# LANDSCAPE PRACTICES ON GAS WELL SITES IN NORTH TEXAS: PERCEPTIONS OF SELECTED INDUSTRY REPRESENTATIVES AND REGULATORS

by

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ABSTRACT

LANDSCAPE PRACTICES ON GAS WELL SITES IN NORTH TEXAS:

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REPRESENTATIVES AND

REGULATORS

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Fossil fuel extraction, a principal industry in Texas, has turned toward natural gas exploration in the Barnett Shale, altering the landscapes of urban and rural communities alike. Improvements in technology have caused dramatic increases in the concentration of gas wells being drilled in large metropolitan areas, such as the Fort Worth area of North Texas. The result is an increase in awareness about urban drilling and its impact on regional environment (BSEEC 2011).

In response, individual municipalities have amended their natural gas well ordinances and now mandate the implementation of regulations, such as permitting processes and the reclamation of sites, through the stages of drilling, production, and site abandonment (BSEEC 2011). As urban environments and these industrial processes merge, city departments, state and federal regulators, and industry members have developed practices to lessen nuisance

impacts, impacts to environmental resources, and interference with existing businesses (GWPC 2009, p. ES-5).

With increases in the production of natural gas comes the growing concerns of human health, environmental impact, and aesthetics, and as influences on the approval, permitting, and locating of gas wells within urban areas, these factors provide a vital role in the simultaneous development of minerals and protection of the health, safety, and welfare of the community (GWPC 2009). According to Drill-Right Texas, an oil and gas development best practices initiative, “the challenge facing us today is how to protect our landowner rights, clean water, air, and public health in the face of rapid energy development” (TOGAP 2010).

This research studied the perceptions of selected industry representatives and regulators in relationship to site location, development, and remediation practices. With the use of in-depth interviews and open-ended questioning, participants were allowed to express their lives, experiences, or situations as expressed in their own words (Taylor and Bogdan 1998). The research concluded with a summary of findings, providing a more complete understanding of gas well remediation and reclamation processes in the urban environment and the developing role and demand for landscape architects.

Through the assessment of themes regarding determinants for remediation efforts and priorities, community values have emerged as the primary factor among respondents’ perceptions. Surrounding land uses are established as core identifiers of community values, and as a result city ordinances regulate interactions among neighboring land uses. The amount of remediation a site receives depends mainly on the surrounding land uses in a metropolitan area, with residential areas demanding the highest amount of screening of noise and aesthetic nuisances. The interview participants provide an insight into the lack of knowledge and awareness of how these gas well sites will affect the future landscape and habitats of urban environments. The selected industry representatives and regulators were focused on the current appearance and remediation of visual impacts, noise, dust, and traffic, with minimal

focus on what these sites will actually look like in twenty years. However, through additional study and future research there may be more exploration and emphasis on the impact and integration of these gas well sites into the development of urban master plans of municipalities.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

This research investigated the perceptions of selected industry representatives and regulators on site location and reclamation practices executed on natural gas well sites in North Texas. Also, concerns, practices, and suggestions for future implications of natural gas well sites and their impact on the landscape and urban environment were identified. While natural gas exploration has boomed in the Barnett Shale play in the past ten years, knowledge about the impacts on urban sites is limited. In addition to observation of gas well sites, review of the regulations of the Railroad Commission of Texas and gas well ordinances of six selected municipalities, provided a base for interview questions, the main research instrument used to gain a greater understanding of the procedures of site selection, development, and reclamation of natural gas well sites in North Texas.

In-depth interviews as defined by Taylor and Bogdan (1998) were used to generate input from selected representatives and regulators involved with the natural gas industry in North Texas. Interview participants from the industry representative group included land developers, environmental engineers, landscape architects, planners, and public relations representatives of energy companies. The municipality regulation group included city employees from environmental services, planning, landscape administration, and gas well inspection departments. Interview data were compared and evaluated using Taylor and Bogdan's grounded theory approach (1998). The results provided insight into the representatives' and regulators' awareness of the impact of gas well exploration in urban areas and on the landscapes.

## 1.2 A Brief History of Natural Gas Exploration in North Texas

During the nineteenth century, a settler, John W. Barnett, took up residence in San Saba County, Texas and named the local stream, the Barnett Stream. In the early twentieth century, geologists identified and recorded thick black organic-rich shale in an outcrop near the stream, naming it the Barnett Shale (Railroad Commission of Texas [RRC] 2011) Figure 1.1 displays the Barnett Shale in Texas, in addition to other natural gas developments across the nation.

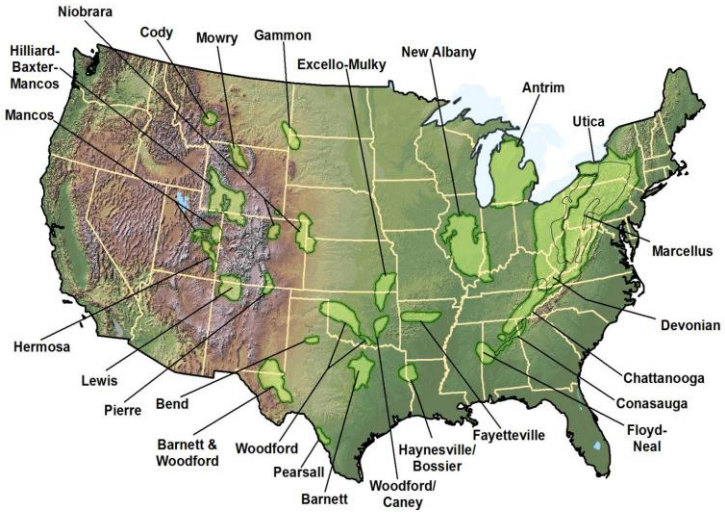


Figure 1.1 Shale Basins in the Continental United States of America
(Source: GWPC, ES-2)

A hydrocarbon-producing geological formation, the Barnett Shale is estimated to cover five thousand square miles. Twenty-five counties, including twelve of the sixteen counties within the North Central Texas Council of Government (NCTCOG) region, have producing wells and it is estimated that $11.1 billion of natural gas are to be produced in 2011 (RRC 2011; NCTCOG 2010; Perryman 2011). In a report conducted by the Groundwater Protection Council (GWPC), it was determined that because sites are chosen for horizontal proximity to gas reserves in the shale and other wells in the immediate area, concerns over health risks, habitat loss, and economic impact on adjacent land value are moving to the forefront of discussion in relationship to local government policies (GWPC 2009).

For the drilling of one well in the Barnett Shale, twenty-to-thirty days are typically needed, followed by production and completion phases. Since the introduction of horizontal drilling in the Barnett Shale in 2002, there has been a steady increase in the drilling of multiple wells per site, increasing economic viability of wells and reducing the need for multiple single-well pad sites (Barnett Shale Energy Education Council [BSEEC] 2011). The number of wells varies from site-to-site and can be drilled over a period of several years after initial approval by a city. Following drilling and hydrological fracturing, wells enter the production phase when natural gas is brought up the well, treated to a useable condition, and sent to market (GWPC 2009, p. 44). Once all hydrological fracturing fluids are removed from the site and the wellheads installed, the pad site is reduced and fenced off, and if in an urban area, landscaping is installed per local ordinances. As of now, these natural gas wells have been estimated to produce for twenty - to - thirty years in the Barnett Shale, becoming more than temporary installments in the landscape (BSEEC 2011).

The RRC maintains jurisdiction over the regulation of oil and gas exploration and production, including hydraulic fracturing and horizontal drilling (Jones 2011). According to the RRC and Texas law, a well operator has the right to use as much of the surface as necessary to explore, drill, and produce minerals from a property, therefore, enabling each rig to have its own "footprint" with its own shape and size (RRC 2011). The leases or municipal ordinances control the amount an operator may use; they also govern the restoration and remediation of the site. General preplanning standards for developing sites suggest the size of the site should be only as large as necessary in order to reduce the construction costs, cost of clearing trees and vegetation, and enhancing the perceived image of the operation by the general public (RRC 2011). Because the practice of horizontal drilling allows the consolidation of the number of wells and fewer pad sites, surface disturbances, such as, access roads, pipelines, and surface facilities may be reduced. However, with the increased number of wells on one pad site, a multiple well pad site takes up more surface area. With improvements in technology that allow

the industry to develop in new areas, including urban and suburban, an increased interest in the implementation of site location, development, and reclamation practices has occurred (GWPC 2009). As a result, regional characteristics and particular project features, including potentially affected species of flora and fauna, allow for the development of site specific requirements and design strategy.

## 1.3 Research Objectives

The objective of this study was to ascertain selected industry representatives' and regulators' perceptions of the impacts of site selection and reclamation practices of natural gas wells on landscapes in metropolitan situations. Opinions were obtained from in-depth interviews with selected participants and evaluated as a means to research the implementation of site selection, remediation, and reclamation standards for natural gas well sites in urban areas. In addition, the information compiled in this research establishes a role for landscape architects in the planning, remediating, and reclaiming of gas well sites throughout the transitions of land uses.

## 1.4 Research Questions

1. What are the perceptions of selected industry representatives and municipality regulators of site selection and development practices for gas well sites?
2. What determines the amount of reclamation that a natural gas well site receives?
3. Do industry representatives and regulators anticipate a need to improve site location, development, and reclamation practices?

## 1.5 Definition of Terms

*Abandonment:* As defined by the Railroad Commission of Texas and includes the plugging of the well and restoration of the drill site to its original condition as nearly as practicable, in conformity with the regulations of this ordinance (Arlington 2011, Sec. 7.03).

*Aesthetics:* A branch of philosophy concerned with the beautiful in art and how it is experienced by the viewer (Laurer and Pentak 2000, p. 264).

*Closed-Loop Drilling Fluid Systems:* System that uses a series of steel tanks that contain all drilling fluid and equipment used to remove cuttings. These systems enhance the operator's ability to monitor fluid levels and characteristics. The result is more efficient use of the drilling fluid and less drilling waste remaining at the end of the operation. Also, the operator may more easily recycle the waste drilling fluid (RRC 2010).

*Completion:* The activities and methods to prepare a well for production and following drilling. Includes installation of equipment for production from a gas well (GWPC 2009, p. 81)

*Connectivity*: A measure of how connected or spatially continuous a corridor, network, or matrix is; related to the structural connectivity concept (Forman 1995, p. 38).

*Corridor*: A strip of land of a particular type that differs from the adjacent land on both sides (Forman 1995, p. 38).

*Disturbance*: An event that significantly alters the pattern of variation in the structure or function of an ecological system (Forman 1995, p. 38).

*Drill rig*: The mast, draw works, and attendant surface equipment of a drilling or workover unit (GWPC 2009, p. 81).

*Exploration*: The process of identifying a potential subsurface geologic target formation and the active drilling of a borehole designed to assess the natural gas or oil (GWPC 2009, p. 81).

*Formation (geologic)*: A rock body distinguishable from other rock bodies and useful for mapping or description. Formations may be combined into groups or subdivided into members (GWPC 2009, p. 82).

*Fracturing fluids*: A mixture of water and additives used to hydraulically induce cracks in the target formation (GWPC 2009, p. 82).

*Fragmentation*: The breaking up of a habitat, ecosystem, or land-use type into smaller parcels (Forman 1995, p. 39).

*Freshwater fracture pit:* A pit used for the collection and storage of fresh water for the purpose of fracture stimulation of gas wells (City of Fort Worth 2008, Sec. 15-31, p.5, BB).

*Gas well pad site:* The area dedicated to all gas well drilling and production activities, including the drill site, all structures, closed-loop systems, dehydrators, parking areas, security cameras, lighting, tanks, tank battery, drilling rigs, separators, compressors, perimeter walls, utilities, and all other features or objects contemplated for use during and after gas well drilling or production, as designated on the gas well development plat or gas well development site plan (Denton 2010, 22-2).

*Green infrastructure:* Interconnected network of open spaces and natural areas (such as greenways, wetlands, parks, and forest preserves) that naturally recharges aquifers, improves water quality, and provides recreational opportunities and wildlife habitats. (Birch and Wachter 2008, p. 329).

*Horizontal drilling*: A drilling procedure in which the wellbore is drilled vertically to a kick-off depth above the target formation and then angled through a wide 90 degree arc such that the producing portion of the well extends horizontally through the target formation (GWPC 2009, p. 82).

*Hydraulic fracturing or fracking*: Injecting a mixture of sand, water, and chemicals into dense rock layers and shale, creating cracks that allow natural gas trapped inside to flow to the earth's surface (Svoboda 2010).

*Landscape functioning:* The movement and flows of animals, plants, water, wind, materials and energy through the structure (Dramstad 1996, p. 14).

*Landscape structure:* The spatial pattern or arrangement of landscape elements (Dramstad 1996, p. 14).

*Lease:* A legal document that conveys to an operator the right to drill for oil and gas. Also, the tract of land, on which a lease has been obtained, where producing wells and production equipment are located (GWPC 2009, p. 82).

*Natural vegetation:* Plant species composition and cover of an area not planted by humans (Forman 1995, p. 39).

*Operator:* The person listed on the Railroad Commission Form W-1 or Form P-4 for a well as the person that is, has applied for, or will be actually in charge and in control of drilling, maintaining, operating, pumping, or controlling any well or pipeline including without limitation, a unit operator (Denton 2010, p. 22-3).

*Perforation:* The creation of "holes" within an essentially intact habitat (Dramstad 1996, p. 35).

*Performance based planning:* An approach that allows planners to devise alternative means of coming up with a desired end. The applicant must provide reliable evidence, or demonstration projects, to prove that the alternative measures will actually work (Marsh 2005, p. 22).

*Plugging:* The filling of concrete and soil of the hole and marking for future notification; must commence within one year after operations have ceased (Varela 2000, p. 1).

