LOCAL GOVERNMENT ROLE IN ENSURING PIPELINE SAFETY

LANDUSE PLANNING, DEVELOPMENT CONTROLS, TRANSPORTATION OF HAZARDOUS MATERIALS

by

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ABSTRACT

This thesis contains an analysis of regulation and public policy relating to transmission pipelines. The federal, state and local governments, along with pipeline companies and construction contractors are responsible for pipeline safety. The paper seeks to ascertain what planning or policy efforts could be intiated by one local government, Fairfax County, Virginia, to enhance the likelihood of pipeline safety in their jurisdiction.

Traditional land use tools, such as setbacks in the Zoning Ordinance, are evaluated, however, it is asserted that alternative measures would be more practical and effective in achieving the local government's goal. The paper introduces proposed alternatives. The proposals include: construction standards which may reduce the probability of rupture of the pipeline; fire access and construction preplanning to attempt to improve response capability; training programs for construction workers to increase awareness of pipeline dangers; lobbying efforts on the part of the local government to affect changes in federal regulations.

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INTRODUCTION

This paper focuses on a local government's planning and policy dilemmas in its attempt to address the issues and dangers of hazardous transmission pipelines.

The paper examines what appears to be a hierarchy of responsibility pertaining to pipeline regulation. Federal, state, and county agencies, pipeline owners and operators, private development companies and their subcontractors, each has a delegated area of responsibility for pipeline safety. The pipeline industry has the status of a national pubic utility. The federal government has the responsibility for regulating the creation and operation of the pipeline. The state government has been delegated the responsibility of regulating construction around the pipeline, presumably because it has more capability to understand and regulate construction in its particular terrain. However, the state delegates some of this responsibility to the local government, in part because of the large amount of time and local expertise required to monitor construction activity.

The local government, in this case Fairfax County, Virginia, can also create construction standards for development near and around the pipeline, but these standards often rely on the knowledge, expertise and cooperation of the pipeline companies to share appropriate information with developers and their subcontractors who may perform the construction work.

When a pipeline accident occurred recently in Fairfax

County, the local government sought to re-examine its role within this hierarchy in order to determine whether additional safeguards could be established within its jurisdiction. The County has directed its efforts through its "traditional" land use control arm, the Zoning Ordinance. This thesis endeavor analyzes the consequences of trying to create local public policy on pipeline safety solely through the Zoning Ordinance. In addition, alternative proposals are suggested which could add safety measures.

CHAPTER I: UNDERSTANDING PIPELINES

As Americans, we have become accustomed to a number of mechanized innovations in our daily lives. Most of us do not have to chop wood for the fireplace in order to stay warm nor do we have to saddle our horse in order to get to town. No, today we have gas forced hot air heating systems to provide us with warmth and automobiles, buses, trucks, and airplanes to transport us and our goods.

There is an underground pipeline system that "crisscrosses" our country to deliver the fuel we need to operate our machinery and modern conveniences. Carrying as much as 50% of our fuel needs, pipelines are the major transporters of energy sources throughout the United States.[1] In addition, the United States Department of Transportation (DOT) has reported that pipelines carry 25% of the total weight of all types of inter-city transported freight. [2] It is well accepted that there exists no other more efficient, or safer, means of transportation of our energy needs for homes, automobiles and businesses.[3]

Many people are familiar with the Alaskan pipeline because of the publicity it received due to its cost, design, and length.[4] The trans-Alaskan pipeline, which is 48 inches in diameter, is mostly above ground, winding through the uninhabited natural forest of rural Alaska for some 800 miles.[5] There are many other pipelines running throughout the United

States,[6] most of which cannot be seen because they are buried underground.[7] These pipelines are not just the small lines which we know travel to houses. Some are as large in diameter as the trans-Alaskan pipeline and travel much, much farther.[8]

The pipelines carry mainly fossil and synthetic fuels but can also carry other chemical products as well.[9] Fossil fuels refer to physical elements which occur in nature and generally are found inside the earth's surface.[10] Synthetic fuels are substances that are man-made, usually in combination with a fossil product, and can be used to produce energy.[11] Generally, fuels are in either a liquid or a gas state.[12] Under certain conditions, liquids can become gases and gases can become liquids.[13] These changes occur when temperatures and pressure applied to the material reach extremes; however, in order to prevent the substance from converting back to its normal state, these external forces must remain at extremes.[14] The liquid or gas states of fuel substances are monitored and regulated while in transit through the pipe.[15]

It is important to note the differences between natural gas and hazardous liquid pipelines. The hazardous liquid pipelines carry a number of different products including: a) low octane unleaded gasoline, b) high octane unleaded gasoline, c) leaded gasoline, d) crude oil, e) jet fuel, f) diesel fuel, g) kerosene and h) heating oil.[16] Natural gas transmission pipelines usually contain 90% pure methane gas only (the other 10% is, in most uses, a tracer element).[17] These types of lines

may have a maximum pressure capacity of more than 1600 psi.[18] The natural gas carried in a transmission line is odorless, colorless, and tasteless.[19]

Pipelines vary in size and diameter.[20] There are different types of pipe for different kinds of fuels. For example, natural gas pipelines are made of plastic while most liquid pipelines are metal.[21] The differences in pipe materials affect the speed at which the substance is moved,[22] and the size of the pipe controls the amount of fuel which is transported within a period of time. The larger the pipe, the more cubic feet or barrels of fuel carried.[23] A barrel is equal to 42 U.S. gallons. When speaking of natural gas, the measurement is in cubic feet.[24]

The pipeline system is made up of a number of different types of lines. The largest of the pipelines is referred to as a trunk line or transmission line.[25] In non-engineering terms, this means that a transmission pipeline, as opposed to a gathering or distribution (main and service) pipeline,[26] is a large diameter pipe that is capable of pumping a gas or liquid product at very high forces and quantities.[27] In contrast, gathering pipelines are usually smaller diameter lines that pump at a lower pressure of 20 to 100 psi.[28] Distribution pipelines are the very small lines, usually carrying natural gas, which connect to homes and businesses and operate at less than 20 psi.[29] As a point of reference, the gas from a stove is usually under about one-fourth (1/4) psi of pressure.[30]

The method of moving fuels through the system is by

pushing them along within the pipe. For liquids, this procedure entails filling the pipe with product, then following it with another product to push the first one through the pipe.[31] (See Appendix 1.) The physics behind the working of the system is complex but it is important to emphasize that fluids in conduits vary in pressure and speed depending on a number of factors, including: a) type of product, b) distance to be carried, c) alignment of pipe, d) gravitational forces, e) diameter of pipe, and f) resistance of opposing object.[32] In order to maintain the flow of the product, boosters called pump stations are located along the line.[33] The pump stations also monitor pressure drops and adjust pressure for unloading the product at different destinations.[34] In contrast, the pressures needed to move natural gas through a pipe are much greater than those needed for liquids.[35] Generally, the Maximum Allowable Operating Pressure (MAOP) for liquid lines can range anywhere from 600 to 800 psi.[36] Due to the richness[37] of liquid products, a leak from this type of a line is less likely to cause a fire or an explosion than a natural gas leak.[38]

Natural gas pipelines work on a principle of compressing the gas to move it through the pipe.[39] This is accomplished by the placement of compression stations along the pipeline. The gas is cooled for transportation in the pipe, then warmed and odorized at its destination.[40] Usually, moisture vapor forms in the gas, so heaters are used at the destination to keep the moisture from freezing.[41] Also, separators are utilized to

remove compressor oil out of the gas. Unlike pure gasoline,[42] methane can be burned in its natural state and is highly combustible.[43]

The pipeline industry itself is a vast operation of many companies involved in transporting fuel. Today, there are more than 239,000 million miles of natural gas[44] and 277,620 miles of liquid[45] transmission pipelines. These figures translate into more than 292 trillion cubic feet of natural gas[46] and 571 billion tons of liquids[47] moving annually through the country. The majority of natural gas is moved by pipeline,[48] whereas pipelines transport 46 percent of all crude oil and refined products.[49] The liquid pipeline operators generally ship nationwide, which is referred to as "interstate."[50] The local companies that operate only within a state are referred to as "intrastate" pipelines.[51] No matter what designation is given, these lines are located everywhere throughout the community, from the distribution lines which connect to private dwellings[52] to the transmission lines which cut through counties and cities.[53] The reason behind the paths of pipeline will be discussed in another chapter, but it should be noted that many pipeline companies have the powers of eminent domain to clear whatever path is needed because they are viewed as a national common carrier.[54]

The large transmission lines (like the trans-Alaskan pipeline[55]) are one almost continuous piece of welded pipe.[56] The pipe, except for compression stations and city gates for

gas[57] and pump stations and tank farms for liquid,[58] is completely buried underground[59] in easements referred to as right-of-ways.[60] The pipeline companies secure these easements from private landowners, local, state, and/or federal authorities.[61] Securing the easement can be a lengthy, and sometimes frustrating, process. The operator must rent or purchase the right to cross through a property owner's parcel or lot.[62] Frustration may arise when an owner is reluctant to sign away a very large strip, generally 25 to 100 feet wide,[63] of land for the pipeline company to dig up.[64] The landowner may see this as not only a disruption, because of the construction process, but also as a loss in land value because the easement, and any future use of or in it, is in the sole control of the pipeline company.[65] This portion of land is lost for development purposes.[66] Also, there may be concern for the environmental impact of the ditching, especially in respect to stream valleys, vegetation, trees, and crops.[67] If an owner's reluctance becomes an impediment, then the pipeline operators can utilize the power of eminent domain to force the owner into providing the right-of-way.[68] Monitoring and maintaining the easement is an important factor in preventing pipeline ruptures.[69]

There is one fact that is clear: no matter if the pipelines are hidden underground, they are still extremely dangerous, and safety measures to secure the easement are crucial. Measures to prevent malfunctions are also necessary.[70] The National Transportation Safety Board (NTSB) conducted a

study in 1973 which showed that most of the "failures"[71] of pipelines were due to outside forces.[72] In 1983, DOT reported that there were 1,741 pipeline failures nationwide.[73] After 1983, federal reporting guidelines were changed, and fewer failures are required now to be reported.[74] Nevertheless, the types and extent of damage from pipeline failures can be fatal.

In 1976, a gasoline pipeline in California was ruptured when workers on a road widening project hit the pipe with excavation equipment. A hole two and one-half inches by five inches was punctured in the pipe.[75] A spray of gasoline drenched the street, the pedestrians, and the buildings across the street from the hit. A dense vapor cloud, so thick that it was difficult to see, formed around the area. About one and one-half minutes after the rupture, the gasoline ignited. The street and the sprayed buildings became a ball of fire. Nine persons were killed, 14 persons were injured, seven buildings and fifteen vehicles were destroyed. The cause of the ignition of the gasoline is unclear, but it is believed to have been caused by a truck engine.

