant manuals and procedures.

- Start discussions with TCEQ and the Railroad Commission to develop spill and leak response measures based on the level of TDS in the water being transported.

Lease Applications

- Require pipeline operators to disclose the TDS of the water they propose to transport. Because the TDS of the water might change over time, a potential strategy could be to allow pipeline operators to provide a range, as long as the range is relatively narrow (e.g., no more than 500 mg/L or 10 percent between the minimum and the maximum values).

- Require operators to disclose the operating and burst pressures as well as the nominal (or design) and maximum flow rate (in gpm) of the proposed temporary pipeline installation.

- Request operators to submit a spatial data file (e.g., in KML or ArcGIS file format) with the lease application, showing the entire location of the proposed temporary pipeline. To control the quality of the spatial data submitted, TxDOT should clearly specify the maximum spatial resolution or zoom level allowed when preparing the spatial data file. For example, when preparing a KML file in a Google Earth environment, applicants should make sure that the zoom level is such that 1 inch on the screen corresponds to 50 feet on the ground.

- Add check boxes to the lease application so operators can indicate if the proposed installation is only longitudinal or if they propose to cross the road using a culvert or a bridge. Use of attachments to any roadway structure requires a considerable level of review by district officials. Conversely, proposed temporary pipelines that only intend to occupy the roadside next to the right-of-way line can be reviewed and approved much faster.

- In Exhibit A of the lease form, change the wording for water production source and end disposal source to origin and destination. This will clarify what information is being requested. TxDOT has incorporated this recommendation into the current lease agreement.

- In Exhibit A of the lease form, add a box for coordinates and permit numbers in case there are no permit numbers for the origin or destination.

Response to Temporary Pipeline Leaks and Spills

- Limit the use of aboveground temporary pipelines to transport water with TDS up to 10,000 mg/L. Produced water (including flowback water) or any water with TDS greater than 10,000 mg/L should use a different mode of transportation (e.g., truck or underground pipelines).

- Implement the following protocol in response to leaks or spills affecting aboveground temporary pipelines (see Table 32):

  - **Fresh water (i.e., TDS up to 1,000 mg/L)**. For this type of water, the recommended inspection frequency (twice daily) is sufficient. In case of any leaks or spills, the pipeline operator must repair the pipeline within 24 hours of detection. Further evaluation or reporting of the event is not necessary.

  - **Slightly saline water (i.e., TDS greater than 1,000 and up to 3,000 mg/L)**. This type of water is acceptable to be transported in aboveground temporary pipelines because short exposure to this type of water would probably not result in significant impact on nearby vegetation or livestock. The recommended inspection frequency (twice daily) is sufficient. In case of any leaks or spills, the pipeline operator must repair the pipeline within 24 hours of detection. Further evaluation or reporting of the event is not necessary.

  - **Moderately saline water (i.e., TDS greater than 3,000 and up to 10,000 mg/L)**. This type of water is not recommended to be transported in aboveground temporary pipelines, but exceptions could be made under certain circumstances at the discretion of the district engineer. The recommended inspection frequency (twice daily) is still sufficient. However, a more stringent leak or spill response protocol must be applied. In case of any leaks or spills:

    - The operator must repair the pipeline within 24 hours of detection.

    - The operator must estimate the amount of water leaked or spilled and the potential environmental impact resulting from the leak or spill.

    - The operator must report the incident to TxDOT within 24 hours of detection of the incident so that TxDOT can document and begin to monitor the spill location. Long-term monitoring is likely to be expected.

    - If the impact of the leak or spill on vegetation in the affected area becomes evident, the operator must conduct a soil assessment and implement appropriate remediation solutions to restore the soil productivity and structure to the conditions prior to the incident. This includes restoring the vegetation in the affected area to its original condition. If TxDOT makes such restorations because of inability of the operator to complete this task, the terms of the lease relating to the environment and liability insurance will apply as appropriate.

- For produced water (including flowback water) or any water with TDS greater than 10,000 mg/L, develop and implement guidelines for underground temporary pipelines, including a requirement that all documentation included in the lease application be signed and sealed by a competent registered professional engineer in Texas.

- Begin discussions with TCEQ and the Railroad Commission for how to handle leaks or spills of water with TDS greater than 10,000 mg/L.

Table 32. Recommended Leak and Spill Response Protocol for Aboveground Temporary Pipelines.