*Primacy:* A right that can be granted to state by the federal government that allows state agencies to implement programs with federal oversight. Usually, the states develop their own set of regulations. By statue, states may adopt their own standards, however, these must be at least as protective as the federal standards they replace, and may be even more protective in order to address local conditions. Once these state programs

are approved by the relevant federal agency (usually the EPA), the state then has primacy jurisdiction (GWPC 2009, p. 83).

*Produced water:* Water produced from oil and gas wells (GWPC 2009, p. 83).

*Protected use:* Any residence, church, public park, public library, hospital or school (Denton 2010, p. 22-3).

*Railroad Commission of Texas:* Statewide governing body that regulates the exploration and production of oil and gas in Texas. Their responsibilities include preventing waste of oil and gas resources, protection of surface and subsurface water, and helping ensure interests of mineral owners (BSEEC 2011).

*Reclamation:* Rehabilitation of a disturbed area to make it acceptable for designated uses. This normally involves regrading, replacement of topsoil, re-vegetation, and other work necessary to restore it (GWPC 2009, p. 83).

*Setback:* The distance that must be maintained between a gas well or other specified equipment and any protected structure or feature (GWPC 2009, p. 83).

*Stipulation:* A condition or requirement attached to a lease or contract, usually dealing with protection of the environment, or recovery of a mineral (GWPC 2009, p. 83).

*Sustainability:* The condition of maintaining ecological integrity and basic human needs over human generations (Forman 1995, p. 40).

*Tank:* A container, covered or uncovered, used in conjunction with the drilling or production of gas or other hydrocarbons or storing fluids (Denton 2010, p. 22-3).

*Watershed:* All lands which are enclosed by a continuous hydrologic drainage divide and lay upslope from a specified point on a stream (GWPC 2009, p. 84).

*Wildlife:* Non-domesticated and nonaquatic animals (Forman 1995, p. 40).

*Workover:* To perform one or more remedial operations on a producing or injection well to increase production. Deepening, plugging back, pulling, and resetting the liner are all examples of workover operations (GWPC 2009, p. 84)

## 1.6 Summary

As the Barnett Shale in North Texas has been explored and utilized for the production of natural gas, reclamation standards have been developed by the Railroad Commission of Texas. With an increase in drilling in urban areas more in-depth remediation and reclamation standards have been amended and included in local city ordinances. These remediation and reclamation standards vary from city-to-city and bring focus to the remediation of nuisance impacts, such as noise, dust, and visual screening in order to enhance the public's perception and the aesthetics of the operation.

Through initial review and analysis of selected city ordinances and observations of sites with aerial photographs and in-person site visits, key concepts are derived and acknowledged, as a means to enhance the understanding of regulations and site conditions. As the methods for producing natural gas continue to develop to meet a growing demand, energy companies, operators, and city staff members strive to find a balance with growing concerns of the impact on the landscape. This thesis includes analysis and discussion of the perceptions of industry representatives and regulators in the natural gas industry and provides insight on the implementation of recommended practices and policies outlined in local city ordinances, in addition to federal and state regulations.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

The literature review includes a description of the basic principles of natural gas drilling and the impacts associated with drilling in an urban environment. Impacts on the landscape, including change and disturbance and reclamation practices influence the treatments enforced by federal, state, and local governments. Planning methods and strategies, including regional design, provide systems to analyze and balance the impacts on the landscape and surrounding habitat and land uses during the exploration and production of natural gas. Through the observation and analysis of the landscape development processes, patterns, and human influences, one works toward Christopher Alexander's idea that "you cannot merely build (the) thing in isolation, but must also repair the world around it, and within it, so that the larger world at that one place becomes more coherent, and more whole; and the thing which you make takes its place in the web of nature, as you make it" (Lewis 1996, p. 87).

## 2.2 Modern Shale Gas Development

### *2.2.1 Increase in Production within Urban Environments*

Texas produces six percent of the total volume of natural gas produced in the lower forty-eight states. Advances in horizontal drilling technologies and hydraulic fracturing, in addition to natural gas market prices, have increased the demand and feasibility of producing natural gas. With increasing demands, natural gas operators have looked to drill within the Dallas-Fort Worth region of North Texas and have greatly increased the number of rigs and wells over the past ten years (GWPC 2009). Figure 2.1 shows that in the Barnett Shale, as of

January 2010, almost 14,000 natural gas wells had entered the production phase and the figure represents the shift from vertical drilling to horizontal drilling (RRC 2011).

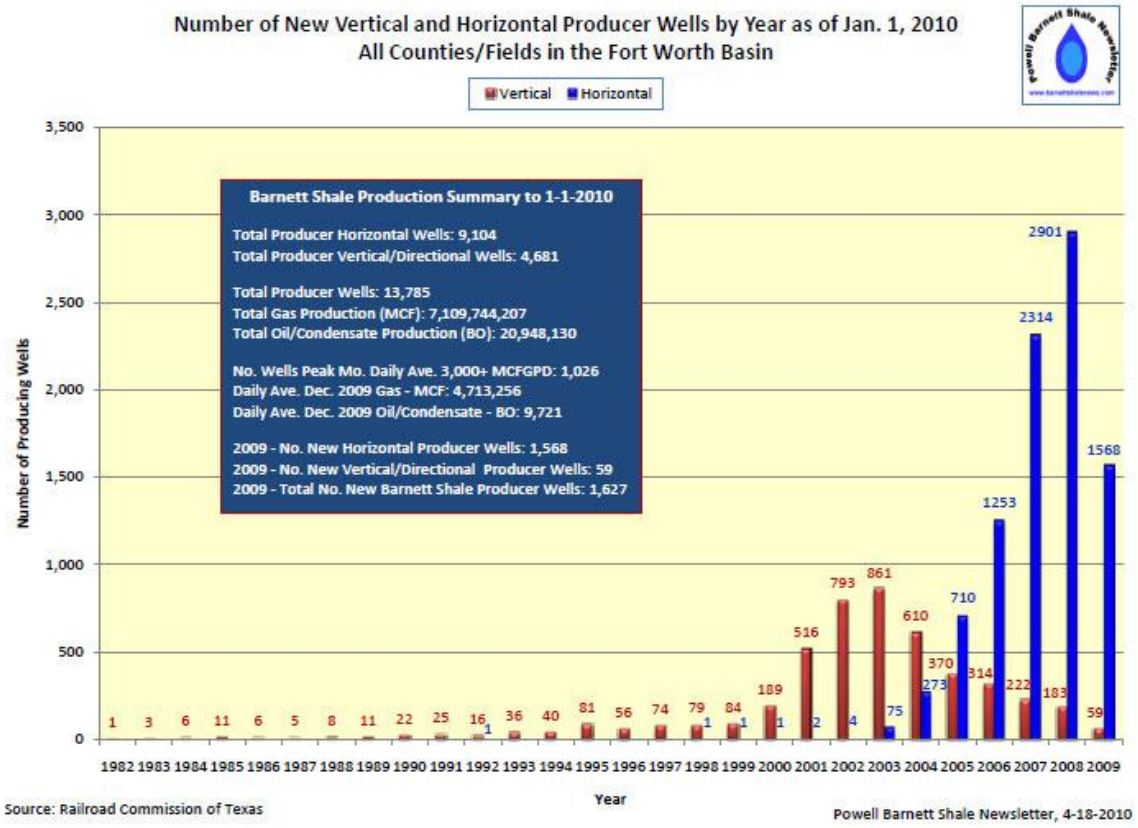


Figure 2.1 Barnett Shale Well Count 1982-2010 (Image Source: RRC 2011)

*2.2.2 Community Concerns*

Development of natural gas sites in rural, suburban, or urban areas quickly heightens the industrial feeling of an area, resulting in concerns regarding water quality, surface conditions, and aesthetic nuisances, including noise, air quality, and visual impacts (GWPC 2009; Vaughan and Pursell 2010, p. 13). Public meetings and opinion surveys are often conducted to address the concerns and offer solutions during the gas wells' presence (GWPC

2009, p. 45). Community members are typically concerned with the noise produced by generators and equipment needed to carry out the drilling and fracking processes. Also, increased truck traffic degrades road quality and intensifies wear on existing roadways. In addition to noise and increased volumes of traffic on streets and roadways, community members are focused on three environmentally degrading factors:

- "Air quality: Newly graded roads can produce dust, impairing air quality and visibility in the immediate area and downwind. Nitrogen oxides from diesel engines and compressors used at drilling sites can also degrade air quality.
- Water quality: Water draining off newly graded surfaces and roads or oil or water accidentally discharged during oil and gas production can increase the amount of sediment, salt, and pollutants discharged into rivers and streams, thereby degrading them.
- Habitat: A high density of drilling and production equipment can, in extreme situations, change the appearance of the landscape from a natural setting to an industrial zone. In addition, the noises, smells, and lights from trucks, drilling and construction equipment, and production facilities can disturb wildlife and people living nearby" (USGAO 2010).

To reduce noise disturbance in urban areas, operators' drilling procedures and equipment are often regulated by the individual city's gas well ordinance. Examples include restricting the use of internal combustion engines with mufflers for drilling operations only and the sole use of electric motors for the pumping of the gas wells (City of Denton 2010, Section 35.22-5).

In reaction to a boom and increase in industrialization in an area, including the increase of natural gas drilling, four stages of government and community reaction occur, as determined by Gilmore (1976) and Freudenburg (1981). The four stages include 1) enthusiasm, 2) uncertainty, 3) near panic, and 4) adaptation (Jacquet 2009, p. 12).

During the *enthusiasm* stage, officials and residents focus on the positive economic impacts that are highlighted and promoted by the energy company representatives and consultants. Negative impacts are either unknown or "dismissed as unlikely in their specific area" (Jacquet 2009, p. 12).

The *uncertainty* stage settles as the community realizes that negative impacts occur in addition to the positive benefits. Community members decide to support or disfavor the natural gas drilling activity, balancing the pros and cons of the gas well site's impacts on their particular area. Officials perform preliminary research; "however, there are few resources or experienced staff to draw upon, while industry and state government claims there is nothing that can be done" (Jacquet 2009, p. 12).

As long-term residents witness community character changes due to natural gas drilling and development, the *near panic* phase leads residents to turn against local officials and other residents. Government officials realize they are ill-equipped, unprepared, or do not have jurisdiction to make the necessary policy changes; government services are overwhelmed and quality of services may decline (Jacquet 2009).

The *adaptation* phase tends to be qualitative. Core problems are identified and as a result, planning/mitigation strategies are developed; "residents become solidified in their beliefs…and accept the reality of the situation at hand" (Jacquet 2009, p. 13).

### *2.2.3 Regulation*

The oil and gas industry is regulated overall by federal standards, including requirements by the Clean Water Act and Environmental Protection Agency (EPA). As the industry has grown, the federal government has directed regulations to state and local government agencies. State governmental agencies, such as the Railroad Commission of Texas, are "responsible for safeguarding public and private water supplies, preserving air quality, addressing safety, and ensuring that wastes from drilling and production are properly

contained and disposed of" (GWPC 2009, p. 43). Those gas well operators who take over management of property, either through a mineral lease or surface land agreement and lease, have the right to: "conduct seismic tests, drill wells at locations they select, to enter and exit well sites and other facilities, to build, maintain, and use roads for access to and from well sites and facilities, to build and use pipelines to serve wells and facilities on the property, to use surface and subsurface water on the leased premises for drilling and production operations" (RRC 2011, *Exploration and surface ownership*, p. 1).

In the Marcellus Shale region, including New York, Ohio, Pennsylvania, and West Virginia, the regulation and permitting of the gas wells are conducted through state divisions. Established in 1984 the Oil and Gas Act of Pennsylvania represents the principal law governing oil and gas well drilling. The Department of Environmental Protection (DEP) oversees the implementation and enforcement of the Oil and Gas Act in regard to locating sites, site preparation, drilling, water withdrawal and storage, waste management, and site restoration (Krancer 2011). In New York, the U.S. Energy Policy Act of 2005 and New York State's Environmental Conservation Law Article 23, exempted natural gas activities from local municipal oversight (Weidenhof, Ngo, and Gonzalez 2009).

In 2007, Huntley & Huntley, an oil and gas operating company, sought permitting to drill within a residential zone in Oakmont Borough, Pennsylvania. After being denied by the Borough's council, Huntley & Huntley appealed the ruling to the Supreme Court of Pennsylvania. The Supreme Court "unanimously ruled that while the conditional use permit had been improperly denied, companies cannot drill in areas where zoning ordinances do not allow them" (Skrapits 2010, p. 1). The Court concluded that "…the Act's [Oil and Gas Act's] preemptive scope is not total in the sense that it does not prohibit municipalities from enacting traditional zoning regulations that identify which uses are permitted in different areas of the locality, even if such regulations preclude oil and gas drilling in certain zones" (Asimos 2009, p. 1).

In 2005, Salem Township, Pennsylvania amended the associated planning and zoning ordinances in an attempt to regulate drilling and accompanying land development. After rejection and dismissal by the Commonwealth Court, Salem Township took the case to the Pennsylvania Supreme Court, citing the ruling of *Huntley & Huntley vs. Oakmont Borough* as a precedent (Ercolino 2008). The oil and gas producers declared that the "ordinance's regulations were preempted by Pennsylvania's Oil and Gas Act … [that they] were also preempted by other state and federal enactments…and they effected a regulatory taking" (*Range Resources-Appalachia, LLC v. Salem Township* 2008, p. 2). In 2010, the Pennsylvania Supreme Court ruled against Salem Township, stating that "…the township's ordinance overlapped and in some cases was more stringent than the Oil and Gas Act, making it 'an attempt by the Township to enact a comprehensive regulatory scheme relative to oil and gas development within the municipality" (Skrapits 2010, p. 1). Malak (2010), an industry consultant and attorney who worked with municipalities, stated that in Pennsylvania, as more cases and appeals were brought to the state court, "…they will [would] give further guidance to municipalities, landowners, and gas companies on what is permissible and what isn't" (Skrapits 2010, p. 2).