In 1979, in Pennsylvania, a man who was in the basement of an office building lit his cigarette creating an explosion which killed him from fatal burns.[76] Six corrosion-caused leaks and a leaking clamp from the gas line connected to the building were discovered. It was speculated that the gas entered the basement by travelling through the ground and entering a drain hole.

In 1980, in Louisiana, a fracture crack in the weld of a crude oil pipeline leaked.[77] The oil seeped underneath a house and was ignited by a gas hot water heater. The fire fatally burned one person, injured another, and destroyed six homes. The cause of the leak was attributed to an imperfection in the base material of the steel pipe.

In 1980, in California, a pipeline which had been operating under too much pressure burst, puncturing a hole in the pavement above and jettisoning naphtha 20 feet into the air.[78] For unknown reasons the spray ignited, shooting flames 70 feet into the air. Five persons were injured, 12 houses were destroyed or damaged, and 11 vehicles were destroyed. The cause of the rupture was determined to be internal corrosion.

In 1983, in Texas, while constructing a housing subdivision development, a drilling rig putting in holes to plant trees struck a liquified petroleum gas (LPG) pipeline.[79] The drill struck and damaged the pipe a number of times, thus thinning the pipewall which, operating under great pressure, ruptured. A pool of petroleum 50 yards in diameter formed and within three minutes exploded. Six persons were killed, and three homes, two trucks, and two cars were destroyed. It was speculated that either a hot water heater, gasoline engine, or electrical switch caused the explosion.

In 1985, and again in 1986, in Kentucky, natural gas pipelines, owned by the same company, ruptured.[80] The 1985 rupture created a crater 90 feet long by 38 feet wide by 12 feet

deep. The gas was ignited and burned an area 700 feet by 500 feet. Five persons were killed, three persons were injured, and five homes and nine pieces of construction equipment were destroyed. The 1986 rupture blasted 480 feet of pipe out of the ground and ignited, injuring three persons and destroying three homes and six vehicles. The cause of the 1985 ruptures has been attributed to undetected corrosion; however, the cause of the 1986 rupture was placed on the company's failure to replace previously detected corroding pipe.

CHAPTER II: REGULATORY OVERSIGHT - NATIONAL

Unequivocally, there is a clear and definite need for protecting and monitoring pipelines. There exists a wealth of technical rules and a multiagency umbrella of federal regulatory oversight relating to pipeline safety. These rules govern the materials used in manufacturing the pipe, construction of the pipeline, safety protections for workers, and inspections of the easements to protect nearby inhabitants and the environment. Federal agencies are concerned with oil industry issues such as operating pipelines, financing projects, constructing the line, transporting products, charging customers, protecting the environment, guarding technology, policing the pipe, protecting land development, analyzing regulations, investigating incidents, and responding to leaks or accidents. In addition, the industry itself is a lead participant in researching and developing pipeline protections and safeguards.

The U.S. Department of Transportation is the primary federal safety overseer of all interstate, and many intrastate, hazardous liquid and natural gas transmission pipelines.[81] DOT regulations establish pipe specifications, pressure capacities, class locations, protective coatings, inspection methods, and accident prevention procedures.[82] The Office of Pipeline Safety, DOT, ensures that all rules are followed precisely and is the only agency that can set interstate transmission pipeline standards relating to the pipe itself, its construction or

repair.[83] It should be noted, however, that the pipeline easements are within the purview of the private pipeline operators, and not DOT; therefore, local jurisdictions may regulate non-pipeline related land development which encroaches on, or crosses through, these easements.

Due to the nature and the quantity of the fuel being transported by pipelines, the federal regulations begin with standards for the pipe itself.[84] It should be noted that the standards vary depending upon whether the product to be carried by the pipe will be liquid, gas, or other substance states. In order to withstand extremely high pressures and continuously flowing volumes, the pipe must be built with specific materials[85] of certain thicknesses[86] and construction specifications.[87] In addition, standards are set for the method of transporting,[88] welding,[89] pressure testing[90] and inspecting[91] the pipe. Augmenting these rigorous standards, and to prevent corrosion, the pipe is coated,[92] then covered with a "cathodic" cover[93] and, sometimes, encased. A cathodic coating is a protective layer placed over the pipe which protects against external corrosion. In order to keep from losing any of the protective qualities, a light electrical charge is continuously run through the cathodic coating. However, if the coating is damaged or ripped, corrosion of the pipe can occur at a much faster rate than if there were no coating at all.[94]

The construction of the pipeline itself is also regulated by DOT.[95] This construction or "spreading"[96] of the pipeline is

"one of the toughest, fastest, most exciting construction jobs in the twentieth century."[97] In brief, the process entails clearing and grading the right-of-way,[98] digging the ditch,[99] laying out the pipe,[100] lowering the pipe,[101] backfilling (burying) and cleaning up.[102] Along with the regulations promulgated by DOT, the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor (DOL) and the Office of Pipeline and Producer Regulation of the Federal Energy Regulatory Commission (FERC), Department of Energy (DOE), specify procedures for protecting construction workers and reducing the impact on the environment, respectively. OSHA has established general rules for protecting workers who are engaged in site clearing, welding, trenching, and excavation activities.[103] Currently, although not as stringent as they once were, OSHA regulations require safety protections for workers around pipelines. However, newly proposed OSHA regulations would require hand digging of trenches, proper support of the pipe, safeguards against erosion, and minimization of other negative effects.[104] The Office of Pipeline and Producer Regulation (OPPR) analyzes the impact of the excavation, for the pipe, on the surrounding lands.[105] Under the National Environmental Policy Act (NEPA), FERC requires that any natural gas pipeline company's proposal for a new line contain an Environmental Impact Statement assessing the topography, physiography, geology, soils, geological hazards, species and ecosystems, biotic resources, hydrology and land uses.

There are numerous other regulations which safeguard the pipes, the pipeline construction workers, and the surrounding environment. OSHA regulations call for weld, pipe, valve and storage tank protections.[106] The Transportation Research Board (TRB) analyzes policy relating to pipeline safety. NTSB, which is an independent federal authority and not part of DOT, has the responsibility of investigating pipeline ruptures. However, NTSB has no regulatory function; only DOT can regulate pipeline companies and pipeline operation.[107] The U.S. Department of Housing and Urban Development (HUD) rules require developers of HUD-funded projects to be set back at least ten feet from the pipeline easement and secure certification from the pipeline company that the pipe meets all DOT specifications.[108]

Considering the possibility of future negative impacts of the pipeline on surrounding areas, DOT has a wealth of rules and standards. DOT requires an evaluation of the area within 220 yards of a natural gas pipe.[109] It should be noted that this requirement does not apply to liquid pipelines. Also for natural gas pipelines, the type of pipe, pipe cover, pipe coating, pipe thickness, pipe weld, and pipe pressure are determined and varied by what are called class locations.[110] Class locations vary with the number and type of buildings intended for human occupancy within a 220-yard area. The "220" yards is measured on both sides of the pipe, so in effect it is actually a 440-yard area.[111] The more densely populated the class location, the more stringent the requirement for operation

of the pipeline. For example, Class Location 1, ten or fewer buildings, requires the pipe to be buried 30 inches below ground level; whereas, Class Location 2, ten to 46 buildings, requires the pipe to be buried 36 inches below ground level.[112]

For protection purposes, DOT regulates pipe materials and requires a cathodic coating of both liquid and natural gas pipelines.[113] The pipe's design, materials, welds, and valves must meet different tests for strength, temperature, and pressure.[114] The pipes, whether steel, aluminum, copper or plastic, must be cathodically coated and the electrical charges must be monitored.[115] Although the class location requirements do not apply to liquid pipelines, DOT does require that a liquid pipeline be located no closer than 50 feet to an existing dwelling.[116] FERC also has established a review criterion which calls for a setback standard that no natural gas pipe be located within 50 feet of any building or dwelling.[117]

Under guidelines established by the Natural Gas Pipeline Safety Grants-in-Aid Program,[118] states may regulate intrastate natural gas pipeline operators. In essence, this means that states enforce DOT regulations which relate to natural gas pipelines. Currently, there is legislation which would also delegate liquid pipeline regulation to states, but there has been no funding for this program as of yet.[119]

Once the pipe is fully buried and ready for operation, DOT rules guide the procedures for operating the pipeline as well. The pipe must be tested to ensure that no weak points exist.

The test is based on the specified minimum yield strength (SMYS) of the pipe.[120] In simple terms, this is a measure of how much pressure a pipe can withstand. For transmission pipelines, the test is for pipes that will be operating at very high pressures.[121] A pressure is established as the MAOP for the pipe.[122]

The pipe system is also controlled by DOT regulations. The pump stations, which are placed at points to keep the flow steady, must meet high standards.[123] The valving systems, which ensure relief of extra pressure, are located at specified spaced distances along the pipeline.[124] Liquid pipelines include tank farms for storing and relieving excess product in the pipe.[125] Gathering and distribution lines must also be checked for leaks or problems.[126]

Observing and double-checking the pipeline and easement for leaks and problems is carried out by the pipeline companies as mandated by DOT.[127] The methods of observation include aerial reconnaissance,[128] line walks,[129] and both pressure[130] and security[131] checks. These safety requirements are enhanced by the following requirements: a) an emergency procedures manual must be kept on site at all pumping stations, and personnel must be fully trained in these procedures;[132] b) training in fire safety and handling of equipment must be conducted with all employees;[133] c) local fire departments must tour the facilities to familiarize themselves with emergency operations;[134] d) all employee operators must know proper shut-down procedures if

leaks are detected;[135] and e) a 24 hour per day crew must be on standby at all times.