Type of Water	What to Do after Leaks/Spills?
Fresh water (TDS ≤ 1,000 mg/L)	• The operator must repair the pipeline within 24 hours of detection.
Slightly saline water (1,000 < TDS ≤ 3,000 mg/L)	• The operator must repair the pipeline within 24 hours of detection.
Moderately saline water (3,000 < TDS ≤ 10,000 mg/L)	• The operator must repair the pipeline within 24 hours of detection. • The operator must estimate the amount of water leaked or spilled and the potential environmental impact resulting from the leak or spill. • The operator must report the incident to TxDOT within 24 hours of detection of the incident so that TxDOT can document and begin to monitor the spill location. Long-term monitoring is likely to be expected. • If the impact of the leak or spill on vegetation in the affected area becomes evident, the operator must conduct a soil assessment and implement appropriate remediation solutions to restore the soil productivity and structure to the conditions prior to the incident. This includes restoring the vegetation in the affected area to its original condition. If TxDOT makes such restorations because of inability of the operator to complete this task, the terms of the lease relating to the environment and liability insurance will apply as appropriate.

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APPENDIX A. REDUCTION IN FLOW RATE BETWEEN RETURN PERIODS

Table 33. Percent Reduction in Flow Rate for Corresponding Reduction in Return Periods for Counties in the Barnett, Eagle Ford, Haynesville, and Permian Basin Regions.

County	Region	Reduction in Flow between Return Periods													
		100 to 50	100 to 25	100 to 10	100 to 5	100 to 2	50 to 25	50 to 10	50 to 5	50 to 2	25 to 10	25 to 5	25 to 2	10 to 5	10 to 2
Andrews	Permian	14	26	40	50	64	14	30	42	58	19	33	51	18	40
Archer	Barnett	11	22	32	42	55	12	24	34	49	14	26	42	14	33
Atascosa	Eagle Ford	11	22	35	45	57	13	27	38	52	16	29	45	15	35
Bastrop	Eagle Ford	12	23	36	46	60	13	28	39	55	17	30	48	16	37
Baylor	Barnett	12	23	36	45	58	12	27	38	52	17	29	46	14	35
Bee	Eagle Ford	11	21	32	40	53	11	24	33	48	14	25	41	12	32
Borden	Permian	12	23	36	45	60	13	27	38	54	16	29	47	15	37
Brazos	Eagle Ford	13	25	37	47	59	13	28	39	53	17	30	46	16	35
Brown	Barnett	10	21	34	43	57	12	27	37	53	17	28	46	14	36
Burleson	Eagle Ford	13	24	37	46	59	13	28	38	53	17	29	46	15	35
Caldwell	Eagle Ford	12	25	37	46	59	15	28	39	54	16	28	46	15	36
Callahan	Barnett	12	23	35	45	58	12	26	37	52	16	29	46	15	35
Clay	Barnett	12	23	35	44	57	13	26	37	52	15	27	44	15	35
Cochran	Permian	15	27	42	52	65	14	32	43	59	21	34	52	17	40
Coke	Permian	12	23	35	44	58	13	26	37	53	15	27	46	14	36
Coleman	Barnett	12	23	35	46	59	13	27	38	54	16	29	47	16	37
Comanche	Barnett	12	24	36	46	59	13	27	39	53	17	30	46	16	35
Cooke	Barnett	13	24	35	44	57	13	26	36	51	15	27	43	14	33
Crane	Permian	13	23	34	43	58	12	24	34	52	14	25	45	14	37
Crockett	Permian	11	23	34	43	57	13	25	36	52	14	26	45	14	36
Crosby	Permian	12	22	34	44	58	12	25	36	52	15	28	46	15	36
Culberson	Permian	12	25	37	47	61	15	28	39	55	16	29	47	16	38
Dallas	Barnett	11	22	33	43	56	12	25	36	51	14	26	44	14	34
Dawson	Permian	13	24	37	48	61	12	28	40	56	18	32	49	16	38
Denton	Barnett	12	24	35	45	56	13	26	37	50	14	27	42	15	33
De Witt	Eagle Ford	12	23	35	44	57	13	26	37	52	15	28	45	15	35
Dickens	Permian	12	23	36	45	58	12	27	37	52	17	28	45	14	34
Dimmit	Eagle Ford	11	24	37	47	60	15	29	40	55	16	30	47	16	37
Duval	Eagle Ford	11	22	35	43	57	13	28	37	52	17	27	45	12	34
Eastland	Barnett	11	23	34	44	57	13	26	37	52	15	28	45	15	35
Ector	Permian	13	25	38	48	62	14	28	40	57	17	30	50	16	39
Edwards	Permian	13	25	37	47	60	14	28	39	54	16	29	47	15	36
Erath	Barnett	13	24	36	45	58	13	26	38	52	15	28	44	15	34