Since 2008, New York State has placed a moratorium on all high volume hydraulic fracturing and drilling procedures, pending an environmental investigation by the Department of Environmental Conservation (DEC). The revised draft of the Supplemental Generic Environmental Impact Statement provides a review of the environmental impacts and how they could be mitigated. Any energy operator that applies for a drilling permit in the New York State limits of the Marcellus Shale must undertake a site-specific environmental review and must fall within the requirements of the State Environmental Quality Review Act and the state Environmental Conservation Law (DEC 2011).

Local ordinances, involving city and municipal codes and community priorities, "are implemented to lessen community impacts and protect environmental resource…[and] include detailed setbacks from residences, roadways, churches, and schools, and means to control

visual and noise impacts including the required use of directional lighting" (GWPC 2009, p. 51). Cities develop ordinances to address development and environmental concerns allowing for variances or approved exceptions on a case-by-case basis. The ordinances form "performance controls and enforce standards and goals; without them, cities do not maintain regulatory strength" (Marsh 2005, p. 164).

Marsh (2005) indicated that the enforcement of ordinances has become selective and "shift(s) over time with changes in national, state, and community interests, politics, and needs" (Marsh 2005, p. 20). According to the Pennsylvania State University Cooperative Extension, "little is documented about how the drilling activities are affecting local governments" in the Marcellus Shale play in the Northeast, where regulation is primarily governed by state environmental agencies (Kelsey 2010, p. 1).


Figure 2.2 Barnett Shale in the Fort Worth Basin (Source: GWPC 2009, p. 18)

When faced with impacts of the industry on the community, "the entire local power and service structure faces a huge task in dealing with boom conditions" (Jaquet 2009, p. 13). In

response to the arrival of natural gas drilling in a community, local governments must “learn to plan, zone, negotiate with the industry, evaluate different people’s needs for compensation, fight for special state laws and for state and federal aid, work new local tax codes, and revamp their infrastructure and services” (Jaquet 2009, p. 13). Local professionals must learn to work with new types of people. The local business structure either has to “adjust to the newcomers… or face insolvency” (Jaquet 2009, p. 13). Figure 2.2 depicts the extents of the Barnett Shale in relationship to the Dallas – Fort Worth region of North Texas, a unique combination of natural resources that underlie a growing and sprawling urban metropolitan environment.

Figure 2.3 Active Drilling Rig in the Barnett Shale Play (GWPC 2009, p. 47)

An alternative to strict or select ordinances is an approach known as performance based planning, which “allows planners a certain amount of freedom to devise alternative means of coming up with the desired end” (Marsh 2005, p. 22). This method of determining an

alternative solution is implemented during the specific use permitting process: a variance request is submitted by the gas well operator and consultants when determining alternative solutions for the construction and screening of the gas well site (City of Arlington 2011). The conditions of a specific use permit may also reflect community input, as "society places higher values on some landscapes" (Jordaan, Keith, and Stelfox 2009, p. 11). Figure 2.3 shows a drilling pad site surrounded by a sound blanket and planted vegetative screen, most likely in response to local gas well ordinances.

## 2.3 Impacts on the Landscape

While determining the impact of a gas well pad's footprint, "simply using the area of land cleared is not a sufficient measure for the effects of development on the landscape" (Jordaan, Keith, and Stelfox 2009, p. 2). After seismic surveys are conducted and an area is determined to be economically viable to drill for natural gas, a well pad is prepared, including the leveling and grading of a site. A major challenge that faces local communities and regulators is the protection of sensitive ecosystems and flora and fauna that may be disturbed or destroyed during site preparation and construction (Kargbo, Wilhelm, and Campbell 2010).

Figure 2.4 Drilling Rig in Rural Upshur County, West Virginia (GWPC 2009, p. 48)

In addition to the construction of the pad site, drilling operations require roads and pipelines to be constructed to aid in the transportation of fluids, equipment, and natural gas from the sites to the market. The impacts of the natural gas well site development affect surrounding landowners, neighbors, and communities. The needs of these stakeholders and affected community members need to be addressed through the permitting procedures and should "include clear and enforceable remediation strategies to ensure minimal impact and maximum restoration of the land associated with natural gas production" (Jacquet 2009, p. 12). In order to minimize the impact on the landscape and surrounding areas, careful planning, location, and construction of the sites and pipeline networks, especially as "space is far more cramped in an urban setting than in a rural setting" (LWV-TC 2007, p. 6).

In an effort to reduce the environmental footprint associated with natural gas drilling, operators, equipment manufacturers, and university and research laboratories are working to improve the technologies and practices implemented by the energy companies and operators. Examples of these efforts include, drilling multiple horizontal wells from a single pad, using smaller and lighter rigs for drilling phases, implementing low-impact development strategies for well pad and road construction, and recycling flowback water (Pickett 2010). The Houston Advanced Research Center (HARC) and Texas A&M University, in addition to industry stakeholders, are developing a program focused on reducing the impact of drilling and production in environmentally sensitive areas. HARC is working to develop an environmental "score card" as a means to measure the environmental impacts of the proposed environmentally friendly drilling (EFD) practices. Haut, HARC program manager, states, "We are helping to emphasize the need for environmental stewardship…safety is a core value of the oil and gas industry…our goal is to make environmental stewardship in every phase of operations a core value as well" (Pickett 2010). Figure 2.4 presents a natural gas well site in

rural West Virginia, an example of the challenges driving the need for developing more environmentally responsible drilling practices.

## 2.4 Change and Disturbance

In addition to measuring the length of edge boundaries created by the pad site, one must take into account how far the effects of change will extend from the disturbed soil and landscape, as depicted by Figure 2.5. This larger zone of change and influence is considered the buffer zone. Changes in vegetation, noise, pollution, indirect and direct changes to the landscape, and avoidance or presence of the landscape affect the development and size of the buffer zone (Jordaan, Keith, and Stelfox 2009).

Through the process of natural gas exploration, drilling, and production, human disturbance occurs in the removal of existing vegetation, the creation of barriers and boundaries, and an increased presence of human activity in areas that are otherwise untouched by human interaction. A disturbance is a primary factor in the change of nature and is a "relatively distinct, rapid event(s) that disrupt(s) communities, species, populations, or the availability of resources" (Peck 1998, p. 51). Regarding natural gas exploration, disturbance patches within the landscape mosaic coincide with openings that are generated by the clear cutting of vegetation, and result in the traditional process of succession.

Despite the often negative public reaction to disturbances, positive opportunities occur as a result of a disturbance, if managed properly. Species evolve and adapt, vegetation structure and habitats are altered, and competition among flora and fauna communities increases resulting in increased biodiversity (Peck 1998). As humans continue to influence and affect landscapes, it is recognized that "technically, we are also 'natural' and part of a variety of ecosystems" and it "is inevitable that we will influence the dynamics of these systems because we are a component" (Peck 1998, p. 55). With improper planning, human influences can create large and intense disturbances on the landscape. Clearing land can alter wind, humidity, and

water-flow patterns and soil erosion may also result. Development introduces exotic species, pollutants, and incurs habitat reduction and fragmentation (Marsh 2005). In an attempt to protect sensitive or species rich communities, buffer zones may be retained and form a spatial shield. Also, replicate patches of vegetation types or with multiple species populations act as beneficial options and opportunities for the relocation of a species that may have been displaced by natural gas drilling.

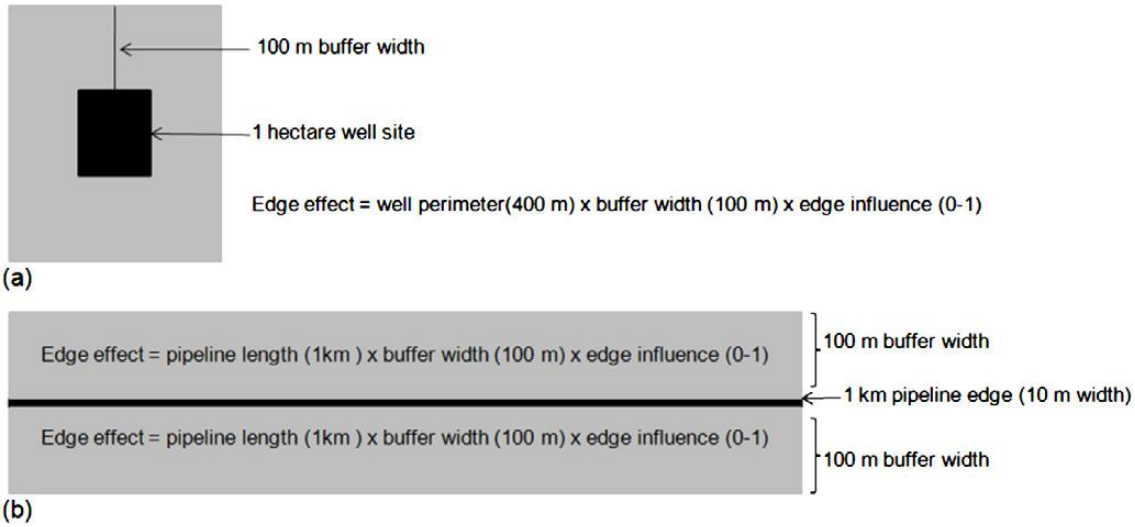


Figure 2.5: Edge and Edge Effects. The black square (a) represents a well site and demonstrates how edge effects are calculated for polygonal features. The black line in (b) represents a pipeline and demonstrates how edge effects are calculated for linear features. The gray areas surrounding the black features represent edge effects (Source: Jordaan, Keith, and Stelfox 2009, p. 5).

By constructing natural gas well pads in an urban environment, a lower amount of land disturbance and fragmentation can be achieved, avoiding or reducing development impact with the expansion into new and undeveloped areas. Existing roads and infrastructure may be used at the new drill sites, reducing the need to clear more land to create new roadways and easements. With intensification and concentration of gas well sites in an area, pipelines and easements may be consolidated, reducing fragmentation and overall impact on the landscape (Jordaan, Keith, and Stelfox 2009). The most effective management technique for an overall area or region is to focus less on a single disturbance and strategically reduce the collective

effects of all prospective disturbances (Peck 1998). The reduction of negative impacts caused by human disturbances “will likely involve coordination among a variety of landowners in many jurisdictions” (Peck 1998, p. 56).

## 2.5 Land Reclamation

### *2.5.1 Plugging and Abandoning*

In contrast to most industrial uses, upon abandonment of a site, a gas well operator must “file documentation with its annual organization report filing to demonstrate that the operator has plugged and removed the surface equipment from these wells” (RRC 2011, TAC Title 13. Part 1. Chapter 3. Rule §3.15). For wells located in the jurisdiction of the City of Fort Worth, a four inch diameter permanent abandonment marker pipe must be welded to the casing underground and extend four feet from the surface for noticeable recognition. The operator abandoning the well is responsible for the restoration of the well site to its original condition, or as nearly as practicable, including

1. Removal of the derrick and all appurtenant equipment.
2. Removal of all tanks, towers, and other surface installations.
3. Removal of all concrete foundations, piping, wood, guy anchors and other foreign materials regardless of depth, except surface casing, unless otherwise directed by the RRC.
4. Filling of all holes and depressions with clean, compactable soil.
5. Removal of all waste, refuse, or waste material.
6. Recording of a five (5) foot no-build easement around the center of the plugged and abandoned well bore in the applicable county deed records (Fort Worth 2009, Ordinance No. 18449-02-2009, Sec. 15-46).

Figure 2.6 displays the fluctuations of drilling processes in Texas over the past fifty years. Depending on market prices wells may be drilled and capped postponing the completion

and production phases of a well until production is viable and economically feasible. The table of drilling statistics also provides information regarding the number of wells that have been plugged, the phase necessary prior to well abandonment and reclamation (RRC 2011).

**Texas Drilling Statistics**

| Year | Drilling Permits Issued | Oil Wells Completed | Gas Wells Completed | Total Holes Drilled* | Total Holes Plugged | Average Rotary Rig Count |
|---|---|---|---|---|---|---|
| 1960 | 15,601 | 9,666 | 2,011 | 17,342 | 8,889 | 604 |
| 1965 | 14,227 | 7,207 | 2,383 | 14,433 | 8,836 | 425 |
| 1970 | 11,034 | 4,987 | 1,796 | 9,438 | 8,310 | 302 |
| 1975 | 20,293 | 7,004 | 3,396 | 14,393 | 10,960 | 638 |
| 1976 | 22,693 | 7,348 | 4,108 | 15,378 | 8,232 | 653 |
| 1977 | 25,189 | 8,121 | 4,399 | 16,577 | 8,129 | 778 |
| 1978 | 26,050 | 8,132 | 5,383 | 17,189 | 7,396 | 855 |
| 1979 | 29,241 | 8,487 | 5,319 | 17,509 | 6,658 | 770 |
| 1980 | 39,442 | 12,322 | 5,331 | 21,427 | 6,673 | 989 |
| 1981 | 47,940 | 15,627 | 5,454 | 26,209 | 9,054 | 1,318 |
| 1982 | 41,224 | 16,296 | 6,273 | 27,648 | 10,435 | 990 |
| 1983 | 45,550 | 15,941 | 5,027 | 26,882 | 11,661 | 796 |
| 1984 | 37,507 | 18,716 | 5,489 | 30,898 | 13,393 | 849 |
| 1985 | 30,878 | 16,543 | 4,605 | 27,124 | 14,479 | 677 |
| 1986 | 15,894 | 10,373 | 3,034 | 18,707 | 15,451 | 311 |
| 1987 | 15,297 | 7,327 | 2,542 | 13,121 | 13,186 | 293 |
| 1988 | 13,493 | 6,441 | 2,665 | 12,261 | 12,566 | 277 |
| 1989 | 12,756 | 4,914 | 2,760 | 10,054 | 11,229 | 206 |
| 1990 | 14,033 | 5,593 | 2,894 | 11,231 | 10,290 | 348 |
| 1991 | 12,494 | 6,025 | 2,755 | 11,295 | 13,089 | 315 |
| 1992 | 12,089 | 5,031 | 2,537 | 9,498 | 11,423 | 251 |
| 1993 | 11,612 | 4,646 | 3,295 | 9,969 | 11,552 | 263 |
| 1994 | 11,248 | 3,962 | 3,553 | 9,299 | 13,657 | 274 |
| 1995 | 11,244 | 4,334 | 3,778 | 9,785 | 11,081 | 251 |
| 1996 | 12,669 | 4,061 | 4,060 | 9,747 | 10,901 | 283 |
| 1997 | 13,933 | 4,482 | 4,594 | 10,778 | 9,336 | 358 |
| 1998 | 9,385 | 4,509 | 4,907 | 11,057 | 8,951 | 302 |
| 1999 | 8,430 | 2,049 | 3,566 | 6,658 | 7,011 | 226 |
| 2000 | 12,021 | 3,111 | 4,580 | 8,854 | 7,219 | 343 |
| 2001 | 12,227 | 3,082 | 5,787 | 10,005 | 8,023 | 462 |
| 2002 | 9,716 | 3,268 | 5,474 | 9,877 | 8,343 | 338 |
| 2003 | 12,664 | 3,111 | 6,336 | 10,420 | 8,720 | 448 |
| 2004 | 14,700 | 3,446 | 7,118 | 11,587 | 8,391 | 506 |
| 2005 | 16,914 | 3,454 | 7,197 | 12,664 | 7,191 | 662 |
| 2006 | 18,952 | 4,761 | 8,534 | 13,854 | 7,504 | 746 |
| 2007 | 19,994 | 5,084 | 8,643 | 20,619 | 6,892 | 834 |
| 2008 | 24,073 | 6,208 | 10,361 | 22,615 | 6,046 | 898 |
| 2009 | 12,212 | 5,860 | 8,706 | 20,956 | 6,390 | 432 |
| 2010 | 18,029 | 5,392 | 4,071 | 9,477 | 6,028 | 659 |

*includes oil & gas wells & dry holes; does not include service wells.