In addition to the federal regulatory authorities which have been presented, there is a vast network of agencies and organizations participating in furthering pipeline safety covers a broad spectrum of issues, from technology to policy. The American Petroleum Institute and American Gas Association serve as leaders in technological advancements,[136] as well as public policy formation and research centers.[137] The Response Team of the National Oil and Hazardous Substances Contingency Plan has prepared guidelines for responding to spills of toxic and dangerous substances.[138] The National Research Council has coordinated a number of studies of pipeline safety.[139] The U.S. General Accounting Office sponsored one of the most in-depth assessments to date of the federal role in pipeline safety.[140] The Environmental Protection Agency, through the newly enacted "Title III" law, establishes emergency planning procedures in communities throughout the country.[141] Also noteworthy is that presently, Congress is considering adding new standards to the federal regulations such as a state-wide one-call program requirement and a rule directing operators to give to state corporation commissions a list of all products carried and maps of the entire pipe system.[142] Other agencies[143] involved in pipeline regulation include: 1) the National Association of Regulatory Utility Commissioners;[144] 2) United States House of Representatives, Committee on Energy and Commerce, Subcommittee

on Fossil and Synthetic Fuels;[145] 3) Technical Hazardous Liquid Pipeline Safety Standards Committee;[146] 4) Interstate Natural Gas Association of America;[147] 5) Council on Environmental Quality;[148] 6) Federal Emergency Management Agency;[149] 7) Toxic Chemical Safety and Health Project of the Environmental Policy Institute;[150] 8) National Emergency Management Institute;[151] 9) U.S. Army Corp of Engineers;[152] and, 10) Intestate Oil Compact Commission.[153]

As detailed above, policies and regulations created by national organizations or federal agencies are concentrated in two main areas: A) controlling the pipeline industry or B) protecting the environment when laying a pipeline. It is striking that no input, except on a limited basis,[154] is given to or received from the local level. This is an enigma when one considers that the federal rules apply only to construction and operation of the pipeline but not protection of the easement. Third party construction in and around the easement is, it appears, under the sole jurisdiction of state and local authorities once the line has been laid.

CHAPTER III: REGULATORY OVERSIGHT - LOCAL

As noted in the previous chapter, after the pipeline operator has laid the line and buried the pipe, any non-pipeline work being done in the easement falls under the jurisdiction of local authorities.[155] This means, for example, that if a private contractor is constructing a building and to access the building must install a road across the easement, the contractor must obtain approval from the owner of the easement, in this case a pipeline company, and in the subject jurisdiction, also must obtain permits to commence construction. Questions arise about the easement. First, how does one know the pipe is there if it is buried underground? If it is buried so deep, then how could it ever be bothered? Is the easement line marked so one can see where the boundaries are, or is it similar to property lines between homes, which can be seen only on a lot diagram but not on the actual ground? If this is an interstate pipeline, do the jurisdictional rules governing the easement vary from state to state? If it is an intrastate line, do the jurisdictional rules vary from town to town? Are not all the federal regulations sufficient to protect the pipeline and the easement? This chapter will focus on one particular jurisdiction's history with regard to the above questions. The jurisdiction is the County of Fairfax in the Commonwealth of Virginia. (See Appendix 2.)

Fairfax County is a suburban/rural county located southwest of Washington, D.C. The population of the County is

close to 700,000.[156] The total land area of the County is 399 square miles.[157] Like many suburban communities, Fairfax County is experiencing the development of rural areas into residential subdivisions, office parks, and industrial centers.[158] This development activity is sometimes near or in pipeline easements. This has led to tragic consequences, although not all accidents have been directly related to development activity.

On March 24, 1972, a private contractor who was doing work for the County hit a two-inch natural gas distribution line with his backhoe.[159] At the time, the line was being operated at only 22 psi pressure. After the damage, the gas company, but not the fire department, was called. Of all of the persons who smelled the gas, only one resident called the gas company. The gas company workers could neither clamp or shut off the gas line. About an hour and ten minutes after the rupture, the first of three houses exploded. One of the contractor's employees and a gas company worker attempted to evacuate the house next door to the explosion, but it also exploded, as well as the house next to it. Ironically, the only resident to call the gas company, and her two children, were fatally injured. Additionally, an employee of the contractor was seriously burned.[160]

On June 9, 1974, due to a manufacturer's defect, a 30" diameter Transcontinental Gas Pipe Line Corporation natural gas transmission line ruptured in Bealeton, Virginia.[161] Flames were seen by airline pilots 100 miles away and reported to be two to

three miles high. An area 700 feet long by 400 feet wide was totally incinerated, a hole was blasted in the ground, 118-feet long by 37-feet wide by 7-feet deep. Shrapnel shot as far as 300 feet. A Fauquier County fire fighter reported that the ground (dirt) was so hot one half mile away from the blaze that water had to be put into fire fighters' boots to keep their feet cool. The noise of the gas escaping, under 718-psi pressure, could be heard over one mile away. In addition, because of excess gas still remaining in the line, the pipe burned for 1-1/2 hours after its complete shutdown. Since the rupture occurred in an open field, there were no injuries; however, if the rupture had been near a densely populated area, then it would have caused a major catastrophe.

On March 6, 1980, due to the failure of pre-existing defects, the 32-inch Colonial Pipeline Company transmission line ruptured in Manassas, Virginia, releasing 33,000 gallons of aviation-grade kerosene at two locations.[162] The kerosene flowed into a ditch and then, via a tributary, to Bull Run River, and finally gushed into the Occoquan Reservoir, killing thousands of fish and game as well as polluting a source of drinking water for Northern Virginia. The hole in the pipe, which measured 10 feet, 10 inches long, was due to a 1,100-feet per second pressure back surge caused by the improper shut-down of the pipeline. Since being laid in 1963, the Manassas leak was the first and only such rupture of this kind in Colonial's 32-inch diameter pipeline, which is 1500 miles long. On October 13,

1983, gas escaped from a valve at a gas company facility in Herndon, Virginia, while a gas company crew was conducting an inspection.[163] The foreman, after not being able to shut off the gas, evacuated the building but then re-entered the facility to try again to close the valves. The gas exploded, fatally injured the foreman, burned two crew workers, and damaged neighboring residences. Although the cause of the explosion was never determined, it was speculated that the vent fan, electric lights, electrical switch, hot water heater, gas furnace, or gas air conditioning could have ignited the gas. The cause of the gas leak was the incorrect shut-down of an incoming gas line prior to the inspection of the valves. The gas in the pipe was at 300 psi pressure.

There are five (5) operators of transmission pipelines in the County; three (3) of these are natural gas,[164] while the other two (2) are hazardous liquid pipelines.[165] (See Appendix 3.)

Though the date of the installation of the first transmission line in Fairfax County is unknown, it is clear that this type of pipeline existed in the County in the 1960's, if not well before that period.[166] During early years, although utilities were supposed to be contacted to locate and mark their lines,[167] it was not until 1973, when the Fairfax County Board of Supervisors adopted Chapter 6B (now Chapter 63 of the Fairfax County Code), Excavation and Utility Line Installation, that regulations existed that specifically govern construction work

in or near utility line easements.[168] These requirements were created as a result of the Board's concern about safety during construction activity, which was heightened by the aforementioned tragic accident in Annandale in 1972. Due to this tragedy, the County initiated a policy of mandating safety requirements when doing any excavation work near an underground utility line.

The Excavation and Utility Line Installation Code includes requirements that a contractor notify all operators of utilities in the area to be excavated in order to locate and mark the existing lines. Private property owners doing work that does not require a building permit are exempt. The Code further specifies that the telephone numbers of all utility companies must be clearly shown on the site, subdivision or engineering plans. When excavation approaches a utility line, the line must be hand dug before any other actions take place, so that its exact location is exposed. If a new gas line is installed, an "alert" marker, which is a three (3) inch wide metal strip with reinforced tape, must be placed 12 to 18 inches above the line. Also, new gas service lines[169] must have an outside shut-off valve. In addition, a communication system (command station), approved by the Chief of the Fire and Rescue Department, must be on-site at all times. All contractors must immediately notify the County's Emergency Operations Center (EOC) and the pipeline operator of any damage. Operators of pipelines must maintain an emergency response crew on a 24-hour basis.

Finally, except for transmission pipelines, the Fire and Rescue squads must be trained to shut-off gas lines.

Since the time of the Annandale tragedy, Fairfax County has been a member of the Metropolitan Area One-Call[170] utility locating service, MISS UTILITY.[171] In Fairfax, a contractor needs only to call one telephone number in order to have all utility companies notified that excavation near their lines is planned. MISS UTILITY, which is a private service paid for by the utility operators, will locate lines during construction but not for the drawing of site plans. For site plans, a utility locating service company must be contacted to dig test pits.[172] Also, as a result of the Annandale incident, the County created a policy which calls for representatives of utility companies to be present at pre-construction meetings, and each company receives a copy of the final approved plans for a site.

After the 1980 Manassas incident, the Board of Supervisors directed its staff to draft amendments to both the Comprehensive Plan and the Zoning Ordinance regarding pipelines.[173] After a lengthy review process, the recommended changes in the Comprehensive Plan were adopted,[174] but the amendments to the Zoning Ordinance were deferred until "further research could be completed."[175] The Environment section (of the Introduction/Countywide section) of the Comprehensive Plan contains language describing the dangers of transmission pipelines:

> "The transportation of natural and other gas and petroleum products and other hazardous liquids through the County in high pressure pipelines presents a

> potential danger to human life and to the natural environment despite rigid federal safety regulations. The County is concerned for the safety of its residents, labor force and visitors, and protection of the environment as may be endangered by the presence of these pipelines and has adopted guidelines for the location of new pipelines and the separation of new development from existing pipelines."[176]

The Comprehensive Plan further defines and delineates the County's environmental policy regarding pipelines by listing the goals of the policy as

> 1. "Ensure maximum human safety and environmental protection by excluding insofar as is feasible, new natural and other gas, petroleum product and other hazardous liquid transmission pipelines from developed areas, including places of public assembly, heavy employment concentrations and high-density residential development, and from areas of environmental sensitivity.
>
> 2. Minimize disturbance of environmental quality corridors (EQCs) by, for example
> - avoiding the siting of transmission pipelines parallel to streams;
> - attempting to cross EQCs at a 90 degree angle or as close as possible to such an angle;
> - siting the line to avoid the disturbance of steep slopes next to streams;
> - implementing sedimentation and erosion controls during construction;
> - limiting off-road vehicle use of the right-of-way by anyone other than maintenance personnel; and
> - limiting tree clearing on the right-of-way to only that necessary for safety and proper maintenance of the line.
>
> 3. Encourage the siting or clustering of all new structures on any property, any portion of which is within 220 yards of a transmission pipeline, at the maximum

> feasible distance from the pipeline consistent with natural constraints, parcel size, property holding and other man-made constraints.
>
> 4. A natural and other gas transmission pipeline means a pipeline other than a gathering line that (a) transports gas from a gathering line as storage facility to a distribution line or storage facility; (b) operates at a hoop stress of 20 percent or more of specified minimum yield strength, or (c) transports gas within a storage field. A petroleum or other hazardous liquid transmission pipeline means all parts of a carrier's physical facilities through which commodities move in transportation including, but not limited to, line pipe, valves, and other appurtenances connected to line pipe, pumping units, fabricated assemblies associated with pumping units, metering and delivery stations, and fabricated assemblies therein and carrier-controlled breakout tankage."[177]

The Fairfax County Office of Comprehensive Planning attempts to implement the policy articulated in the above-referenced discussion in cases of rezonings[178] and "special exceptions."[179] In addition, new transmission pipelines require approval of the County government.