County	Region	Reduction in Flow between Return Periods													
		100 to 50	100 to 25	100 to 10	100 to 5	100 to 2	50 to 25	50 to 10	50 to 5	50 to 2	25 to 10	25 to 5	25 to 2	10 to 5	10 to 2
Fayette	Eagle Ford	12	24	37	47	59	14	28	39	53	17	29	46	15	35
Fisher	Permian	11	22	33	42	56	12	25	35	51	15	26	44	14	35
Freestone	Eagle Ford	12	24	36	45	58	13	27	38	52	16	28	45	15	35
Frio	Eagle Ford	12	24	36	46	59	13	27	38	53	16	29	46	16	36
Gaines	Permian	15	26	41	51	65	14	31	43	59	21	34	52	16	40
Garza	Permian	10	21	32	42	57	12	25	36	52	15	27	45	15	36
Glasscock	Permian	10	22	34	45	59	13	27	38	54	16	29	47	16	38
Goliad	Eagle Ford	11	23	34	44	57	13	26	36	51	15	27	44	14	34
Gonzales	Eagle Ford	12	24	37	46	59	14	28	39	54	17	29	46	14	35
Grayson	Barnett	11	22	33	44	54	12	25	37	49	14	28	42	16	32
Grimes	Eagle Ford	13	24	35	45	57	13	25	36	50	15	27	43	14	34
Guadalupe	Eagle Ford	13	24	35	45	58	13	26	37	52	15	27	45	14	35
Haskell	Barnett	13	24	36	45	59	13	27	37	53	16	28	46	14	36
Hill	Barnett	12	23	35	45	58	13	26	37	52	15	28	45	15	35
Hockley	Permian	13	24	39	49	63	13	29	41	57	19	33	51	17	40
Hood	Barnett	13	26	36	46	59	14	26	37	53	14	27	45	15	36
Houston	Eagle Ford	12	23	35	46	58	13	26	38	52	15	29	45	16	35
Howard	Permian	11	22	35	45	60	12	26	38	55	16	29	48	16	38
Irion	Permian	10	21	33	42	57	12	26	36	52	15	27	45	14	35
Jack	Barnett	11	22	34	44	57	13	26	37	52	15	28	45	15	35
Jackson	Eagle Ford	10	21	32	42	55	12	24	35	50	14	27	44	14	34
Jim Wells	Eagle Ford	11	22	33	43	56	12	25	36	51	14	27	44	15	35
Johnson	Barnett	12	23	34	44	58	13	25	36	52	14	27	45	15	36
Jones	Barnett	11	23	35	45	58	13	26	37	53	15	28	46	15	36
Karnes	Eagle Ford	11	23	34	44	57	13	26	37	51	15	27	44	14	34
Kent	Permian	11	22	33	43	57	12	24	36	51	13	26	44	15	35
Kinney	Permian	12	24	36	46	59	14	27	38	53	16	28	46	15	35
LaSalle	Eagle Ford	11	21	32	42	55	12	24	34	49	13	26	43	14	34
Lavaca	Eagle Ford	12	23	34	44	57	12	25	36	51	15	27	44	14	35
Lee	Eagle Ford	12	25	37	47	60	14	29	39	55	17	30	47	15	36
Leon	Eagle Ford	13	26	39	48	60	15	30	40	54	18	30	46	14	34
Limestone	Barnett	13	25	37	47	59	13	28	39	53	17	29	46	15	35
Live Oak	Eagle Ford	11	21	33	42	55	11	25	34	49	15	26	43	13	33
Loving	Permian	12	25	39	49	63	14	31	43	58	19	33	50	17	38
Lubbock	Permian	13	24	37	46	60	13	27	38	54	17	29	48	15	37
Lynn	Permian	13	23	37	47	61	12	27	40	55	17	31	49	17	38
Madison	Eagle Ford	13	24	36	46	59	13	26	38	53	15	29	46	16	36
Martin	Permian	13	24	37	47	61	12	27	39	55	17	31	49	16	38