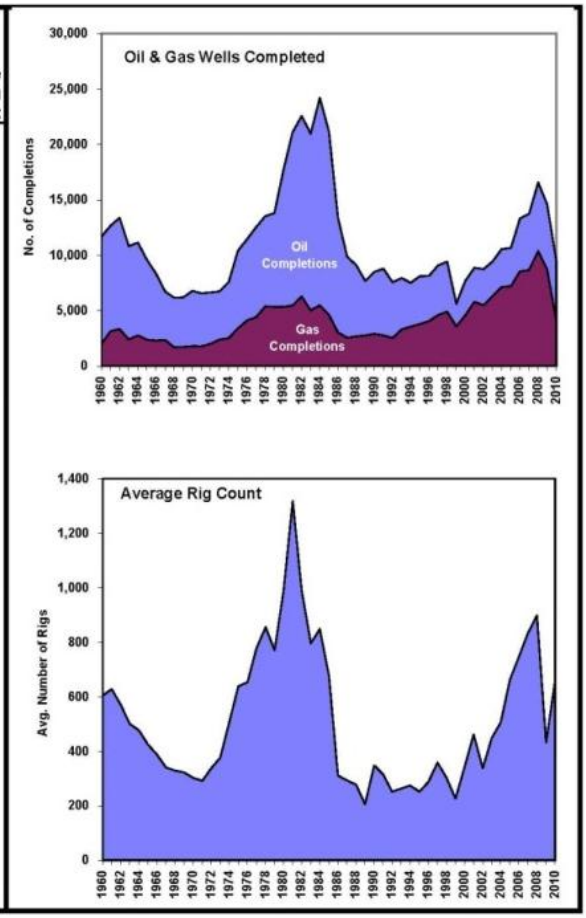


Figure 2.6 Texas Drilling Statistics 1960 – 2010 (Image Source: RRC 2011)

*2.5.2 Industrial Site Reclamation*

According to ALL Consulting, a national oil and gas engineering, planning, and construction management company, “new oil and gas developments bring change to the environmental and socio-economic landscape, particularly in those areas where gas development is new” (Arthur, Langhus, and Alleman 2008, p. 1). One option of change includes

"…the transformation of derelict industrial sites into public spaces…and…represents a significant enhancement to the quality of life and land use" (Loures and Panagopoulos 2007, p. 791). When community concerns and awareness of industrial sites increase, community members shift toward "…a new commitment to the transformation of once-industrial sites to new cultural and environmental uses" (Loures and Panagopoulos 2007, 791). Through the reclamation and restoration of industrial sites, such as natural gas pad sites, a planning approach must develop and include knowledge, new technologies, and collaborative design. When properly abandoned in accordance with the RRC or city ordinance regulations, the reclamation of gas well sites and surrounding landscapes should integrate five fundamental principles:

- Protect and conserve quality landscapes
- Develop a clear vision and strategy for an area
- Apply collaborative design principles
- Allow resources for long-term aftercare of new landscapes
- Enhance biodiversity, social stability, and economic development

(Loures and Panagopoulos 2007, 793).

After drilling and developing the wells through the production phase, the original extents of the pad site may no longer be needed. The decision to reduce the impact of the site results in the interim reclamation or remediation of the site. In urban sites this phase most notably occurs with the filling in and re-grading of the freshwater fracture pits (Fort Worth 2009). Masonry walls or fencing are constructed at the edge of the final pad boundary and trees, shrubs, hydro-mulch, and seeding are installed to provide a vegetative buffer and screen around the site. This process may only take place on a few sides of the site until the final pad limits are set and the pad site reduced to production size (Arlington 2011).

*2.5.3 Management Practices*

With proper planning operations on gas well pad sites production of natural gas may continue in concurrence with the reduction of disturbed areas and footprints. Blending the disturbed area into the native environment reduces long-term visual impacts. The Bureau of Land Management (BLM) suggests balancing cut and fill during construction of the site. After drilling, all areas not needed for the operation and maintenance of the gas wells and equipment should be restored as closely as possible to the previous conditions (BLM 2011). Constructing natural gas well pads often includes the removing of trees and clearing the land, removing protective vegetative cover and contributing to the possibility of soil erosion (Marsh 2005). Although well pads are to be graded to prevent runoff from the pad site, erosion can occur along the banks and berms surrounding the site (RRC 2011). Silt fences and perimeter berms aid in the mitigation and reduction of soil erosion from a site (Marsh 2005). Using retaining walls may reduce surface disturbance and erosion, retain existing vegetation, and protect roots from damage (BLM 2011).

Most cities require the replacement of removed trees, or the deposit of monetary reimbursement into a fund, as designated by each city's tree preservation ordinance (Town of Flower Mound 2011). The amount of trees, species, and proposed planting locations are represented on a landscape plan, which is submitted with the gas well permit. The spatial arrangement of the trees and size and intensity of the buffer is typically delegated through the city's landscape ordinance or development regulations. Each site must take into account surrounding land uses and protected uses (City of Arlington 2011). Except for street frontage and unique requirements within the development code, it is recommended that edges "that are scalloped and irregular are more natural-looking; straight lines should be avoided" (BLM 2011, *Vegetative manipulation,* p. 1). In order to reduce impact to existing vegetation and maintain a natural appearance, BLM (2011) recommends that a variety of tree and shrub species should be retained and edges should be feathered, reducing any strong contrasting lines. Re-

vegetation of sites may be enhanced by mulching cleared areas, furrowing slopes, choosing native plant species, fertilizing, mulching, and watering vegetation, and replacing soil, brush, rocks, and so on, over disturbed earth surfaces, allowing for natural regeneration rather than introducing an unnatural looking grass cover (BLM 2011).

In addition to providing soil stability, positive relationships between "various forms of vegetation cover and psychological and social responses of urban dwellers" have developed (Lee, Taylor, and Hong 2008, p. 171). In neighborhood environments, trees reduced the negative impacts of industrial facilities, including environmental pollution, risks, and negative visual perceptions. Vegetation provided aesthetic amenities to residential properties and increased property value. Through their study, Lee, Taylor, and Hong (2008) concluded that "foliage coverage within a neighborhood is positively correlated with property values" ( p. 175). It was also suggested that "by providing more foliage cover, urban planners and managers might be able to reverse or moderate the negative effects of disamenity facilities," such as natural gas well sites (p. 176). There was no absolute conclusion if landscaping within the neighborhood or near the disamenity facilities would be more effective, and Lee, Taylor, and Hong (2008) called for a need of a comparison study. The planning, development, and construction of natural gas pad sites could provide an opportunity for such a study due to their proximity to a variety of land uses and screening requirements of individual specific use permits.

Screening the pad sites with masonry walls or fencing, in addition to including vegetation, is often required and primarily dependent on surrounding land uses and the local municipal gas well ordinance or development plans (City of Arlington 2011). Fencing color and materials are typically "uniform, non-reflective tones, similar to the Bureau of Land Management Standard Environmental Colors chart… including, but not limited to green, brown, tan, and black and be complementary to the fence and painted equipment" (Town of Fort Worth 2011, Sec. 34-428). Figure 2.7 depicts a fenced and landscaped drill site in Lewisville, Texas, utilizing dark green vinyl screening fabric. BLM (2011) recommends using earth-tone paints and stains,

natural stone for walls, native building materials and rustic designs, natural-appearing forms to complement landscape character, and screening with the use of natural landforms and vegetation.

Figure 2.7 Screened and Landscaped Drill Site in Lewisville, Texas (Source: Personal photo)

## 2.6 Regional Design

Through the studies of landscape patterns and analysis of both rural and urban sites, Lewis (1996) observed a necessity for a regional design process. While studying the landscapes of Wisconsin, Lewis (1996) recognized that the increased rate of change in land uses and their nature contributed to resource depletion, soil erosion, and an overall impact on the landscape and terrain. Lewis (1996) concluded that “contemporary pressures…produce more and more commodities to satisfy more and more people…and result in [the] exploitation of resources to the detriment of renewal and preservation of the land” (Lewis 1996, p. 13).

Land uses in North Texas are constantly changing in response to the needs of an expanding population. A call for land and social ethics is being made to bring to the population's attention "…because land-use controls are far from permanent…and…preservation of our critical natural and cultural resources must become more deeply rooted not just in our laws but in our culture and ethics" (Lewis 1996, p. 23).

As gas drilling in urban areas of North Texas continues, more and more public concerns surface, involving the public health and the visual and audible impacts on the surrounding communities. The impact on the landscape as a whole has not reached a status of primary concern. Growing awareness of landscape patterns and benefits of habitat networks along natural vegetation corridors may enhance the understanding of natural landscapes and their qualities. With that understanding "come the benefits of sensible land-use decisions as well as personally and socially rewarding benefits of enjoyment of our surroundings…and the satisfaction of greater understanding of an incredibly complex, dynamic, and beautiful whole" (Lewis 1996, p.29). In his analysis of the regional landscape as patterns instead of objects, Lewis found that "one can discern patterns that diminish the quality of life, sense of place, options of choice, and sustainability, as well as patterns that enhance" (Lewis 1996, p. 29).

### *2.6.1 Rural Landscape Patterns*

On the outskirts of large metropolitan areas and interspersed through urban developments and suburban outliers, rural areas provide an alternative destination from the cities. The rural regions still exist as the majority land mass in North America, the United States, the Southwest region, and more specifically, Texas. Lewis (1996) has determined that field patterns of rural areas such as forests, grasslands, and crops are dissected by linear environmental corridor patterns. As Forman (1995) explains, corridors provide a protected transportation route for the movement of wildlife through the various patches of landscape. Within these corridors, water, wetlands, and varied topography create diversity in the

landscape. Spatial patterns vary in width, dependent on the slope of bordering topography, existing vegetation, and urban uses and elements. Nodes, or patches, are located throughout the corridors and provide diversity along the pathways. These factors tie into Forman's (1995) landscape principles and contribute to the overall success of the landscape as a species rich habitat.

The development of gas well sites in rural areas of North Texas is governed by the RRC and any surface land use agreement between the land owner, mineral owner, and operator. This agreement determines the location of the site and implementation of additional development and reclamation practices on the property during drilling, production, completion, and abandonment phases (RRC 2011). The sites are located in areas that are projected to have the least impact on daily use of the land, including cattle ranching and farming. Site selection is primarily guided by the landowner (BSEEC 2011).

### *2.6.2 Urban Landscape Patterns*

Within the more dense urban fabric of a region, field patterns are created and influenced by land uses such as residential areas, industrial zones, and park systems. Networks of corridors align with transportation routes, open-space patterns, topography, and architectural boundaries. Size and layout of streets, the height of structures, and the size and nature of parks and open spaces all contribute to the designation of spatial patterns within urban areas. Nodes continue to add diversity within the corridors and may also act as stepping stones within the landscape (Lewis 1996). Figure 2.8 provides an example of an urban townscape pattern at night, highlighting the definition of corridors, transportation routes, and development patterns that are primarily determined by the street layout.

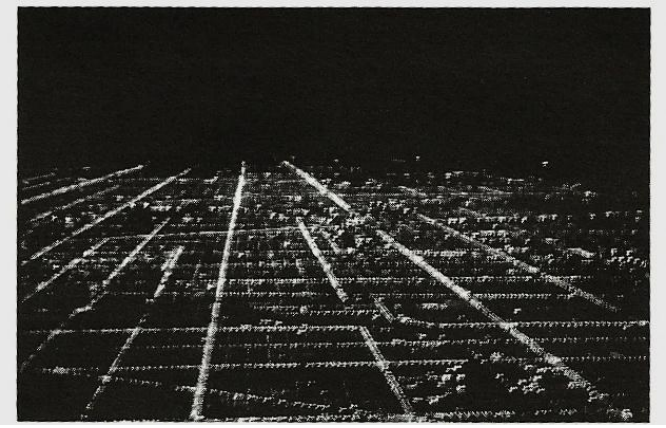

Figure 2.8 Urban Townscape Pattern (Source: Lewis, p.88)

*2.6.3 Resource Patterns*

In addition to rural and urban patterns, Lewis (1996) highlights the importance of awareness of resource patterns within the planning and construction of cities and transportation networks. Figure 2.9 displays the influence of an agricultural field as a determinant of the shape and type of edge created by the surrounding vegetative buffer. Riparian corridors, irrigation needs, and access points also influence the extents of agricultural areas and the boundaries created between adjacent land uses. Industrial uses may require the use of certain raw materials that are to be harvested from regulated resources or emit particular byproducts (Lewis 1996). As a result, wind patterns and landform patterns influence the location of such sites. The groundwater patterns take into account the access and availability of the underground water supply and the safeguards needed to protect such an important and necessary resource. The excavation and extraction of underground minerals or petroleum products are to be positioned in the most efficient or appropriate locations to develop a raw material or energy pattern (Lewis 1996).