The Department of Environmental Management (DEM), the County's building and construction review and inspection agency, invites pipeline operators to its pre-construction meetings with builders who plan excavation near existing utility lines. DEM staff also participates in Fairfax's Hazardous Material Core Group, which is reviewing both emergency preparedness planning and environmental issues related to toxic materials including pipelines.[180] In addition, in a joint effort with the Virginia

Occupational Safety and Health Administration (VOSHA) and the Heavy Construction Contractors Association (HCCA), DEM is training private contractors to be sensitive to the complex technical aspects of excavations in pipeline easements. Thus far, DEM has trained over 3,000 private contractors in pipeline excavation work.

As well as maintaining a direct telephone line with each transmission pipeline company, Fire and Rescue Department staff has established a liaison with personnel from all hazardous liquid and natural gas operators to study and pre-plan emergency procedures for each individual pipe. The Hazardous Materials Unit of the Fire and Rescue Department is staffed by well skilled experts in the management of toxic substance spills and fires, including those involving petroleum and natural gas products. Fire and Rescue personnel are also members of the Hazardous Material Core Group. Additionally, the Fire and Rescue Department maintains a close working relationship with other Metro area fire services, which are prepared to offer support in any needed situation, an offer which is reciprocated by Fairfax County. In addition, the Dulles International Airport fire unit not only has a direct line with Fairfax, but also monitors Northern Virginia fire department radio calls.

The Department of Public Works (DPW), which constructs and maintains County owned utility lines, keeps current on all developments in the utility pipeline construction industry. DPW has two (2) staff members who participate in the Northern

Virginia Utility Committee (NVUC).[181] NVUC not only serves as a problem-solving forum for line operators, it is also an effective way of keeping local jurisdictions and operators up-to-date on new line installations and aware of new technological advancements in the industry as a whole.

HCCA is the local trade association for construction contractors and is involved in numerous pipeline safety projects including membership on the Northern Virginia Utility Committee and the MISS UTILITY Liaison Group. The latter has formed a subcommittee which will review possible strategies for convincing the State Legislature that the state-wide requirements for contacting utilities may need to be strengthened. Although it does require that a contractor notify all utilities prior to excavation, the Commonwealth of Virginia currently has no One-Call requirement.

The State Water Control Board (SWCB), through the Underground Safety Act of 1968,[182] has the authority in Virginia to monitor storage and transportation of hazardous substances which may affect groundwater or surface water. Petroleum and gas pipelines fall into this category. Additionally, the SWCB is responsible for developing water resource conservation and protection policies.

CHAPTER IV: THE PIPELINE INCIDENT

There is an umbrella of federal and state regulations relating to pipeline safety. However, the Fairfax County legislative body saw a need to enact further guidelines and procedures to ensure that underground utilities, including natural gas and hazardous liquids pipelines, are protected. It can be argued that the County was not only a leader in establishing such stringent local safety policies,[183] but that it had the best possible oversight mechanisms that could greatly minimize the risk of damage to the pipe.[184] The assurances of such extensive requirements were believed by the legislators to almost invisibly shield the pipe from harm: hand-digging to determine the location of the pipe; a one-call notifying system; no blasting allowed in the easement; training in shut-off procedures; locating services; training in work around lines; attending pre-construction meetings; indicating utilities on development plans; displaying telephone numbers for all utilities on development plans; notifying operators of work schedule; permanently marking the line; verifying rough grading by the operator; examining all plans by contractors; properly supporting exposed lines; maintaining 24-hour emergency response crews; and, imprisoning and/or fining violators.[185] It can be submitted that if the Fairfax County Board of Supervisors did not believe that this was the best regulation possible (Chapter 63, Fairfax County Code) it would have enacted more regulations. The Board states in the Code that the regulations are "for use

in the effective prevention of construction-related accidents...."[186]

With all these County Code provisions, and with the state and federal regulations in place, in 1987, at a subdivision development in Fairfax County, damage caused by a third party occurred to a transmission pipeline.[187] The accident itself and the immediate aftermath were life-threatening.[188] Other damage from the accident was also extensive.[189] In addition, long-term impacts may be foreseen from this damage. A valid question may be asked about this accident: how could such an event happen, especially in a jurisdiction where the "apex" of pipeline safeguards were in place?[190]

The subdivision development was being constructed by a national builder, U.S. Home Corporation.[191] The development was located in the far western region of the County. This area is comprised of very large rural lots, sparsely populated regions, and large vacant parcels of land.[192] The Comprehensive Plan calls for this area to be built with varying styles of housing stock, including moderately-priced housing.[193] With this goal in mind, the developer applied for, and received, approval of a development plan that included townhouses of 16-foot width and quadruplexes.[194] In Fairfax County, these housing types are usually necessary in order for the units to be moderately priced.[195] The U.S. Home development would total 660 units. The subdivision was to be part of a larger development which includes developments by a number of other firms.[196]

In the staff report analyzing the development proposal, which was submitted by the Office of Comprehensive Planning to the Planning Commission and the Board of Supervisors in 1984, two references were made to the existence of a pipeline.[197] The first served to identify the location of development by stating its relationship to the pipeline: "...located east of Centreville Road abutting the...pipeline."[198] However, the second reference was a stipulation that the development would have a "...50 to 60 foot building (structure) setback from the pipeline easement...."[199] A "setback," which is undefined in the Fairfax County Zoning Ordinance,[200] is a margin of spacing placed between a structure and a physical feature of some kind. Probably the most typical "setback" is for buildings from the street. The Fairfax County Zoning Ordinance refers to these as "minimum yard requirements."[201] The staff report continued by noting that "[t]he guideline for setbacks from such easements is 35 feet."[202] It should be noted that the setback proposed for developments and the staff's guidelines for setbacks vary depending on the company submitting a proposal and/or the staff person reviewing it.[203] There are no written or uniform guidelines for setbacks in Fairfax County. Also contained in this staff report was an environmental analysis of the development proposal.[204] The environmental analysis in its entirety was as follows: "There are no significant environmental impacts resulting from this special exception action."[205]

The site plans called for the construction of major transportation and other infrastructure improvements. Much of this work was to cross the pipeline easement, with the operator's permission, including sewer, water, road and trail encroachments or cut-throughs:

> "...Pipeline Company presents no objection to the proposed construction of a 12" DIP water main, [street], 6' unimproved surface trail, 19" x 30" HERCP storm sewer, and 8" sanitary sewer crossing its 32" & 36" petroleum products pipelines and related easement with minimum vertical clearances and reinforced concrete slabs as shown on...[the] drawing."[206]

The developer and pipeline operator entered into a contractual agreement about the type, timing, and extent of construction activities that could be conducted in the easement, as well specifying notification to the operator:

> "1. Notify...at least 48 hours prior to construction, subsequent maintenance or repair, so Colonial may provide a representative at the site. Notify the undersigned...if...cannot be reached.
>
> 2. The unimproved surface trail shall maintain a minimum vertical separation of 3.0' between finished surface and top of pipe for the full with [sic] of Colonial's easement.
>
> 3. Concrete slab protection is to be installed under Singleton way [sic] street per Colonial's drawing 1-TP-4a attached.
>
> 4. Removal or relocation of Colonial's pipeline markers shall not be permitted without the approval of a Colonial representative.
>
> 5. All underground utilities i.e. pipe

storm drains, sewers, water lines, natural gas lines, electric and telephone cables shall maintain a minimum vertical clearance of 2.0 feet over or under Colonial's 32" & 36" pipelines for the full width of Colonial's easement.

6. Trees are not permitted on Colonial's right of way.

7. No mechanized ditching shall be allowed within five (5) feet of the extremities of the 32" & 36" pipelines.

8. Test holes are required to determine the exact location and elevation of the pipelines. Notify...(per Item 1) so that...may provide a representative at the site.

9. Stockpiling of spoilage or top soil over the pipelines is not permitted.

10. Blasting near the pipelines shall not be permitted without the approval of a Colonial representative as to time and method.

11. Temporary equipment crossings over the pipelines are permitted with five (5) vertical feet of cover at selected locations as approved by Colonial's field representative. Colored strips of plastic shall be placed under the temporary fill at original grade so that original grade will not be disturbed when temporary fill is removed. No equipment or vehicles may be parked over the pipelines.

12. Permanent structures are not permitted on the easement. Manholes, junction boxes, valve boxes, fire hydrants, service meters, storm drain inlets, and utility poles are considered permanent structures.

13. Erosion control measures within the easement including diversion dikes, sediment traps, silt fences, gravel

outlets, and emergency spillways will require approval of Colonial's field representative as to equipment and method.

14. No excavation or construction is permitted over Colonial's pipelines or within its easement without a Colonial representative being present. Sub-grading, grading and placement of fill over the pipelines will require the approval of Colonial's field representative as to equipment to be used and method of construction.

15. U. S. HOME CORPORATION, agrees to defend and hold Colonial Pipeline Company harmless from all loss, cost, or other expense, including personal property and bodily injuries, whether occurring to it or to Colonial, or the respective employees, agents and servants of either, or to third parties, which are proximately caused by or arise from the installation, maintenance, or repair of the herein permitted works, with the exception of claims due to the sole negligence of Colonial, provided U. S. Home or its agent perform such maintenance or repair.

16. This approval is granted only to the extent of and with no actual or implied diminishment of Colonial's rights and interests and without either express or implied warranty."[207]

The following summary of the incident that occurred in Centreville, Virginia, will show that although there was clear knowledge that the pipeline ran through the development site, that federal, state, and local laws were in place, and that a contractual agreement existed between the developer and the pipeline owner, collectively these measures were not sufficient to prevent the accident.

Summary of Incident

On the morning of June 11, 1987, a transmission pipeline, located in the Singleton's Grove subdivision in Centreville, Virginia, was ruptured by a ripper attached to a D-9 Caterpillar. An employee of the subcontractor, hired by the developer, was operating the tractor in an easement containing 32-inch and 36-inch pipelines. The pipelines are owned and operated by Colonial Pipeline Company.

Colonial Pipeline Company products are run almost continuously from Texas to New Jersey through lines with diameters from 30 inches to 40 inches and have a maximum capacity of pumping 2,400,000 barrels (100,800,000 gallons) per day. The Colonial system in Fairfax contains two major transmission lines (32-inch and 36-inch diameter pipes) as well as two smaller lines (6-inch and 22-inch), which carry products to Dulles International Airport and a tank farm in Fairfax City. Of Colonial's transmission lines located in the Centreville easement, the 32-inch line was laid in 1963 and the 36-inch line in 1980.