County	Region	Reduction in Flow between Return Periods													
		100 to 50	100 to 25	100 to 10	100 to 5	100 to 2	50 to 25	50 to 10	50 to 5	50 to 2	25 to 10	25 to 5	25 to 2	10 to 5	10 to 2
Maverick	Eagle Ford	12	24	37	48	61	14	29	41	56	18	31	49	16	37
McLennan	Barnett	13	25	36	46	59	14	27	38	53	15	28	45	15	36
McMullen	Eagle Ford	11	22	33	43	57	13	25	36	51	14	26	44	14	35
Midland	Permian	12	23	36	46	60	13	27	39	55	16	30	48	16	38
Mitchell	Permian	12	22	34	44	58	11	25	36	52	16	28	46	15	36
Montague	Barnett	12	24	35	45	58	13	26	37	52	15	27	45	15	35
Nolan	Permian	12	23	34	43	58	13	26	36	52	14	26	45	14	35
Palo Pinto	Barnett	13	23	36	45	58	12	26	37	52	16	28	45	15	34
Parker	Barnett	12	24	34	44	57	13	25	36	51	14	27	44	15	35
Pecos	Permian	11	21	32	43	56	12	24	36	51	14	27	44	15	35
Reagan	Permian	10	20	32	42	57	11	24	36	52	15	28	46	15	37
Reeves	Permian	12	24	37	48	61	14	29	41	56	17	31	49	17	38
Refugio	Eagle Ford	10	20	31	40	54	11	23	34	49	14	25	43	13	34
Robertson	Eagle Ford	13	24	36	46	59	13	27	38	53	16	29	46	15	36
Runnels	Barnett	10	20	32	42	56	11	25	35	52	15	27	46	14	36
San Patricio	Eagle Ford	11	21	31	41	55	11	23	34	50	13	26	43	14	35
Schleicher	Permian	11	21	32	42	56	11	24	35	51	14	27	44	14	35
Scurry	Permian	11	21	33	43	56	12	26	36	51	15	27	44	14	34
Shackelford	Barnett	11	23	34	44	58	13	26	37	52	15	28	45	15	36
Somervell	Barnett	13	25	35	45	58	13	26	37	52	14	27	44	15	35
Stephens	Barnett	12	22	34	44	58	11	25	37	51	16	29	45	15	35
Sterling	Permian	11	22	34	43	58	12	26	37	52	15	28	46	15	36
Stonewall	Permian	11	24	35	45	59	14	27	38	54	15	28	46	15	36
Sutton	Permian	12	23	33	42	57	12	24	35	51	13	25	44	14	35
Tarrant	Barnett	13	24	35	44	57	13	26	36	51	14	27	44	14	34
Taylor	Barnett	11	21	33	42	57	12	25	35	52	15	27	45	14	36
Terrell	Permian	11	21	31	41	55	11	23	34	50	13	26	44	14	35
Terry	Permian	14	26	40	49	63	14	30	41	57	19	32	50	16	39
Throckmorton	Barnett	11	21	33	43	57	12	25	36	51	15	27	45	14	35
Tom Green	Permian	12	23	34	43	57	12	25	35	51	14	26	44	14	34
Upton	Permian	11	21	34	43	58	12	26	36	53	15	28	46	14	36
Val Verde	Permian	11	23	34	44	57	13	26	37	52	15	27	45	14	35
Victoria	Eagle Ford	12	22	32	42	55	11	23	34	49	13	26	43	15	34
Ward	Permian	13	26	39	49	64	15	29	42	59	17	31	51	17	42
Washington	Eagle Ford	12	23	34	44	57	13	25	36	52	14	27	45	15	35
Webb	Eagle Ford	10	21	32	41	54	11	24	34	49	14	25	42	13	32
Wharton	Eagle Ford	11	22	34	43	56	13	25	36	51	15	27	43	14	34
Wichita	Barnett	12	24	35	44	57	13	26	36	50	15	27	43	14	33

County	Region	Reduction in Flow between Return Periods													
		100 to 50	100 to 25	100 to 10	100 to 5	100 to 2	50 to 25	50 to 10	50 to 5	50 to 2	25 to 10	25 to 5	25 to 2	10 to 5	10 to 2
Wilson	Eagle Ford	12	24	36	46	59	14	27	38	53	16	28	46	15	36
Winkler	Permian	14	27	39	48	63	16	29	40	57	16	29	49	16	40
Wise	Barnett	12	24	35	44	57	13	26	37	51	15	27	44	15	35
Yoakum	Permian	14	28	40	51	64	16	31	43	59	18	32	51	17	40
Young	Barnett	11	22	33	42	56	13	25	35	50	13	25	43	14	34
Zavala	Eagle Ford	12	23	34	43	56	12	25	35	50	14	26	42	14	33