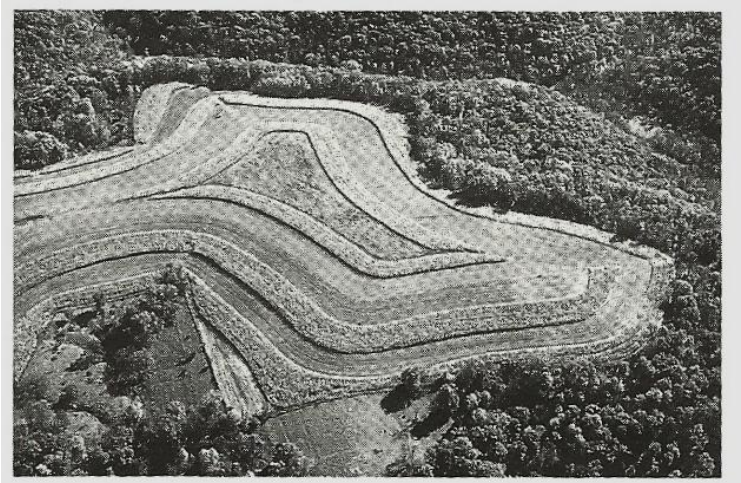

Figure 2.9 Rural Landscape Resource Pattern (Source: Lewis, p. 88)

## 2.7 Summary

This chapter describes the impacts, challenges, and responses associated with natural gas drilling and extraction processes. Natural gas production has increased in the past ten years, including in the dense urban areas of the Dallas – Fort Worth region of North Texas. As a result of the increasing technologies and viability of the industry, attention and concerns have been raised concerning the public health, safety, and welfare of the citizens affected by the impact of the industry. Environmental and developmental impacts on the landscapes surrounding the drill sites are also being considered.

# CHAPTER 3

# RESEARCH METHODS

## 3.1 Introduction

The study focuses on municipalities within four core natural gas producing counties: Denton, Johnson, Tarrant, and Wise, as determined by the RRC. An additional municipality, a bedroom community, in Parker County is also included due to its proximity to Fort Worth (RRC 2011). Diverse conditions of the selected municipalities include extraterritorial jurisdiction, land availability, strictness of regulations, proximity to the Dallas-Fort Worth region of North Texas, and the recent amendments of gas well ordinances. In addition to these considerations, this chapter includes the approach to obtaining reliable data; the recruitment process for interviews; the method of selecting the study cities and their ordinances; interview questions, challenges and limitations to the research; the predictable outcomes and overall scope of the research; and a summary of the methodology for this research.

The foundation for the study emerged from the researcher's professional experience with the gas well permit approval process in Arlington, Texas. As shown in Figure 3.1, drilling in the Barnett Shale has boomed in the past ten years, resulting in a need to amend ordinances to meet public and industry demands (RRC 2011). Hydraulic fracturing in urban areas is a relatively new process, resulting in a lack of data regarding the correlation of gas well drilling and its impacts on urban landscapes. This lack of information, acknowledged as a limitation, encouraged the interest and development of this study. Examples of inconsistent data within the study include poorly worded interview questions, a limited number of municipal ordinances, and a limited amount of stakeholder representation. It should be noted that attention was given to

recruit an equal representation of industry representatives and city regulators. The data collection methods are reviewed in this chapter, in addition to the challenges of this study.

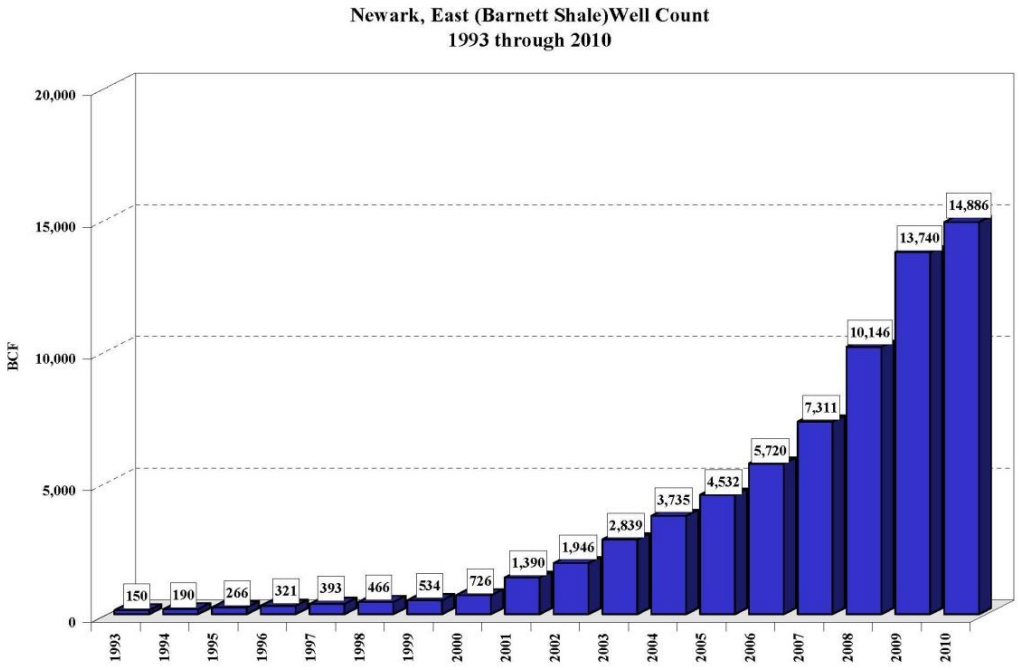


*Figure 3.1 Barnett Shale Well Count 1993-2010 (Image Source: RRC 2011)*

## 3.2 Approaches to Obtaining Reliable Data

While analyzing the selected cities, the researcher became familiar with the specific regulations of each ordinance, leading to an enhanced rapport with interview participants through familiarization of terms, conditions, and industry language and jargon (Taylor and Bogdan 1998, p. 48). Review of local gas well ordinances, considered an emergent analysis process by Taylor and Bogdan, revealed significant similarities and distinctive regulations that were logged as possible discussion points for interviews or future studies. During the reviews, unique requirements, interesting regulations, or points needing additional clarification were noted for future discussion during the interviews.

As another emergent step in the process selected gas well sites in urban and rural environments of North Texas were visited to enhance understanding of site conditions. These site visits provided opportunities to observe surrounding land uses, possible planning processes, the presence of landscape elements, (including re-vegetation), and screening with the use of vegetation, fencing, or masonry walls. Observations of various landscape elements, site characteristics, and site practices increased familiarity with industry processes and aided in the development of the research and interview questions.

Qualitative or in-depth interviewing was chosen as the most effective method for inquiry because it provided exposure to a broad range of settings and conditions as time constraints limited the ability to observe all individual sites and applications in the North Texas region (Taylor and Bogdan 1998). In-depth interviews, consisting of open-ended questions, allowed the interview participants to express "their lives, experiences, or situations as expressed in their own words" (Taylor and Bogdan 1998, p. 88). Unlike structured interviews, in-depth interviewing was viewed as "flexible and dynamic…unstructured" and allowed time to learn about the participant's points of interest, even prior to focusing on the research at hand. Another benefit of in-depth interviewing occurred in the ability to conduct the interviews in situations that were specifically arranged for the purposes of the research, allowing flexibility and comfort for the participant (Taylor and Bogdan 1998, p. 88). The research participants represented both public and private interests in the development of gas well sites. With their level of experience and exposure to current practices, it is assumed that the selected interview participants had familiarity and knowledge regarding site selection, remediation, and final reclamation of gas well sites.

## 3.3 Interview Questions

After reviewing selected local gas well ordinances of North Texas and regulations of the DEP and DEC of the Marcellus Shale region, elements of site selection and remediation

practices, or lack of regulations, were noted. These concepts were compared to site observations made while visiting selected sites in the Dallas-Fort Worth region of North Texas. The following interview questions were developed to gain a further understanding of the perceptions of industry representatives and regulators involved with natural gas drilling and permitting in North Texas.

1. What determines site selection for a natural gas well in North Texas?
2. What determines the remediation efforts applied to a natural gas well site?
3. Are current regulations appropriate for remediation of sites during natural gas drilling and production?
4. What would you change about current site remediation practices?

## 3.4 Method for Selecting Study Region

The RRC indicated that four core counties--Denton, Johnson, Tarrant, and Wise--were affected the most within the five thousand square mile expanse of the Barnett Shale, as they had a large number of gas wells and produced the greatest amount of natural gas (RRC 2011). Due to time constraints, the study area included only a few selected municipalities. At least one representative municipality from each core county was sought for further review and analysis of their current gas well ordinance. After discussion with the planning and zoning department representatives of Decatur, Texas (Wise County), and Cleburne, Texas (Johnson County), it was decided to omit these municipalities from the study region due to the minimal presence of drilling within city limits and the distances to the Fort Worth urban area. However, one smaller municipality–Weatherford, Texas–was selected for study due to its proximity to Fort Worth, designation as a bedroom community, and retention of primarily residential land uses. The municipalities with gas well ordinances and represented by stakeholders were chosen due to the following features:

- Arlington, Texas – Tarrant County
  - Amended the ordinance most recently (approved December 7, 2011)
  - Included site restoration plan requirement
  - Incorporated a tiered-landscape plan, dependent on surrounding land uses
- Denton, Texas – Denton County
  - Hosted a gas development task force public meeting recently (August 2011)
  - Drilling not restricted due to availability of undeveloped land
  - Incorporated regulations for drilling within city limits and extraterritorial jurisdiction
- Flower Mound, Texas – Denton County
  - Considered one of the most stringent ordinances in North Texas
  - Increased setback distance from 500 feet to 1,500 feet from a gas well to a residence with mineral interest in latest amendment (July 2011)
  - Addressed gas drilling as it impacts the values included in SMARTGrowth development plan
- Fort Worth, Texas – Tarrant County
  - One of the first city gas well ordinances for this region (December 2001)
  - Served as a model gas well ordinance for other cities
  - Included a site restoration plan regulation
- Mansfield, Texas – Tarrant and Johnson County
  - Allowed construction of gas well in close proximity to public baseball fields
  - Considered a growing community with gas well activity on outskirts and edges of city development
  - Provided jurisdiction for Tarrant and Johnson County

- Weatherford, Texas – Parker County
  - Considered a bedroom community in close proximity to Fort Worth
  - Limited amount of gas wells within city limits
  - Established residential and agricultural community

## 3.5 Interview Protocol and Participants

Interview participants were recruited primarily through professional connections made over a twelve month period during intern work required by the researcher's employer. Other participants were recruited through e-mail or phone calls made to selected departments of previously selected municipalities. Additionally, the researcher recruited participants using the "snowball technique," as described by Taylor and Bogdan (1998). Highly regarded professional colleagues suggested contacts in alternative municipalities or firms and provided contact information for the researcher.

With participant consent, a Sony digital voice recorder was used to document all interviews, allowing full participation in conversation while capturing the entirety of the interview. After the interviews, the digital recordings were transcribed into Microsoft Word documents with the aid of Dragon speech recognition software. Once the interviews were transcribed, all digital voice recordings were destroyed to protect the identity and anonymity of the participants. The identities of the interview participants remained anonymous throughout the transcription and analysis process.

Aside from a thank you e-mail, no personal data were sent to the interviewees after their sessions. They were all provided copies of the research document to review for technical accuracy. It should be noted that in two cases of recruitment, using e-mail and phone recruitment methods, the potential participants declined. One municipality regulator, a gas well coordinator, declined due to a professed unfamiliarity with the role of landscape remediation in

the gas well development process and the other, a gas well review committee coordinator, did not respond to either e-mail or phone call.

### 3.6 Challenges and Limitations to Research

Among the challenges and limitations to this research was difficulty in recruiting a balanced selection of industry representatives and municipality regulators. The participants had direct connections to the natural gas industry, either through direct employment or administrative correlation. The ability to gain honest and personal opinions about that industry and those connections was a concern and viewed as a possible limitation. Broad interview questions were formed to allow interview participants to express their opinions about current regulations, implementation, and overall success. In order to focus the research on the impacts of gas well sites in accordance with landscape architecture and the planning of the sites, the researcher did not investigate chemical impacts or technical needs and requirements for the actual drilling, fracking, completion, or production processes.

Delimitations of the study included the researcher's decision to narrow the expanse of the Barnett Shale to focus specifically on six municipalities, their associated ordinances, and public and private natural gas industry representatives who are involved with each. The six municipalities were chosen due to the individual approaches of each municipality to natural gas drilling within their jurisdiction. The six municipalities were Arlington, Denton, Flower Mound, Fort Worth, Mansfield, and Weatherford.

Limitations to the study included time constraints to complete the review of ordinances, site visits, and the scheduling of interviews. Also, the lack of industry representatives and regulators for each municipality limits the representation of the study region. However, selected interview participants expressed familiarity with several of cities' ordinances outside of their individual jurisdiction or area of professional involvement.