The tractor was being operated with a rock ripper to loosen soil and rock so that the land grade could be brought down to the elevation of previously-installed curb. The ripper struck the 32-inch gasoline line, causing unleaded gasoline to be sprayed up to 150 feet into the air. It would be learned later that the tractor operator claimed he did not know he was

working within the easement.[208]

Colonial reported that, at the time of the rupture, gasoline product was flowing at 190 pounds of pressure, or 13,500 barrels per hour. This would mean that the gasoline was being transported at a flow rate of approximately 567,000 gallons per hour.[209] Colonial also stated that, for operational reasons, the line's pressure had recently been lowered to the 190 psi; therefore, it can be speculated that if the line had been operating at its full capacity, the spill could have been of an even greater magnitude.

Once punctured, the geyser-like plume of gasoline was sprayed into the air in a northeast direction. Due in part to the effects of both wind speed and direction, the location of the hole was also a determinant in the angle of trajectory of the spray. As well as covering asphalt and foliage, gasoline product rained on top of the nearby townhomes. It has been estimated that the plume lasted from 10 to 13 minutes--about the time needed for personnel at Colonial's pump station to identify that product was being lost, and then to carefully and systematically shut down the pipe so as not to create a back surge effect.[210] Colonial estimated that 15,540 gallons of gasoline escaped from the pipeline. This estimation is based on a computer model that simulated the actual pipe conditions at the time of the rupture.

Miraculously, as many federal and local investigators have pointed out,[211] the gasoline did not ignite. The various

possible reasons for non-ignition of the product were the subjects of many hypotheses. First, pure gasoline is not combustible, only the vapors from the liquid can be ignited. At the site of the puncture, the product may have been too pure (rich) to explode. Second, the bulldozer may have been faced in such a direction that the product was spraying away from its diesel engine.[212] Third, the on site telephone, used to call in a report of the rupture, must have been located outside of where vapor clouds were forming.[213] Fourth, at the time of the rupture, although lit cigarettes were in close proximity to the spray, again, either the product was too rich to ignite or the cigarettes were extinguished before dangerous vapors could form. Fifth, the townhomes, serviced completely by electricity, contain no pilot lights which could have triggered an explosion.[214] Sixth, the time of day (9:47 a.m.) was too early for the asphalt to be hot enough to cause combustion. Finally, the only other probable source of fire could have been an automobile, which was driven directly through the spray.[215]

The Fairfax County Fire and Rescue Department was the first County agency to respond to this emergency. The initial call (occurred at 9:52 a.m.) reported a natural gas rupture, which later was changed to leaded gasoline, which changed again to unleaded gasoline. Whether the gasoline was leaded or unleaded would not have affected the response capabilities of the Fire Department. However, this difference would have factored in during the clean-up operations. If it had been

leaded gasoline, all buildings, structures, roads, foliage and soils probably would have been completely removed due to the toxicity of the product.[216]

A Fire and Rescue command post, was established approximately one-quarter mile away from the point of the break,[217] and Fire officials decided not to send in equipment until the pipeline had been shut down. Once the plume ceased, fire personnel and equipment were moved as close as possible to the site of the rupture.[218] Foam trucks from Dulles International Airport assisted County firefighters in spreading ten thousand gallons of Aqueous Film Forming foam, which is the necessary treatment for this type of spill.

The County and neighboring fire companies, who had previously established a mutual emergency aid program, worked together to ensure that the situation was under control at all times. By 1:12 p.m., some three hours after the spill began, the fifth and final alarm went out. At that point, over 150 firefighters were on the scene.

The affected area was evacuated as a precautionary measure until all danger of surface ignition was over. Approximately 300 homes and a nearby elementary school were evacuated from Singleton's Grove and neighboring subdivisions. Everyone, including Colonial personnel, was barred from entering the subdivision for any reason until the Fire Marshall determined that no risk existed for a potential explosion.[219]

Initial Stages of Cleanup

The incident occurred at the crest of a hill which caused the gasoline to follow the path that rain water normally takes into the storm water management[220] system. Gasoline at the rupture and along unpaved overland flow paths infiltrated the soil and percolated downward.[221] The gasoline entered the storm water sewer lines and a vast amount was contained in the storm water detention ponds surrounding the site. As a precaution, artificial and/or natural flushing[222] of the storm sewer system occurred at least once a week for three consecutive weeks after the incident. This action served to remove any free gasoline in the water system.

On the evening of the incident, gasoline was detected in a spring at the head of an unnamed tributary located approximately 300 yards south of the spill site. Initially, about eight gallons of gasoline per hour were collected.[223] The amount of gasoline subsided to 2.5 gallons per hour prior to a heavy rainfall on June 21, ten days after the accident. Rain significantly affected the flow of gasoline discharging from the spring by displacing gasoline that was trapped or held in place in soil and rock.[224] After the rainfall of June 21, the rate of gasoline discharging from the spring increased back to eight gallons per hour. The flow of gasoline gradually subsided. During the week of August 10, one gallon per 24-hour period was collected.

Until mid-August, the gasoline collection system at the

spring was manned 24 hours a day. At that time, Colonial Pipeline replaced the manual collection with a mechanical oil water separator[225] to collect gasoline coming from the spring. This system allows water from the spring to run into a tank where the gasoline was skimmed off the top of the water. The water passes through another tank that contains absorption booms and finally releases the water to flow into the tributary. As an added measure, absorption booms were placed downgradient to the tributary. During the month of October, approximately 4 gallons of oil and grease were collected by the mechanical oil/water separator.

The unnamed tributary eventually flows into Little Rocky Run, a stream which flows into the Occoquan Reservoir, the main source of drinking water for the region. Containment and absorbent booms were used along Little Rocky Run, but very little gasoline appeared except at the confluence of the tributary and Little Rocky Run. A dam with underflow outlets was also constructed on Little Rocky Run for precautionary purposes. The gasoline did not appear to contaminate the Occoquan Reservoir or the area wells. The Virginia Water Control Board (VWCB), Colonial Pipeline Company and U.S. Home Corporation individually sampled the Occoquan for gasoline elements.[226]

Testing and Analysis

Numerous tests were conducted to examine the extent of contamination at the site, including analyses of soil and liquid samples for hydrocarbon elements and vapors[227] which are indicators of gasoline; monitoring for explosive vapors; identifying potential pathways for movement of gasoline in the subsurface via a seismic refraction survey;[228] and, installing monitoring wells[229] to determine if pockets of gasoline existed underground, if shallow groundwater beneath the site was contaminated, and the direction of groundwater.[230] Soil and liquid samples were taken in the areas that were either directly or indirectly affected by the spill in an effort to conduct a comprehensive testing program.

Surface samples were taken at the development site to determine the extent of contaminants in the soil. Test holes[231] were dug to gather subsurface soil samples for chemical testing. Laboratory results indicated a small number of positive samples. Very few of these samples contained high concentrations of hydrocarbons.

Organic vapors were monitored as a precaution at the test hole sites.[232] The VWCB felt that any intrusions into bedrock might create additional pathways for the gasoline to migrate. The test holes were bored to a rocky substrate,[233] which was impenetrable with a backhoe, a maximum of 5 feet in depth. To monitor gasoline vapors, 2 inch PVC slotted pipe[234] was installed in the test holes.

A seismic refraction survey was conducted on site to

characterize subsurface material types and to identify potential pathways for movement of gasoline in the subsurface.[235] The results of the seismic survey coupled with regional geohydrological[236] data assisted in the determination of where to place monitoring wells. The purpose of the monitoring wells was to identify the thickness and distribution of gasoline floating on the water table[237] and the concentration of dissolved[238] constituents in the groundwater.

Soil vapor levels were monitored throughout Singleton's Grove to identify those areas that warranted additional remedial[239] action as a result of gasoline contamination. Two areas were identified where removal of vapors in the soil and bedrock was needed. Separate soil gas vacuum extraction systems[240] were employed in each of these areas to draw-out constituents.

Vacuum extraction has been applied in a variety of gasoline and other constituents spills throughout the United States.[241] The process involves a series of extraction wells which are manifolded to the intake side of a blower. Air is then drawn through the soil, the gasoline is volatilized[242] and the vapors are withdrawn through the extraction system. These systems operate until the constituents are consistently lower in each extraction well; and piezometers[243] indicate that the extraction wells are effectively purging constituents from the unsaturated soil and bedrock zone.

A soil vapor monitoring program was undertaken along the

perimeter of townhouse units. The purpose of soil vapor monitoring was to provide assurance that residual subsurface gasoline contamination would not result in the accumulation of vapors in structures being built on site that might constitute a threat to the health and safety of current and future residents of the subdivision.[244] To date, remediation efforts continue at Singleton's Grove.

Legislative Response

The Board of Supervisors' immediate response to the accident at Singleton's Grove was that "setbacks" were needed from natural gas and hazardous liquid pipelines.[245] The Board decided that these setbacks should be established through an amendment of the Zoning Ordinance.[246]

This was not the first time that the Board had made such a request for "setbacks" from pipelines. In actuality, there have been numerous other similar health and safety directives to County staff to research, evaluate and present for codification such regulations. In fact, the list is rather lengthy. On September 17, 1976, the Board wanted an ordinance which would prohibit transmission pipelines in subdivisions.[247] On June 9, 1980, due to the Colonial pipeline leak in Manassas, the Board wanted a zoning change to prevent subdivisions from being built too close to pipelines.[248] On June 28, 1982, the Board requested that staff "...take another look at" requiring a 250-foot setback.[249] On October 17, 1983, after the fatal gas

explosion in Reston the previous weekend, the Board requested that staff "look into actions which can be taken to assure the citizens that they are not living adjacent to explosive situations..." and come back "...with language that would tighten up the requirements..." of the Comprehensive Plan.[250] On July 23, 1984, after a 300-gallon jet fuel spill, the Board directed staff to evaluate the Government Accounting Office Report on pipeline safety and analyze whether the Board needed "...to take some action concerning the County's land use plans in order to protect life and property."[251] On November 19, 1984, the Board requested staff to research "...whether the gas lines were not previously required to be shown on site plans..." and "...the possibility of providing a procedure where citizens can contact the County and be notified as to what easement work is being performed in the communities."[252] On January 14, 1985, the Board directed staff to "...continue to prepare a Zoning Ordinance amendment requiring a 10/35 foot setback...require all rezoning applicants whose property was within 660 feet of a high-pressure pipeline to obtain a statement from the pipeline operator regarding the condition and pressure of the pipeline...."[253] As of this date, neither Fairfax County nor any other local government in the country is known to have a "setback" requirement from pipelines.[254]

CHAPTER V: ALTERNATIVE STRATEGIES

As noted in the previous chapter, a desire of the Board of Supervisors of Fairfax County was to create a safe "setback" distance from natural gas and hazardous liquid transmission pipelines for all buildings and structures.[255] This desire appeared to be based on the belief that a "setback" would serve as a type of safety barrier between the pipelines and places of human occupancy.[256] The Board has directed County staff (on numerous occasions) to draft the legal text which would establish a required distance. However, no proposal of this kind has ever been presented by County planners to the Board for its approval. The probable reason for this apparent nonfeasance is the fact that County staff was unable to calculate the environmental impact of spills, which would be necessary to establish the appropriate distance. In addition, there is uncertainty about issues of financial constraints, liability, and regulatory takings.