APPENDIX B. INTERVIEW GUIDE

TxDOT Project 0-6886: Engineering Guidelines for Installing Temporary Pipelines within the Right of Way

PROJECT BACKGROUND

Moving the enormous amounts of water and other fluids needed for unconventional oil and gas energy developments requires considerable resources. Fluids can be transported by truck or by pipeline. For temporary pipelines, TxDOT issues permits that are usually valid for up to 90 days. In practice, districts have observed a wide range of practices related to the installation, operation, and maintenance of these facilities. The purpose of the research is to examine current practices and to develop engineering guidelines for permitting, installing, operating, and maintaining temporary pipelines within the state right of way. In addition to the report, research deliverables include (a) a guidebook for permitting, design, construction, operation, and maintenance of temporary lines; and (b) recommendations for changes to policy, manuals, procedures, and accommodation rules.

INTERVIEW PURPOSE

As part of the research, the researchers are meeting with selected stakeholders across the state. The purpose of the interviews is as follows:

- Review existing practices.
- Begin to develop ideas for potential strategies and recommendations for sustainable temporary pipeline practices.
- Identify potential locations to conduct field visits and collect data about the characteristics, condition, operation, and impact of temporary pipelines.

INTERVIEW FORMAT

The interview will be in the form of on-site meetings. Meetings will take place at four counties in the Eagle Ford Shale Region, four counties in the Permian Basin Region, and two counties in the Barnett Shale Region. Potential contacts include, but are not limited to, maintenance, right of way, pavement, and operations personnel; county and/or city engineers; Texas Department of Public Safety and emergency response personnel; temporary pipeline owner/operators; and energy developer engineers and technicians. Individual meetings will typically last no more than two hours.

INTERVIEW TOPICS

Examples of discussion topics include the following:

Accommodation practices:

- Use and effectiveness of accommodation policy for temporary pipelines.
- Other documentation regarding accommodation of temporary pipelines.

- Permitting process for installing temporary pipelines.
- Main gaps or issues in the current state of the practice.
- Strategies for improvement or optimization of existing business practices.

Interaction with existing utility installations:

- Use of One Call process prior to temporary pipeline design and construction.
- Databases to track the location of temporary pipelines.
- Coordination with utility owners.

Temporary pipeline design practices, standards, and specifications:

- Design and construction standards and specifications for temporary pipelines.
- Special specifications, provisions, and variances.
- Surveying and as-built standards and specifications.

Materials and construction methods and procedures:

- Acceptable and problematic materials for temporary pipelines.
- Construction procedures for installing temporary pipelines.
- Construction inspection practices.
- As-built production.

Temporary pipeline operation and maintenance procedures and requirements:

- Pipeline maintenance and inspection protocols.
- Process or system for tracking pipeline maintenance activities.
- Levels of responsibility and communication for maintenance and emergency response.

Roadside maintenance impacts:

- Issues affecting roadside maintenance activities due to temporary pipelines.
- Coordination with stakeholders prior to/during roadside maintenance activities.
- Process for resolving conflicts.
- Additional maintenance expenditures due to temporary pipelines.

Highway drainage impacts:

- Impacts to drainage structures caused by temporary pipelines.
- Standards and specifications for using existing drainage structures by temporary pipelines.
- Communications and training.

Safety to the traveling public:

- Use of roadway cross-section elements for non-transportation purposes.
- Safety issues affecting motorists due to temporary pipelines within the right of way.

- Standards and requirements for temporary pipeline installation to address safety concerns (e.g., barriers, cables, clear zones, signing).

Environmental issues and emergency response practices:

- Levels of responsibility and liability in case of emergencies.
- Monitoring and reporting of leaking or damaged temporary pipelines.
- Communication protocols in case of emergencies.
- Cleanup procedures.

Outreach, communication, coordination, and training:

- Public awareness and outreach regarding temporary pipelines.
- Communication and coordination with all stakeholders that occupy the right of way.
- Training for TxDOT, pipeline operators, utility owners, and other stakeholders.