## 3.7 Predictable Outcomes

In the Barnett Shale of North Texas, an estimated 14,000 wells have been drilled as of January, 2010 (BSEEC 2011). As a result, development has become focused primarily on the urban and suburban environments surrounding Fort Worth, Texas (GWPC 2010, p. 16). City department administrators and industry consultants are working to develop "reasonable and uniform limitations, safeguards and regulations for present and future operations related to the exploring, drilling…of natural gas…within the City to protect the health and general welfare of the public… [and to] minimize the potential impact to property and mineral rights owners, protect the quality of the environment and encourage the orderly production of available mineral resources" (Fort Worth 2008, sec. 15-30).

While private industry stakeholders are involved in the processes leading to permit approval, they are also involved in remediation, maintenance, and reclamation of the site after the well has been abandoned. City regulators oversee the approval of gas wells and the continuous regulation and inspection of gas wells until they are returned to their previous conditions (BSEEC 2011). In terms of site selection process, it is assumed that the stakeholders note the prominence of geological studies and city ordinances as the primary determinants.

With site remediation, it is assumed that industry representatives and municipality regulators view setbacks and surrounding land uses as the basis for the efforts used in the interim remediation of a site. Aesthetics, including masonry walls and vegetative screening, drive the participants' responses when discussing interim remediation, the status of the site when it is between well pad site construction and well drilling and the final reclamation of the site. After reviewing the gas well ordinances of the six selected municipalities, it is noted that they have been amended at an average rate of every two to three years. With the rapid rate of

change, it is assumed that municipal regulators view current gas well location, development, and reclamation practices as insufficient and in need of adaptation.

## 3.8 Summary

The purpose of this study was to ascertain the perceptions of industry representatives and regulators regarding permitting, development, and reclamation processes of natural gas wells. In-depth interviews consisting of open-ended questions enabled participants to express their “lives, experiences, or situations as expressed in their own words” (Taylor and Bogdan 1998, p. 88). The collection of participants of this study was assembled based on their representation of the selected study area, including the cities of Arlington, Denton, Flower Mound, Fort Worth, Mansfield, and Weatherford, and their familiarity with the local ordinances in regard to site location, remediation, and the overall impacts of natural gas drilling on the landscape.

# CHAPTER 4

# ANALYSIS AND FINDINGS

## 4.1 Introduction

Interviews were conducted with city departmental representatives and private consultants from municipalities within the determined study area, as described in Chapter 3. These individuals were selected in part because they had direct experience with current gas well drilling ordinances and procedures in their respective communities. Interviews were the chosen data collection technique to establish industry representatives' and regulators' perceptions of remediation and site reclamation because it enhanced the understanding of the interpretation and application of the regulations on the urban gas well sites. Data from the interviews were transcribed and analyzed according to Taylor and Bogdan's grounded theory approach (1998). The data collected showed that there were similar perceptions among stakeholders in the determining factors of site selection, remediation efforts, and suggested improvements for regulations.

## 4.2 Recruiting Results

The methods for recruiting interview participants from the selected municipalities involved three approaches: prior professional relationship, email or phone recruitment, and the snowball technique (Taylor and Bogdan 1998). Regulators from the selected municipalities were sought to provide the public perspective due to their familiarity with the gas well permit and policy development procedures. Throughout this study, municipal regulators were referred to as Respondent M. Industry representatives and consultants were recruited to provide their

perceptions as mediators between the operators and the city permit procedures. Industry representatives were identified as Respondent IR for purposes of data analysis.

The number of respondents from the phone and email recruitment yielded three city departmental regulators. The most successful recruitment method was having a professional tie to the participants, resulting in four private consultants, one city regulator, and one public relations representative of an oil and gas operating company. Through the snowball technique and recommendations through professional contacts, one private consultant and two city regulators were obtained.

## 4.3 Interview Analysis

Interviews were conducted face-to-face and, upon consent of the participant, were recorded with a Sony digital voice recorder. Recordings were transcribed by the researcher with Dragon speech recognition software. After the Microsoft Word documents were transcribed, the data were analyzed using the grounded theory approach, or the development of a theory that was indicated by the data and was relevant to the study (Glaser and Strauss 1967).

A theory was said to be grounded to the extent that it is derived from–and based on–the data themselves (Taylor and Bogdan 1998), in this case from themes developed from the responses of the interviewees in regard to the interview questions. Through analysis of the interview data, “themes and patterns based on conversation topics, vocabulary, recurring statements, meanings, and feelings” were derived (Taylor and Bogdan 1998, p. 143). From the themes, the data were reviewed and compared as to how they fit within the particular theme. Through the continuous comparison of patterns in the interview transcriptions, themes were brought to attention and expanded. With the comparison of additional data, irrelevant data were discarded, themes refined and confirmed, and a “theory [was] built that develop[ed] directly from data rather than from a priori assumptions, other research, or existing theoretical frameworks” (Taylor and Bogdan 1998, p. 137-8).

## 4.4 Themes from Data

Through the analysis of industry representative and regulator interviews, emergent themes were developed by the researcher regarding the locating of gas well sites in urban environments, remediation practices and regulations, and improvements for future practices involving the regulation of gas well drilling and remediation. These themes included the following:

- Determinants of site location
  - Exploration by operators
  - Availability of land
  - The importance of city regulations
  - Surrounding land uses
  - Environmental considerations
- Determinants of site remediation
  - City ordinances
  - Surface reclamation plan
  - Environmental permits
  - Community values
- Site remediation standards
  - Vegetative screening
  - Masonry walls
  - Fencing
  - Noise
- Final reclamation standards
  - Lack of experience
  - Reclamation for future land uses

- Improvements for future practices
  - Planning
  - Broader governing body
  - Timeframe for reclamation
  - Restoration according to surroundings
  - Maintenance

### *4.4.1 Determinants of Site Location*

#### 4.4.1.1 Exploration by operators

In discussions regarding the process site selection for gas well exploration and drilling, respondents cited the primary selection methods as the geological surveys and research conducted by a gas well operator and landmen in regard to availability of land. Respondent IR3 stated, “The most driving factor is what happens underground,” meaning the seismic surveys and presence of natural gas deposits determine the viable locations for gas wells. Respondent M2 verified a process of analyzing geological data and developing options for locations by noting that “…the well pad must be sited in an area that is geologically acceptable and they can tap the portions of the unit they want to drill.” After the geological surveys were completed, the gas well operators “…figure out that the gas well site needs to go here” (Respondent M2). Respondent IR1 added, “They have a significant amount invested in their asset from mineral leasing to future royalties to the cost of site construction and drilling.”

#### 4.4.1.2 Availability of land

A recurring theme regarding site selection procedures was the availability of land and the acknowledgement of the need for landowner consent. The size of available property, or “…how many acres the landowner has” (Respondent M2), plays into site selection because operators need sufficient space for their drilling and production operations. With the discussion

of site selection respondents mentioned that operators or landmen are instructed to “talk to the landowner … find out if the landowner is even going to consider putting a gas well on his site” (Respondent IR4), since “…one major influence is the property owner. You have to have their agreement to locate a site on their property,” and “you have to have a willing participant” (Respondent IR1).

#### 4.4.1.3 The importance of city regulations

Along with geological assessments, city regulations and ordinances were the main factor in the final location of natural gas wells. City regulators admitted that their role was limited and “…we generally don’t get involved with the actual site location process other than the approval” (Respondent M5).

The importance of regulations and ordinances in municipal districts is verified by respondents who note that “…once they narrow down a particular location or locations, that is when they generally approach the city and determine whether or not that is a viable location within the city to do the drilling” (Respondent M5), and “…in an urban setting, I would say the city ordinances determine where you set a site” (Respondent IR2).

In regard to the setbacks dictated by the ordinances and locating gas well sites, respondents replied that “…most companies put them wherever they think they can fit them” (Respondent IR3). As for areas with more dense populations and development, respondents stated that in those areas “…you would have a considerable amount of setbacks” (Respondent M4) and that “…operators will tend to trend toward areas that do not have such dense development” (Respondent IR1) and “vacant areas. Just from the cost perspective, it’s cheaper” (Respondent M4).

As different cities have different regulations and definitions of protected uses, the setbacks also vary from city to city. Respondents indicate that setback distances play an important role in site location because “…setback distances affect how you evaluate the site

and location…and…Those setbacks can be reduced if you have waivers from the affected property owners" (Respondent IR1). In regard to obtaining waivers from affected property owners in an attempt to reduce setback distances, respondents acknowledged that different cities had different definitions of protected uses, but that each city had similar requirements in that the operator has "to have the waiver in hand before they will let you advance or even submit the application to go less than (the recommended distance)" (Respondent IR1).

#### 4.4.1.4 Surrounding land uses

Respondents are of the opinion that operators choose sites with minimal regard to surrounding land uses. For example, while discussing site location strategies, Respondent IR3 stated that "…once they locate a site, they start contacting the property owners, but not really looking into adjacent types of uses, whether it (is) residential or hospitals." Another respondent confirmed that drilling companies "…prefer not to plan too much," and he added that "…there's only more planning in urban areas because they're required to do it …that's where the ordinances and the political environment come into play" (Respondent IR4). In relationship to the lack of planning according to surrounding land uses, one city regulator (Respondent M6) stated that "…we have noticed that not only is it [drilling] something that would take place in an industrialized part of the city, but could very well take place more often than others in a very residential or commercial-like setting."

#### 4.4.1.5 Environmental considerations

Environmental impacts and considerations in regard to site selection were rarely mentioned. One city regulator admitted that site selection was determined by environmental setbacks and that "environmental areas, such as floodplain or tree habitat, potentially affect where the pad site could be located" (Respondent M4). A consultant, Respondent IR2, mentioned that "…if all of the good sites have been drilled for the most part, in the prime areas,

all you are left with is floodplain, sometimes park land." When sites are located in areas of environmental importance and consideration "…you get into regulatory concerns above the municipal level… state, federal, Clean Water Act, which regulates whether you can build a pad in a wetland" (Respondent IR2).

### *4.4.2 Determinants of Site Remediation*

#### 4.4.2.1 City ordinances

Throughout discussions on the remediation that is applied to the gas well sites, a theme regarding city ordinances became clear. Multiple respondents noted that ordinances were the only regulations that held companies to any standard above the Railroad Commission standard. Respondent IR4 stated that "…from an operator's perspective, if they weren't dictated, they probably are not going to be done." Another respondent suggested that "…nobody is going to do anything until someone tells them what to do or what's required" (Respondent IR3).

In addition to city ordinances, tree mitigation plans were mentioned by two respondents as important determinants for the amount of reclamation and re-vegetation a site received. During the discussion of remediation efforts after a gas well has been constructed, one of the respondents mentioned that the operator has to "…mitigate for all that plant material" and they can do so by either paying into a "…tree mitigation fund to plant trees elsewhere in the city or they will go in and plant trees and shrubs, mainly trees, around the gas well site" (Respondent IR5).

#### 4.4.2.2 Surface reclamation plan

During the discussions of efforts for site remediation, respondents demonstrated familiarity with the incorporation of surface reclamation plans into several city ordinances; the City of Fort Worth and the City of Arlington to be specific. Respondent IR2 stated that an operator would "…submit a plan that shows what portions you are going to be reclaiming and

how you're going to do it" and that "…you show the pad area being converted back …re-graded so it drains like natural conditions and then re-vegetated." Respondent IR6 read from the City of Arlington Ordinance 11- 068, amended and approved on December 7, 2011:

*"In Arlington, in addition to following the state requirements, the site restoration plan shall be submitted with the initial gas well permits on an approved site. At a minimum this plan shall document the following: existing conditions of the property prior to drilling activity, including site photographs and detailed description of the site restoration methods that will ensure the site is restored to predevelopment conditions, including site grading, vegetative restoration, and abandonment of equipment and facilities."*

Another respondent stated that "…if we don't have that reclamation plan…how can we ensure that it is what the citizens want and get clear direction to the operators, if we don't even have it identified" (Respondent M1).

#### 4.4.2.3 Environmental permits

Additional permits were required if gas well sites were located within environmentally sensitive areas or floodplains. These permits included a floodplain development permit obtained from either the county or city. Only one respondent from the interview pool referred to the environmental permit regulations. Respondent IR2 revealed that the Army Corps of Engineers required an RGP-11, or regional general permit 11, for filling in wetland areas "…specific for oil and gas exploration facilities," and that the Army Corps of Engineers "…require their own restoration plan."

#### 4.4.2.4 Community values

One of the significant themes that developed during discussions on remediation was the importance of community values on the amount of interim remediation that a site receives. One respondent stated that the specific use permit process was "…very similar to zoning a

piece of property" and that the city had "…a large degree of discretion in that case…and…they will frequently apply additional conditions on your case that may not be in the ordinance" (Respondent IR1). While discussing landscaping, noise, and air quality remediation, Respondent IR1 responded that the importance or priorities of those factors "…are all determined by each individual community."

Surrounding land uses were combined into this theme because it became apparent that respondents viewed the surrounding land uses and their inhabitants as representing surrounding community values. In regard to discussing the operator's view of surrounding land uses and their demands, Respondent IR3 stated that "…if someone is outspoken on certain things they want or are concerned about, then they step it up a notch and say, 'Well I can't do the minimal. We are going to have to do more to satisfy the surrounding land uses.'"

Respondent M5 also confirmed that remediation efforts were determined by "…the proximity to surrounding land uses and their impact on those surrounding land uses." Proximity to residential land uses was frequently mentioned by respondents as one of the prime land use concerns. While discussing well locations in relationship to residences, Respondent M5 admitted that "…the proximity of location or distance to those residential property boundaries and home sites, are usually things the city will take into perspective when we consider the locations within our corporate boundaries."

One respondent viewed community values as skewed, stating "…I think the community values are sometimes subjective because a lot of times not everyone is for urban gas drilling" (Respondent M6). When describing the subjective statement, the respondent declared, "a lot of times we are hung up on the small things that come with the actual drilling process, which is maybe an aesthetic aspect of landscaping or screening." However, he also confirmed that some community members were interested in "…the long term bigger picture items, such as the availability of this land in the future to put something else that can be an economic generator for the city" (Respondent M6).