In order to derive a numerical distance, a great many factors must first be evaluated. A starting point for such an effort may be to determine whether the setback is to protect against the potential dangers of a natural gas fire or the effects of a hazardous liquid spill. Although many of the data inputs would be identical, there are important differences to consider in determining the respective setback distances.[257]

In attempting to predict the maximum potential amount of a hazardous liquid which can be spilled from a rupture, certain

pipeline information would be needed. At the exact location where the setback will be required, the maximum product lost must be determined by calculating an extremely lengthy and complex series of formulas. The formulas require data on (a) all pipe sizes; (b) all pipe lengths to pump stations up and downstream from the site; (c) all gradients of the pipe along the entire length of the system; (d) type of pipes; (e) products carried in the pipes; (f) wall thickness of pipes; (g) pressure inside of each piece of pipe; (h) time needed to register pressure change from the site point to pump stations; (i) location of all relief valves and tank farms, including the length and type of pipes connecting them; and (j) time needed to complete entire shut down procedures, including the sequence of the procedures.[258] Due to security concerns within the industry, a great deal of this data is protected information which is not available to the general public.[259]

The U.S. Department of Housing and Urban Development (HUD) contracted with Arthur D. Little, Inc., (ADL), a scientific research group, to calculate safe setback distances from hazardous facilities.[260] Included in the ADL study was a detailed evaluation of transmission pipelines. The study focused on a number of factor equations such as spill diameter, intensity of fire, and overpressure from an explosion.[261] The cumulative solutions to these equations were also used to produce a specific setback from pipelines.

The pitfall of using only the HUD study method to

calculate a setback distance for Fairfax County is that the spill is calculated for a level, impervious surface. This presents three distinct problems. First, there is no site that is known in Fairfax County that contains only an impervious surface area.[262] Second, different soils, clays and bedrocks will cause product to migrate different distances.[263] Finally, if a liquid spill reaches a major groundwater vessel, then the product could spread for miles.[264]

If all pipe-specific information about the line is available, the calculation to determine fire radius and explosion impact would be as or more difficult to determine than the amount of product that would be spilled. First, for the entire area, the direction that product would flow would have to be projected and modeled. This would entail factoring in soil conditions, the amount of impervious surface (including roads, sidewalks, parking lots and trails), the wind direction and speed, the humidity, and determining areas where product may stop and build up.[265] In addition, the topography and slope of the surrounding terrain must be analyzed. The soil types, including grain size, amount of organic matter, thickness and location, should be evaluated, as well as the soil's permeability, porosity and flow percolation rates. Seismic studies of the underground elevation of bedrock and its fractures should be performed, along with determining water table levels and groundwater gradients and flow paths; this information should be verified by drilling wells in order to

discover their precise locations and depths. All of this data will be needed to determine where a spill may flow to, thus enabling ignition at another source. Also, the type of product will vary the types of fires or explosions and their ranges.[266]

Thus, the variables in the setback calculation will include:

a) pipe diameter, wall thickness, grade of metal

b) pipe pressure, length of pipe from project break to both pump stations, gradients

c) pressure conversion to gallons per second flow rate

d) product transported

e) product's chemical formula

f) product's flashpoint

g) product's solubility in water

h) products's molecular weight

i) product's National Academy of Science fire rating

j) product's acute toxic level

k) product's specific gravity

l) product's lower flammable limit

m) average weather at site

n) relative humidity at site

o) thermal conductivity of soil

p) density of soil

q) heat capacity of soil

r) type of soil

s) type of clays

t) depth to bedrock

u) slope of ground

v) location of groundwater

w) groundwater flow rate

x) diameter of spill

y) height of fire

z) pressure of blast

aa) thermal radiation from fire

bb) probability of occurrence.

To reiterate, these variables change for each liquid product or gas.

The probability that the pipe will rupture is also a part of the HUD study.[267] This is based on the national average number of accidents per year.[268] Although the number of injuries from the pipeline appears to be low, as stated by the Fairfax County Executive, "...any [emphasis added] occurrence will have a potentially severe impact on life and property if inhabited structures are within the impact area."[269] This fact is supported when the impact of a fire[270] is calculated for a scenario where the gasoline had ignited at Singleton's Grove.

Deriving a safe setback distance through calculation of a series of equations appears to be theoretically possible if all of the variables are determined. Even the pipeline companies use computer modeling to determine the amount of a spill from a pipe. However, since so many variables, such as weather[271] and soil conditions,[272] are unpredictable, there is no

accurate method of computing a safe distance. The only known successful method of calculating spills and distances of impact is on the trans-Alaskan pipeline.[273] That calculation included a spillage profile of the geological resources. However, the methodology utilized is not available to the general public because of fears of sabotage and industrial competition.

The difficulty in relying on the setback calculations for pipelines as presented in the HUD research was realized by HUD itself. In the 1984 proposed rulemakings advertised in the Federal Register, HUD added specific language to its provisions which require an "Acceptable Separation Distance"[274] (ASD) from hazardous facilities[275] for HUD-assisted projects. The purpose of the language was to clarify that the ASD rule does not apply to pipelines. For pipelines, HUD uses what it calls a Minimum Property Standard (MPS)[276] of 10 feet from the pipeline easement. It was noted in Chapter II, DOT and FERC require that new pipe be set back 50 feet from any structure.[277]

Although it appears to be a foregone conclusion that setbacks are, at best, difficult to support scientifically, this safeguard may still be a viable approach. DOT has observed that in most accident cases, especially those involving natural gas pipelines, there is no danger outside of 220 yards (660 feet).[278] Therefore, there is some technical basis to support the establishment of a setback. However, concerns may arise that a setback for these purposes could be a "taking"[279] without just compensation.[280]

The probability of whether or not a pipeline setback of this kind would be classified as a "taking" is unclear because no specific case that could be discovered has tested this concept.[281] Nevertheless, there is case law[282] which has discussed and defined the land use "regulatory taking"[283] issue. Understanding some of the complexities of the judicial interpretation and treatment of "takings" will clarify the boundaries of this legal issue. It should be noted that the laws affecting this issue cross both the local and state ordinances, court rulings and codes, as well as federal and state constitutions.

The constitutional limitations placed on zoning as to "takings" have been outlined by the courts in different ways for differing regulations. Historically, the test used by the U.S. Supreme Court has been based mainly on determining whether the regulation promotes a public purpose that is more important than the right to private property. This means that a "taking" has not occurred unless the land use regulation is unreasonable.[284] The penalties for an unreasonable regulation can include an inverse condemnation,[285] compensation or a federal Civil Rights[286] Act remedy. These penalties have also been applied to zoning regulations.[287]

In comparison to other "taking" claims, setbacks may be looked at in similar light as environmental regulations.[288] If considered as one would consider an environmental problem, there are two categories of environmental regulation in which the

courts might find a similarity to setbacks: wetlands or floodplains.[289] In the case of wetlands regulations, the setting aside of land in the area is to protect the natural environment,[290] whereas floodplains regulations protect property owners.[291] However, wetlands are not similar to pipeline setbacks because the area being protected is neither an occurrence of nature nor a natural resource for local benefit only. Floodplains, although an occurrence of nature, may be a danger to life and property[292] in a similar manner to pipelines; therefore, setbacks for pipelines may not be considered a "taking."

There have been two recent U.S. Supreme Court cases concerning issues related to "taking." One of the cases involved floodplain regulations; however, the Court did not rule on whether a taking had in fact occurred.[293] The other case involved a decision about taking of land for public use, in which the owners of the land must be compensated. In brief, a condition was placed on a building permit for rebuilding a beach home which required the property owner to give the locality an easement to use for public access to the beach.[294]

The Court held in Nollan Et Ux v. California Coastal Commission that "although the outright taking of an uncompensated, permanent, public-access easement would violate the Takings Clause, conditioning appellants' rebuilding permit on their granting such an easement would be lawful land-use regulation if it substantially furthered governmental purposes

that would justify denial of the permit. The government's power to forbid particular land uses in order to advance some legitimate police-power purpose includes the power to condition such use upon some concession by the owner, even a concession of property rights, so long as the condition furthers the same governmental purpose advanced as justification for prohibiting the use."[295] The holding continued by stating that "...[here] the Commission's imposition of the access-easement condition cannot be treated as an exercise of land-use regulation power since the condition does not serve public purpose related to the permit requirement. Of those put forth to justify it--protecting the public's ability to see the beach, assisting the public in overcoming a perceived 'psychological' barrier to using the beach, and preventing beach congestion--none is plausible."[296] In the case text of Justice Scalia's opinion for the Court, he noted that "California is free to advance its comprehensive program, if it wishes, by using its power of eminent domain for this 'public purpose'...but if it wants an easement across the Nollans' property, it must pay for it."[297]

It can be argued that the Nollan case differs drastically from setbacks from pipelines, in that there is a direct connection between the public purpose for the setback and the benefit to the property owner. The setback does not appear to be as inconsequential or insignificant (on its face) as a requirement to reach the beach. There are health and safety concerns that could rationalize a setback, not merely tanning

and swimming.

If it were determined that a setback is a "taking," a question of compensation may arise. It is clear that the amount of compensation would vary based on the location and amount of land. The costs cannot be determined,[298] but the land area can be estimated. If the estimate is based on a hypothetical lot with a 50-foot setback and an assumption is made that it is a square acre[299] abutting a straight-line easement the amount of land in the setback area would be 10,435.5 square feet.[300] This would mean that nearly 25 percent of the hypothetical lot would be in the setback.[301] And, for every linear mile[302] along the easement, 264,000 square feet would be in the 50-foot setback.[303] If the estimate is based on a 660-foot setback, the setback would occupy 3,484,000 square feet per linear mile, or 80 acres.[304] In Fairfax County there are 151 miles of transmission pipelines; therefore, a 50-foot setback would equal 79,728,000 square feet or 1830.3 acres.[305] A setback may be viewed as a taking if the distance could be viewed as excessive, merely because of the complete loss of use of so much land.[306] If the setback is 50 feet, this may appear to be reasonable to the state[307] and court.