*4.4.3 Site Remediation Standards*

4.4.3.1 Vegetative screening

A recurring theme regarding remediation practices was the use of vegetative screening and buffering. Vegetative screening in the form of streetscapes was mentioned during discussions of remediation standards. Respondent M1 stated, “A lot of communities have landscape requirements along their streets” and that “for every other development, we have buffers between this property and the next one…so why don’t we do the same thing for these sights?” In regard to locating a site near a natural vegetative buffer, Respondent M3 suggested “locating the pad site where there is an existing stand of trees or maybe some type of ridge from a right-of-way to help screen it.”

4.4.3.2 Masonry walls

Throughout discussions on remediation efforts within the urban environment, the use of masonry walls became an important theme and one that had the widest variation of opinions. Respondent M1 replied with statements such as, “…it is aesthetic and has good security” and in addition to aesthetics, “…it is the durability…the lastingness.” When discussing surrounding land uses, the respondent claimed that an eight-foot masonry wall was “…not as easy to climb as chain-link” and “…in a neighborhood, it [a masonry wall] is better to look at and more secure” (Respondent M1). In reference to the respondent’s particular municipality, Respondent M3 claimed that “…masonry walls are not required for gas well pad sites. I do not think that walls add to the aesthetics.”

One respondent discussed the implementation of Arlington’s recently approved tiered landscape system for the screening of the sites and stated that “…if you are in an industrial area and a gas well is considered an industrial use, you don’t have to put a wall around it” (Respondent IR6).

#### 4.4.3.3 Fencing

Regarding interim remediation efforts, respondents brought up chain-link fencing, wrought iron fences, or wooden fencing as a means to provide a security buffer around the site and to screen the site from view. As a means of containment, one respondent stated that "…a lot of places, development and surface development included, utilize black chain-link fence or wrought iron… considerably cheaper than masonry" (Respondent IR1). Another respondent mentioned the use of fencing with "…a monochromatic color scheme, to try to blend it into the surroundings" (Respondent M3).

Within the fencing theme, one respondent noted that "…either wrought iron or black or green chain-link fence" is required for security measures. The City of Fort Worth's gas well ordinance was influenced by the local department of public safety and the recommendation was made to allow "…a patrolman to drive-by and look into the pad site" (Respondent IR1).

#### 4.4.3.4 Noise

While discussing remediation standards, noise was mentioned by several respondents, one of whom suggested that the operators should "understand that their activities affect the lives of the people that drive the streets, live in the area, and work in the area" (Respondent IR1). Addressing the noise concerns, respondents used statements such as "…there are ways to remediate those ill effects of drilling activity" (Respondent IR1). "The sound curtains and sound walls are up during drilling and fracking, typically" (Respondent M3). Another respondent noted that "…sound wall companies and engineers have designed materials and ways to mitigate that noise to be under a certain decibel level" (Respondent IR1).

*4.4.4 Final Reclamation Standards*

4.4.4.1 Lack of experience

Only a few respondents had actual experience with fully reclaimed sites as few such sites exist in the urban environment. Respondent M4 declared that "…as far as remediation for a pad site when it is done and completed, we don't have a lot of pad sites that have done that… and…there's not really a lot of experience plugging and abandoning wells and remediating pads." While discussing this topic, Respondent M6 exclaimed, "We don't know!" Another respondent remarked, "Nobody has thought about it" (Respondent IR6).

Many municipalities have guidelines in place for future reclamation of entire sites. Respondent M3 declared that "…they (gas well operators) are required to reclaim [a] site as close as possible to the original condition of the property" and later stated, "Whether it is planting trees, restoring prairie habitat, grassland, whatever, they are required to do that." Respondent IR2 declared that "all of that compacted earth, crushed rock, in theory would come out. That is going to be a real problem in the future in my opinion," in regard to the vague space left when a site has "some pretty vegetative screening around it, but inside that you have to restore that per Railroad Commission regs." Another respondent claimed, "I don't think they are thinking that far ahead. They know they want them to be re-forested and restored, but I don't know if they have properly taken into account how that has to happen" (Respondent IR6).

4.4.4.2 Reclamation for future land uses

One theme that was deducted was the future transformation of gas wells into alternate land uses. Respondent M1 stated, "We are going to require that if the well is plugged and the site restored, then it could be anything because that well no longer exists, other than the fact that you cannot develop directly over it." Also, Respondent M1 claimed, "If you cleared the site

and could actually build, then I don't know of any communities that would restrict you from building on that location."

### *4.4.5 Improvements for Future Practices*

#### 4.4.5.1 Planning

In discussing improvements for the site location and remediation processes, many respondents revealed that a greater coordination between operators, developers, and city planners needs to take place. A trend regarding the permanency of these well sites evolved during the discussion of the planning and siting of gas wells. This theme was verified with statements such as "…operators and everyone said that it was just going to be temporary…and…Several decades…20 to 30 years… that is not temporary" (Respondent M1). One respondent claimed that "…it has become such a reactionary process in terms of how we want to regulate things" and that with the coordination of a master plan by the drilling companies and operators then the "city can work that into their own comprehensive plan …so there are no surprises" (Respondent M6). On a more site specific level, respondents suggested that companies "look at existing land-use and proposed land-use" (Respondent IR6) prior to remediating the land.

#### 4.4.5.2 Broader governing body

During conversations about possible future improvements to municipal ordinances, another theme arose; that of the need for some broader governing bodies to regulate standards. Respondents were varied in their opinions of whether it should be a state or regional power. Respondents remarked that it was "…hard for operators to even track the requirements for remediation, much less actually do the remediation" (Respondent IR2). When discussing a regional governing body, Respondent IR2 exclaimed, "NCTCOG does that for almost every

other planning area; why not natural gas?" The same respondent noted that "…no regional body …oversees planning that is tied into the oil and gas industry."

While discussing overall aesthetic regulations, one respondent suggested, "It would be nice if there were some urban drilling guidelines for aesthetics…and [that would] develop a program for how this can be done on a site by site basis. State guidelines for aesthetics around gas wells could be transferred down to the municipalities"(Respondent IR6).

#### 4.4.5.3 Timeframe for reclamation

Another theme that emerged concerned the determination of a time-frame for the reclamation of a site. One respondent stated, "I would rather them [the drilling company] re-drill a site that has already been drilled…If there's already contamination, let's keep it there" (IR2). In support of a delayed landscape installation and site remediation, Respondent IR3 suggested that the gas well operators "…wait until drilling is complete…that way you don't have issues of pipelines coming in and tearing out certain things and not being maintained correctly, just because of the traffic in and out [of the site]."

#### 4.4.5.4 Restoration according to surroundings

During discussions about remediation practices respondents remarked on the need to re-vegetate and remediate sites according to their previous conditions or in accordance with their surrounding conditions. Respondent M2 declared a desire to "…see more natural plants, natural grasses, natural trees, natural shrubs, things that were found there before it was cleared." Another respondent stated, "I think vegetative screening would be so much better than a rigid wall" (Respondent IR6). Respondent M1 admitted to knowing "…several sites that have gotten the alternative (landscape plan) approved because it was a better fit for what that site has."

#### 4.4.5.5 Maintenance

Respondents referred to the need for greater prioritization of the maintenance of the landscapes. Respondent IR6 states, “Maintenance is a huge deal because even if they did all this great work, if they don’t take care of it then it’s just a waste of money.” Another respondent admitted, “We’ve had so many that will plant all of the required plants and they will look decent and then they do nothing but ignore them and they all die” (Respondent IR5).

## 4.5 Summary

This chapter included the analysis and findings regarding the perceptions of selected industry representatives and regulators. Recordings from respondent interviews were transcribed then analyzed according to Taylor and Bogdan’s (1998) grounded theory approach. Interview data collected revealed similar perceptions among stakeholders in the determining factors of site selection, remediation efforts, and suggested improvements for regulations. The priorities of determinants varied among perceptions of site location, remediation efforts, and future practices. Most participants admitted a lack of knowledge and experience with final site reclamation, or did not bring it up during discussion. The following summaries of the themes were derived from the data analysis.

### *4.5.1 Determinants of Site Location*

The primary determinant of locating a gas well site is the availability of natural gas resources below the surface. Through seismic surveys, operators research which areas and units would produce enough natural gas to profit with the current market value. Landmen representing gas well operators check for the availability of land, locating a site that provides enough surface area to conduct all phases of drilling and production and meets the regulations and setbacks of the particular municipality. City regulations, through planning, development, or gas well ordinances, dictate the final location of the pad sites. Permitting processes allow

municipalities to place additional regulations on a site, creating a site specific or performance based plan for the gas well site. Environmental considerations, other than water and air quality, appear to be the least amount of concern regarding industry representatives and regulators. Regulations are put in place to protect wetlands and sensitive environments, but little research has been conducted to determine the impacts of the sites on the landscapes.

### *4.5.2 Determinants of Site Remediation*

In addition to the required landscape and site plans for permit approval, surface reclamation plans are being incorporated by municipalities in preparation for future development of sites after plugging and abandonment. These efforts to plan for the future are a result of trial and error methods made during the last decade and due to an increased awareness that sites should be planned like any other utility or infrastructure. In addition to planning for these sites for the immediate future and the next few years while sites wells are being drilled, the sites have to be planned out for the next twenty-to-thirty years, or their expected lifespan.

Community values provide the structure on which municipalities build their regulations. If property values and screening of sites are the main focus of a community, additional conditions are required to be met by the operators to guarantee approval for permitting. Surface land use agreements reflect the individual values of a landowner and his requirements and stipulations for approval of drilling on his property. As community members and landowners become more educated about possible results and impacts of natural gas drilling, more regulations are likely to be adopted to guarantee proper planning, management, and protection of important elements and values.

### *4.5.3 Site Remediation Standards*

Screening the industrial site from view is the principal goal of community members and surrounding land owners. Industry representatives and regulators confirmed that site

remediation requirements include vegetative screening, masonry walls, and approved fencing, or combination therein. Trees and shrubs are planted in an effort to incorporate the site into the surrounding landscape. Required and approved trees are often regulated by individual municipalities, according to their landscape requirements. The incorporation of regional plant lists and screening standards would aid in the unification of regulations. In an effort to increase the success of remediating the sites a regional planting and screening guidelines would also support native plant restoration that is regionally appropriate.

*4.5.4 Final Reclamation Standards*

A limited amount of sites that have been fully reclaimed exist in the urban environment. Urban drilling has boomed in the last ten years and the average life expectancy of a producing gas well is twenty-to-thirty years. A limited amount of knowledge and experience regarding final reclamation exists, restricting the knowledge of industry representatives and regulators regarding site reclamation. The inclusion of surface reclamation plans into the permitting process is a response to this lack of experience. A large amount of sites have been drilled in urban areas, and despite a minimal amount of examples, industry regulators are planning for the future development of these gas well sites.

*4.5.5 Improvements for Future Practices*

Industry representatives and regulators cite the need for future planning of the gas well sites into the master plan of developments, cities, and the Barnett Shale region overall. Planning the necessary infrastructure, pipelines, and roadways for the well sites reduces excess disturbance of land and establishes more efficient systems. A broader governing body, such as NCTCOG can unify regional industry plans and the information would be available to any planner or developer, encouraging the integration of the sites into the planning process of communities. Time requirements for re-vegetation of a site and construction of walls and fences

vary from city-to-city. Industry representatives and regulators suggest that the landscape and walls or fences not be installed until all wells have been drilled, minimizing the need to replace the landscape and screening elements should a pipeline need to be installed. Restoring the sites according to surrounding landscape characteristics enhances the ability of a well site to blend into the existing landscape. Also, any landscaped site is less of an eyesore if properly maintained, including commercial sites or natural gas well sites.

# CHAPTER 5

# CONCLUSION

## 5.1 Introduction

This chapter includes a discussion of the findings which originated from the open-ended, in-depth interviews regarding the perceptions of selected industry representatives and regulators of the site selection and remediation practices of natural gas well sites. It also reports on how those findings apply to the study's research questions:

1. What are the perceptions of selected industry representatives and municipality regulators of site selection and planning practices for gas well sites?
2. What determines the amount of reclamation that a natural gas well site receives?
3. Do industry representatives and regulators anticipate a need to improve site location, development, and reclamation practices?

This chapter also includes a discussion about the relevance of the study to landscape architecture. It concludes with recommendations for further study.

## 5.2 Perceptions of Selected Industry Representatives and Regulators

During analysis of interview transcripts from the industry representative and regulator categories, themes regarding natural gas exploration and remediation processes arose. This section contained a discussion of conclusions that were drawn from these themes and their association with the research questions. While opinions of the stakeholders were similar, interviewees placed varying emphasis on the determinants used in the selection of natural gas well pad sites and the degree to which remediation efforts were applied.

*What are the perceptions of selected industry representatives and municipality regulators of site selection and planning practices for gas well sites?*

Participants responded similarly when they alluded to the prioritization of site selection based on 1) geologic analysis and availability of land, and 2) importance of city ordinances, including setback requirements from protected uses. From definitive statements such as "…the most driving factor is what happens underground" (Respondent IR3), and a city regulator's statement that "…we generally don't get involved with the actual site selection process other than the approval," (Respondent M5) the importance of these two determinants could be concluded.

Other themes that developed included the regulatory impacts of surrounding land uses, either regarding setbacks or projected remediation requirements, and environmental considerations. Setbacks played a crucial role in the development of gas well sites by limiting sites' proximity to protected uses as defined by each municipality. With limited availability of land within the boundaries of denser communities, the role of city ordinances included monitoring and regulating the ability of operating companies to locate the sites "…wherever they think they can fit them" (Respondent IR3).