The remaining aspect of setbacks which causes concern is the question of liability. In other words, can the government be held to tort liable[308] for damage to property or injury to person if the "safe" setback distance it has established proves to be inadequate? There appears no liability for a legislator

acting in a legislative capacity.[309] Land use and zoning have long been deemed to be legislative acts.[310] Notwithstanding any current court decision, the setback, if placed in a zoning ordinance, would be a mechanism that could help create more safe conditions, but not guarantee them. However, the publicity of a liability lawsuit, however unfounded, would be very undesirable for elected County officials.

Another basis for analysis of setbacks is the comparison with the other setbacks specified in the zoning ordinance.[311] Most significant among the comparables is probably the 200-foot setback from railroad tracks.[312] This setback is based on assuaging the noise from the tracks, which is a protection of person and property from the impact of a harm. Zoning ordinances contain many setbacks: landscape and screening regulations; yard requirements; wetlands regulations; floodplain rules; industrial districts; parking screening; service drive requirements; and landfill specifications.[313]

The question returns to whether or not the public benefit of land use regulation outweighs one's private rights. Governments can often utilize unchallengeable public bases or necessities to accomplish other goals (setbacks) which may be subject to controversy. While any court may reject beach visits as a compelling public purpose, if the government had declared that path an emergency access, the court may not have found the denial of the permit unreasonable. Another example of this philosophy is Fairfax County's 200-foot setback from rails.

Although this regulation was created to protect against the effects of noise, it also keeps places of human occupancy away from rail cars transporting ultra-hazardous materials,[314] with high accident rates.

In evaluating the pipeline safety issue and studying the site of the Centreville incident, it is clear that there is a need for a quick and unhampered response to any leaks along a pipeline. When the Singleton's Grove accident occurred, the Fairfax County Fire and Rescue Department responded with 150 to 200 firefighting personnel and 49 fire apparatus units. In this case, at the hot zone,[315] the location of many of the fire units was predetermined by the location of already-improved roads at the site. Since some fire apparatus weigh as much as 62,000 pounds,[316] locating on or traveling over product-soaked soil could have resulted in the immobilization of these trucks. Also, because many of the townhomes or quadruplexes had not been completed yet, fire department personnel were unimpaired on maneuvering and approaching the leak site without being confined to only the easement itself or a limited area.

Fast, easy ingress for emergency personnel and vehicles may be one of the most important factors in the quick assuaging of the effects of a pipeline leak or fire. Therefore, a restricted pipeline approach swath area clearance or pipeline emergency ingress/egress maneuverability corridor strip should be required along each side of any natural gas or hazardous liquid transmission pipeline easement. In order to allow for

the proper placement of emergency personnel and equipment in case of a rupture in the pipe wall, this restricted swath area should be restricted to fire equipment only, and should contain enough room for vehicular turnaround from any point or location along the entire length of the natural gas or hazardous liquid transmission pipeline easement. The easements themselves should not be included in the calculations of the required maneuverability swath because, first, the pipe may be located anywhere inside an easement[317] and, second, in the future, another pipe may be laid next to an already existing pipe without any prior notification as to its exact location.[318] The approach corridor for emergency assistance needs will provide the minimum safeguard for persons and properties adjacent to or in close proximity of these pipelines. A report by Arthur D. Little, Inc., ascertained that one major attenuating factor in evaluating the effects of fire on places of human occupancy is the time needed for the fire department to respond to the situation.[319]

Presently, the Fairfax County Public Facilities Manual[320] proposes a change in the required width of an access way for fire apparatus, from 18 feet to 24 feet. However, this access way provision does not include the necessary turnaround space needed for maneuvering of fire trucks, which would be a minimum of 45 feet.[321] It has been established that 45 feet will allow for the appropriate turning path radius essential to specific fire apparatus to enter a restricted approach swath, especially

when other vehicles are parked on the connector street directly in front of the corridor's entrance way.[322] If a roadway is, or will be, located adjacent to and parallel with the easement, then no swath area will be required on that side of the easement.[323]

In order to ensure that the response of Fire and Rescue is always unimpeded, the ingress/egress strip should be completed prior to the approval of any other work at a site. Since the goal of the swath area is to provide fire personnel flexibility in selecting the best location for their apparatus, at no time should any obstruction be permitted within the ingress/egress clearance.[324] In addition, whereas the swath strip must be able to withstand vehicular travel, a gravel surface should be used as cover over the area, which should be dedicated[325] to the County to maintain. The reason for graveling, instead of requiring a finished road, is that the corridor should not be utilized as a crossway for private automotive traffic and bicycles, nor parking for the same. If a finished road is put in, nearby residents will be tempted to use the swath for a roadway and the storage of boats or recreational vehicles. Graveling may not completely prevent this type of activity from occurring, but hopefully will decrease the likelihood of such an inappropriate and illegal use.

If the swath zone were established, all land falling within the clear zone swath should be figured into the formula

used for calculating the district size requirements.[326] Additionally, full density credit should be given for all land area within the emergency swath clear zone. The rationale is that this land will be dedicated to the County, by deed, making it the County's responsibility for maintenance and care. The dedicated land may be included in calculations for open space requirements, since it is inevitable that the clear zone swath will be utilized for pedestrian traffic such as walking or jogging; although the mechanized vehicle prohibition should be strictly enforced.

The swath concept is based on a premise that creating this fire accessibility will increase safety, but it is also, in effect, a setback. This could be one alternative route to achieving the same goal as establishing a setback from pipelines. There may be other approaches to the safety issues which will also control the land (but not necessarily in the traditional sense).

In discussing the setback issue, it becomes apparent that a population segment is inadvertently dropped from the sphere of protection: construction workers. At Singleton's Grove, the homes could have been set back a full 220 yards, but this would not have stopped the rupture. If the intent is safety, it can be submitted that accident prevention is a factor also. Land use regulation will not prevent accidents caused by construction activity. The Board of Supervisors was aware of this concern. In the Board discussion of June 15, 1987,

following the rupture in Centreville, it was requested not only that setback rules be drafted for adoption, but also that there should be rules to minimize the number of street crossings over transmission pipelines. Also, the Board asked how to protect against encroachments of the easement and what limitations were placed on the County regarding construction close to the pipeline.

Another pipeline safety precaution is that the Ordinance sections specifying the requirements for development and site plans should now incorporate language in harmony with the purpose and intent of the Comprehensive Plan. That is to say, the proposed new language in the Zoning Ordinance will now require that any development within 660 feet (220 yards) of a pipeline easement must receive from the pipeline operator a statement certifying that the line is in compliance with all required federal and/or state safety standards. This requirement will not only make developers very aware of the existence of a natural gas transmission pipeline, but will also ensure the persons who will occupy any buildings near a line that the pipe is in sound operating order. In addition, and again to enhance the safety of persons who will be living or working near any hazardous liquid or natural gas transmission pipelines, no Residential Use Permit (RUP) or Non-Residential Use Permit (Non-RUP) will be issued until all construction work in the pipeline easement is completed.

Enhanced construction standards, increased regulatory

enforcement, newly created emergency response accessibility, additional training programs, and improved industry-related activities are proposed here as a recommended course of action the County can take in order to create a stronger likelihood of safety in relation to the pipelines traveling through Fairfax County. Specific recommendations include:

A. Reduce Probability of Rupture

1. Add to Chapter 63 a requirement that anyone doing construction must check the plats for the location of pipelines, including private citizens who are doing their own work.

2. Highlight, in color, the location of easements on plans.

3. Require pipeline markings on all plans before rough grading plans are approved to include the exact pipe depth, gradient and location.

4. Increase the number of public utility inspectors so that there is ample staff to be on-site whenever work is being done in a transmission pipeline easement.

5. Fence the entire easement, temporarily, prior to any construction activity so that it cannot be entered without pipeline and DEM representatives present. Fences can be removed once construction is finished.

6. Do not allow anything to be constructed in or through transmission pipeline easements except necessary roads and utility crossings (all work to be done by the pipeline company's specialist).

7. Stiffen and enforce the fine for failure to hand-dig and not notifying MISS UTILITY.

8. Place markers along the easement, not only along the pipeline.

9. Allow only build-up or over-fill, not down grading, of soil over transmission pipes.

10. Require test pits every five feet along the

pipeline for determining its depth contour.

11. Restrict blasting within 50 feet of a transmission pipeline.

12. Require the tiling of pipeline after any excavation in the easement.

B. Improve Response Capability

1. Provide Fire and Rescue with Aqueous Film-Forming Foam.

2. Install warning systems along the easement for quicker evacuation in case of a leak or fire and which both pipeline operators and emergency services can activate.

3. Notify the Fire Department or any work in any transmission pipeline easement so they will know the exact location and the basic products that are involved.

4. Establish an emergency preplanned routine between the pipeline operators and all emergency services to enable all involved to move in systematic unison when responding to a rupture.

5. Prepare pipeline emergency plan using Fire and Rescue's emergency plan and the Federal Emergency Management Agency guidebook.

6. Mandate that respirators are to be worn during any transmission pipeline rupture at the "hot zone."

C. Increase Awareness and Training

1. Increase the advertising of MISS UTILITY and pipeline safety throughout the County.

2. Require any contractors from outside the County who plan work here to participate in the DEM-sponsored training on pipeline trenching procedures or to be licensed to perform such work.

3. Notify nearby citizens when work is being done in any pipeline easement.

4. Designate Pipeline Specialists in DEM, OCP, Fire and Rescue, Police Department, DPW, and

Department of Housing and Community Development.

5. Mandate OCP, on rezonings, to take into account the Comprehensive Plan pipeline recommendations.

D. Expand Coordination, Lobbying, and Policy Analysis Efforts

1. Establish a County pipeline coordination team that will report to the Board of Supervisors and is made up of both County agencies and private citizens' groups, with one team member to sit on the Northern Virginia Utility Board.

2. Lobby for a statewide one-call requirement so any contractor who is doing business in another jurisdiction in Virginia will know, when he/she comes to Fairfax, that it has a one-call system.

3. Study development to determine how many buildings and structures are within 220 yards and 50 feet of pipeline easements.

4. Lobby the State Corporation Commission to require that pipelines check depth of cover annually to determine if erosion is occurring.