*What determines the amount of reclamation that a natural gas well site receives?*

Of all of the themes derived from the interviews and transcripts, the most-mentioned determinant of reclamation efforts is community values. One way that cities protect their community values is through regulations within the development of their specific use permits. Because most municipalities have a specific use permit approval process that a gas well site must pass, the approval process serves as an opportunity for community members to request certain conditions above the required ordinance standards and negotiate for their acceptance and implementation. If community members are outspoken about their demands, then

“operators step it up a notch…and have to do more to satisfy the surrounding land uses” (Respondent IR3).

In addition to community values city ordinances were deemed the primary source of reclamation enforcement, above and beyond the RRC requirements. Industry representatives and regulators also were aware of the importance of city ordinances that demanded certain aesthetic and security standards from the operating companies. From interview data, it was concluded that industry representatives and regulators were aware of an emerging trend of including surface reclamation plans into the amended ordinances. By requiring the development of reclamation plans, the operators and city regulators were preparing for the future reclamation of the gas well sites and how they would be planned regarding their surroundings. Environmental permits were mentioned as another way to require the remediation of sites with the mention of the “U.S. Army Corps of Engineers and their own restoration plan” (Respondent IR2) with any encroachment of a well site into the wetlands.

Surrounding land uses affect the amount of reclamation a site receives because gas well sites are located, planned, and developed according to their proximity to neighboring protected uses and the regulations that each city has in-place. These policies regarding interaction and compliance with surrounding land uses regulate the extent to which a site is remediated with aesthetic and safety elements. Buffer widths, vegetation types, and masonry or screening standards are dictated by the surrounding land use. Through review of the selected municipalities’ gas well ordinances, it is understood that residential land uses demand the highest standards of screening and buffering, followed by commercial development, and industrial land use sites.

*Do industry representatives and regulators anticipate a need to improve site location, development, and reclamation practices?*

Interview data report that there is a great desire to "…choose the most appropriate location…so that we do not see any disruption of day to day activity that would take place in an urban area" (Respondent IR6). Interview participants stated that while the drilling operation is an industrial use, it is not always be possible to situate a gas well site within a city's industrial zone, especially when site location and preferences are determined by geological formations and access to the gas reserves. Respondents agree that appropriate measures have been taken when siting the wells where they will have the least impact. Interview data suggest that some developers are apt to incorporate gas well sites into their master plan if a "…landowner wanted to go ahead and try to develop those minerals before all of this developed around them" (Respondent IR6).

The interview process confirmed that participants are aware of the need for reclamation standards for plugged and abandoned wells. There are a limited number of sites that have been fully reclaimed in the study area, and most are located in more rural areas of municipalities, or their extraterritorial jurisdictions.

The initial emergent theme on this topic was one of lack of experience in final site reclamation and lack of awareness of how pad sites affected the land and surroundings after they were plugged, abandoned, and reclaimed. Respondent IR6 admitted, "I don't think they are thinking that far ahead. They know they want them to be re-forested and restored, but I don't know if they have properly taken into account how that has to happen."

## 5.3 Discussion

By analyzing interviews and presenting the themes, several positions can be proposed regarding the perceptions of industry representatives and regulators concerning site location, remediation efforts, reclamation strategies, and future suggestions for amendments and improvements of current remediation practices. Concepts and theories about these positions are discussed in this section.

Interview data support the idea that industry representatives and regulators have important roles in the location, remediation, and reclamation of gas well sites, especially in the urban condition. When asked about the determinants of site selection, respondents answered quickly, displaying familiarity and strong opinions with the site selection process based on their past experiences.

Regarding determinants for remediation efforts and priorities, community values evolved as the primary factor. Surrounding land uses were seen to play a role in community values because city ordinances that regulate interactions among neighboring land uses were believed to be based on community values. Future amendments of the remediation practices are apt to incorporate more of these community concerns and demands into the regulations instead of requiring additional application and approval of a specific use permit.

The amount of remediation a site receives relies mainly on surrounding land uses, as regulated by each city's gas well ordinance. With implementation of a tiered landscape plan or buffer requirements, cities have mandated the intensity to which buffer requirements are applied, using vegetative screening, masonry walls, chain-link, wrought-iron, or wood fencing. Each municipality addresses the screening issue as per their community values expressed partially through their zoning and development plans.

The recommended time of installation differs among the participants in this study. This suggests a need to determine the most efficient and beneficial time to install remediation procedures. While communities demand that these industrial sites be screened as soon as

possible, operators and consultants suggest that the screening and walls be constructed after all drilling has been completed, minimizing the need to remove newly planted vegetation or constructed screens and walls to provide access for pipelines, pad expansion, or other unanticipated procedures.

Maintenance of sites typically falls on operators during drilling and production on a well site. This is seen as a low priority in comparison to the extraction of natural gas. During drilling, the operator's primary focus is on the procedures associated with the drilling of the wells, the transportation of all equipment and materials, and on the safety and practices of all crew members on site. Little concern is given to the maintenance of the landscape. If landscapes are installed after the drilling and production phases have been completed, more attention could be given to the overall maintenance and success of the landscape.

Interview participants provided insight into the lack of knowledge of how these gas well sites affect future landscapes and habitats in urban environments. Data confirm that industry representatives and regulators are focused on the current appearance of the sites and the remediation of noise, dust, and traffic with minimal focus on what these sites will actually look like in twenty years. Data also suggest that there is minimal preparation for how well sites are to be incorporated into the surrounding environments, whether it is dense urban development or more passive and green uses. Respondent M6 stated that "…it is such a fragmented process…and…it has become such a reactionary process in terms of how we want to regulate things."

During the interviews, respondents expressed interest in strategies for developing a formal regional plan that would integrate the industry as a utility thus including it into regional or municipal master plans. Respondent M6 stated that "…I think the biggest complaint or problem with the industry in itself is the lack of a master plan, not only in Arlington, but in the Barnett Shale." The respondent also stated that "…urbanized areas for decades have been planning long-term in terms of where they want to see certain types of growth or development…Well then

how do we do that in a very efficient and cooperative way?" (Respondent M6). Participants responded excitedly when discussing the future improvements of gas wells and their incorporation into the urban condition, most with a common goal of planning the sites appropriately. Respondent IR5 stated that "…when you look at it [the end result], you wonder how did they get that gas well nestled into that wooded area." To develop the site after reclamation and incorporate it into the surroundings as if a gas well never existed on the site appeared as an emerging consideration among respondents reflecting a change and adaptation within the industry.

While the development of standard industry guidelines is suggested by the respondents, it is important to develop appropriate recommendations that incorporate the qualities and requirements of each site in each unique region. Distinct and regionally specific best development and management practices need to be applied to address the soil conditions, vegetation, wildlife, and sub-biomes of each site. Environmental and landscape issues that face communities in the Cross Timbers and Blackland Prairie in North Texas are not the same as those found in the high desert, the high plains, the Rocky Mountains region, or the Catskills of the Northeast. Regional and site specific studies are recommended in order to develop planning, development, and reclamation standards and provide the greatest reclamation success for each site.

## 5.4 Relevance to the Field of Landscape Architecture

Expanding more than five thousand square miles and including urban areas within the Dallas-Fort Worth region of North Texas, the Barnett Shale has been considered the testing ground for many state-of-the-art technologies and procedures regarding the drilling and production of natural gas. The estimated impact of the Barnett Shale development includes an annual output of $11.1 billion of natural gas and the creation of 100,268 jobs in this region alone (Perryman 2011). By means of this economic impact, landscape architects are employed by

natural gas companies as design consultants to bridge the gap between the industry and public perceptions. As a result of advancing technologies and procedures, an increased presence of natural gas drilling and development has occurred within dense urban areas and municipalities of at least 25 counties, including the four core producing counties of Denton, Johnson, Tarrant, and Wise (RRC 2011). As of 2009, over 10,000 wells have been drilled and an estimated 20,474 wells have been permitted from 1993-2010 (GWPC 2009; RRC 2011). Market prices determine the drilling rates for new gas wells; however, existing gas wells are planned for abandonment and reclamation within the next twenty-to-thirty years, at least.

Landscape architects are employed as consultants for gas operators and energy companies because more cities have amended their ordinances to reflect the demand for remediation regulations. Ordinances are being amended based on the results of trial and error practices. Establishing a role regarding the development and integration of remediation practices, landscape architects provide possibilities for the future development of these industrial sites. Improving aesthetics and the developing these sites provide opportunities to assist in the development of sites with regard to the greater landscape including regional habitats and community fabric. Industry representatives and regulators are moving toward a holistic approach regarding the return of the site back into the surrounding environment, the inclusion of the site into proposed and existing land uses, and the planning of these sites within the urban environment. As a steward of the land and community, a landscape architect has the opportunity to develop the gas well site, knowing that "…just because they are industrial, doesn't mean they have to look industrial" (Respondent IR6).

## 5.5 Recommendations for Further Study

The following recommendations for further study result from questions raised during interviews with industry representatives and regulators. The recommendations provide

opportunities to develop and enhance the natural gas industry and landscape architecture profession.

1. Analyze the unique environmental concerns and constraints associated with each natural gas basin in the United States.
2. Analyze the ecological relationship between the disturbance created by the natural gas well sites and the surrounding vegetation of a selected study site.
3. Develop procedures and standards for determining re-vegetation success on natural gas well sites in Texas.
4. Analyze of the spatial impact of urban drill sites with the use of Geographic Information System instruments.
5. Analyze stormwater runoff for natural gas well sites in an urban area with the use of the Soil and Water Assessment Tool (SWAT).
6. Analyze the impact of a natural gas well site if designed with best management practices and low-impact development guidelines.

## 5.6 Summary

This chapter included a discussion about the perceptions of selected industry representatives and regulators in regard to the developed research questions. From the analysis of interview data, themes regarding natural gas exploration and remediation processes arose. Discussion of the developed themes was also included in the chapter. Through analysis of interview data and drawing conclusions from themes, the relevance of the study to landscape architecture and the natural gas industry and its associated planning and development practices was drawn. Recommendations for further study were extracted from discussions with interview respondents and questions raised during the analysis of data.

# APPENDIX A

## INTERVIEW QUESTIONS

## INTERVIEW QUESTIONS

The following are the questions that will be asked of each interview participant:

1. What determines site selection for a natural gas well in North Texas?

2. What determines the remediation efforts applied to a natural gas well site?

3. Are current regulations appropriate for remediation of sites during natural gas drilling and production?

4. What would you change about current site remediation practices?

It is noted that other questions may arise in the interviews, based on the responses of the interview participants, and that the information will be subject to use in the analysis and conclusion of this research.

APPENDIX B

SAMPLE EMAIL AND PHONE RECRUITMENT SCRIPT

SAMPLE EMAIL AND PHONE RECRUITMENT SCRIPT

Good Morning/Afternoon/Evening,

My name is Sarah Kuehn, a graduate student in the Program in Landscape Architecture at the University of Texas at Arlington. I am currently working on my master's thesis involving the impacts of natural gas exploration on the landscapes and habitats of North Texas. I am interested in the opinions of stakeholders on the current regulations and practices involving site selection and the remediation of sites during natural gas exploration and production.

Would you be willing to participate in this research? The interview is strictly voluntary and your identity will remain anonymous throughout the interview, recording of the interview, analysis of data, and any future discussion of the thesis. I understand the discussion of the topic is directly related to your employment, therefore, discretion will be kept with the utmost importance.

The interview will last approximately one hour and will take place at a site that suits your preference and availability.

I greatly appreciate your time and look forward to hearing from you soon.

Please contact me at (970) 310-8104 or skuehn7@gmail.com.

Thank you,

Sarah Kuehn

APPENDIX C

SAMPLE CONSENT COVERLETTER

SAMPLE CONSENT LETTER

Sarah Kuehn
1801 Scouts Vista #534
Arlington, TX 76006
October xx, 2011

Dear Sir/Madam,

With this letter, I, Sarah Elizabeth Kuehn, would like to verify that your participation in this interview is completely voluntary and of your own account. Your identification will remain entirely anonymous throughout the entire research project, in the results and conclusion, and in any future discussion of this thesis.

The interview session and conversation will take place for approximately one hour, but may have a shorter or longer duration, depending on the ability to cover all necessary questions. The conversations may be recorded with a voice recorder. If you prefer not to be recorded with a tape recorder, please let me know, and I will only take written documentation of the interview. All interview documentation will be transcribed for research analysis and then destroyed to avoid future identification or implication. The transcribed research information must be maintained for three years after the completion of the thesis, as per University of Texas at Arlington requirements.

In advance, I appreciate your participation in the interview and for your contribution to this research. If needed, please feel free to contact me, my faculty advisor, or the IRB chairperson by the following:

Principal Investigator: Sarah Kuehn
Phone: (970)310-8104
Email: skuehn7@gmail.com

Faculty Advisor: Pat D. Taylor, Ph.D., ASLA, FCELA
Phone: (817)272-2801
Email: pdt@uta.edu

Regulatory Services: Robin Dickey, MA
Phone: (817)272-9329
Email: robind@uta.edu

Sincerely,

Sarah Kuehn

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## BIOGRAPHICAL INFORMATION

Sarah Kuehn is a Masters of Landscape Architecture candidate for Fall 2011 and is currently employed by Mycoskie McInnis and Associates, where she is a draftsperson, designer, and planning apprentice. Through her employment with MMA, she has been involved in the gas well permitting process, with first-hand experience in preparing exhibits, tree mitigation plans, and analysis of overall appearance and inventory of gas wells throughout Arlington and surrounding areas. Sarah received her bachelor's degree from Colorado State University in Landscape Horticulture with a design and contracting concentration. Upon graduation, Sarah worked for a Viridis Gardenscapes, a residential design-build firm in Manhattan, Kansas. Previous work experience includes golf course maintenance, sod farm harvesting and maintenance, and an internship with American Civil Constructors in Denver, Colorado. As avid outdoorswoman, Sarah enjoys outdoor activities, including fishing and hunting, all of which contribute to her appreciation for the surrounding landscape, its beauty, value, and importance.