5. Establish a task force of County, state and federal agencies and construction and pipeline industry representatives to evaluate the Centreville accident in reference to emergency communications, emergency response by pipeline, fire department and police, coordination of the response at the site, and its clean-up.

As a final note, the influence of the federal government's role on the County's decision-making options should not be left out of a debate on the possible strategies to protect pipeline safety. This influence is present because the County's desire to establish a setback is due in part to occurrences that have been due to pipe defects and corrosion. Only the federal authorities can regulate how the pipe is operated and maintained. The GAO study as well as numerous NTSB reports have

pointed out the flaws in the DOT regulations and their enforcement. The County's only option to effect changes such as these is to lobby the federal government. As was discussed in Chapter I, the County does not have the authority to tell the pipeline companies where to place their lines so as to avoid densely populated areas, thereby reducing the danger of a faulty pipe. Only the federal government can act to increase the standards.

The alternative strategies proposed here may restrict development and incur costs, but because they are not based in the Zoning Ordinance, they do not have the legal and financial consequences that seem to accompany a setback. Yet there appears to be fear on the part of the County which is an obstacle to adopting these alternative solutions. The concern over possible publicity of lawsuits regarding taking or liability may accompany these proposals. Also, in the existing pro-development atmosphere, elected officials are concerned over how imposing fire swaths will impact on the aesthetic and architectural integrity of residential developments. Private developers may not be able to build their buildings and homes as large as they would like, and, the loss of excess land will affect affordability, a competing goal.

Although there may very well be valid concerns over the alternative solutions, it is submitted that the proposed solutions are, as alternatives, a less bitter pill to swallow than attempting to establish a setback. Some eighteen months

after the Singleton's Grove accident, the Board appears to be at a stalemate and has not enacted any new policies regarding pipeline safety, land use or otherwise. If the County's goal of taking action to increase safety from pipeline accidents is sincere, then the alternative proposals should be initiated, rather than doing nothing until the next pipeline accident.

NOTES

[1]Ralph Kubitz, DOT, interview by author, 24 November 1987, Washington, D.C.

[2]U.S. Department of Transportation. Research and Special Programs Administration. Annual Report on Pipeline Safety. [Washington, D.C.] U.S. Department of Transportation, Research and Special Programs Administration, 1985.

[3]American Petroleum Institute, 1984. Facts about Oil, 21:

> Pipelines move volumes of crude oil and petroleum products across the country so silently and efficiently that most people aren't aware that they exist. Yet they are the largest single oil transportation system; at some point, all domestic and imported oil moves through pipelines. In fact, pipelines rank third among all types of domestic freight carriers in terms of tonnage handled.

U.S. DOT's Annual Report on Pipeline Safety, Calendar Year 1985, reported that there were 31 fatalities from pipeline failures for that year. The American Gas Association has reported that in 1985 there were approximately 45,800 non-pipeline related transportation deaths in the United States.

[4]Ibid., 20-22.

[5]Ibid., 20.

[6]Ibid., 21.

[7]Ibid., 21:

> Pipeline design also reduces the visual impact that a line might have. Most pipelines are placed underground. Laying a pipe begins with digging a ditch deep enough to ensure an adequate cover for the pipe. Then various lengths of pipe are brought to the site and joined by welding. The line is laid in the ditch by hoists or side-booms mounted on tractors. Finally, the trench is filled with earth to cover the pipe and then the right of way is cleaned up and regraded.

[8]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry. Petroleum Extension Service, The University of Texas at Austin, 13:

> In 1965, the largest product pipeline built to date went into operation between Houston, Texas, and a terminus in New Jersey in the metropolitan New York area, a distance of 1,533 miles. In the line's earlier operation, the injection rate was slightly below 50 percent of the design capacity. The system had a trunk line composed of 36/32/30-inch diameter pipe, with laterals ranging from 6- to 22-inch diameter. By 1983, the same system had expanded to 2,885 miles of 40- to 32-inch mainlines and another 2,365 miles of laterals and related lines.

[9]U.S. Department of Transportation. Research and Special Programs Administration. Pipeline Safety Regulations. [Washington, D.C.]: U.S. Department of Transportation, Research and Special Programs Administration, 1986.

[10]American Petroleum Institute. 1984. Facts about Oil, 9:

> Geologists and geophysicists have developed the organic theory to explain petroleum's presence in the earth. This theory holds that crude oil and natural gas are a product of the decayed remains of prehistoric marine animals and plants....

[11]Ibid., 26:

> Petrochemicals consist of organic and inorganic chemicals. Organic chemicals, which contain carbon atoms, trace their origin to the remains of plants and animals from which all hydrocarbons are derived. Inorganic chemicals come from non-living origins.

[12]American Gas Association. 1982. Natural Gas Energy. JN Company for the Educational Programs Division.

[13]Ibid., 31. Known as "bottled gas," LPG (Liquified Petroleum Gas) consists primarily of propanes and butanes, highly volatile gases that are extracted from refinery and natural gases. LPG has a unique double characteristic. Under moderate pressure, LPG liquifies and can be easily shipped by pipelines, railroad tank cars, or trucks. Released from its storage tank, LPG vaporizes and burns with high heat and a clean flame.

[14]Ibid., 31.

[15]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance.

[16]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry, 85.

[17]American Gas Association. 1982. Natural Gas Energy.

[18]James Hicks, Director of Operating Section Services, American Gas Association, telephone interview by author, 4 April 1989, Arlington, Va.

[19]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.

[20]American Petroleum Institute. 1984. Facts about Oil, 21:

> While pipelines can be as small as 2 inches in diameter for a gathering line, they can be as large as 56 inches for a trunk line. Before World War II, very few lines were larger than 12 inches in diameter. But as the demand for oil increased with the war, pipelines developed the larger pipe that now is used to carry vast quantities of petroleum and petroleum products.

[21]U.S. Department of Transportation. Research and Special Programs Administration. Pipeline Safety Regulations.

[22]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry, 16.

[23]Ibid., 9, 24.

[24]American Gas Association. 1982. Natural Gas Energy.

[25]U.S. Department of Transportation. Research and Special Programs Administration. Pipeline Safety Regulations.

[26]American Petroleum Institute. 1984. Facts about Oil, 21:

> There are three kinds of pipelines: gathering lines, usually the smallest, move oil from producing wells to field storage tanks; crude oil trunk lines transport oil from the storage tanks to refineries; and product trunk lines transport refined products to regional distribution centers.

[27]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry, 16.

[28]James Hicks, Director of Operating Section Services, American Gas Association, telephone interview by author, 4 April 1989, Arlington, Va.

[29]Ibid.

[30]Al Garnett, DOT, interview by author, 24 November 1987, Washington, D.C.

[31]American Petroleum Institute. 1984. Facts about Oil, 21:

> Pipelines can carry many different shipments, each following the other. Each shipment, composed of a particular petroleum product or grade of crude oil, is known as a batch....Initially the batches were separated by slugs of water or kerosene, but today they are sent through the pipeline in an order that allows compatible products to follow each other. When batches must be kept separate, pipelines use inflatable batching spheres, which look like inflated bowling balls, to keep the different products from contaminating each other. To determine what batch is arriving at any given time, recording equipment follows the flow of the products.

[32]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry, 41.

[33]American Petroleum Institute. 1984. Facts about Oil, 21:

> Moving oil through pipelines requires pumps to create the pressure to push the oil along at a speed usually between three and five miles an hour. The distance between pumping stations depends on the terrain, the type of oil or product being moved and the diameter of the pipe itself. Some pumping stations are remotely controlled. A centrally located operator controls these pumps and monitors and controls the flow rate and pumping pressure in the system....This control is essential because pipelines do not carry just a single shipment of oil at a time.

[34]Ibid., 41.

[35]American Gas Association. 1982. Natural Gas Energy.

[36]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.

[37]Ibid.:

> Richness is the purity measure of petroleum products. Due to its chemical composition, pure gasoline will not ignite - only the vapors (a mixture of gasoline with air) are flammable. However, since gasoline evaporates very rapidly, any exposure to air can prove to be highly combustible.

[38]Ibid.:

> A vapor mixture of 25 ppm (parts per million) of gasoline to air is needed for a combustion to be able to

occur. For natural gas, a mixture of 5-15% methane (the chemical name of natural gas) to 85-95% air is needed before combustion can occur.

[39]Ralph Kubitz, DOT, interview by author, 11 August 1987, Washington, D.C.

[40]Ibid.

[41]Ibid.

[42]Ibid.

[43]Ibid.

[44]American Gas Association. 1982. Natural Gas Energy.

[45]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry, 1.

[46]American Gas Association. 1982. Natural Gas Energy.

[47]American Petroleum Institute. 1984, 3d ed. Introduction to the Oil Pipeline Industry, 1.

[48]American Gas Association. 1982. Natural Gas Energy.

[49]American Petroleum Institute. 1984, 3d ed. Introduction to The Oil Pipeline Industry, 1.

[50]U.S. Department of Transportation. Research and Special Programs Administration. Pipeline Safety Regulations.

[51]Ibid.

[52]American Gas Association. 1982. Natural Gas Energy.

[53]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance.

[54]American Petroleum Institute. 1984, 3d ed. Introduction to The Oil Pipeline Industry, 15.

[55]Ibid., 10.

[56]Ibid.

[57]American Gas Association. 1982. Natural Gas Energy.

[58]American Petroleum Institute. 1984, 3d ed. Introduction to The Oil Pipeline Industry, 1.

[59]Ibid.

[60]American Gas Association. 1982. Natural Gas Energy.

[61]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance, 48.

[62]American Petroleum Institute. 1984, 3d ed. Introduction to The Oil Pipeline Industry, 102.

[63]American Gas Association. 1982. Natural Gas Energy.

[64]American Petroleum Institute. 1984, 3d ed. Introduction to The Oil Pipeline Industry, 54-55.

[65]Ibid., 91-92.

[66]Ibid.

[67]Ibid.

[68]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.

[69]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance.

[70]American Petroleum Institute. 1984, 3d ed. Introduction to The Oil Pipeline Industry, 93:

> Certain cardinal principles have assured the success of pipeline operations. One of the most important of these principles is the best way to do the job is the safest way. The transportation of petroleum liquids has always been a potentially hazardous business. For more than a century, industry has kept this basic fact in mind and has spared no effort nor expense to keep the potential hazard from becoming an actual hazard.
>
> Two adjectives apply to petroleum liquids because of their inherent nature: flammable and volatile. Flammable means that they will burn under certain conditions; volatile means that they will vaporize when unconfined, with the vapors forming an explosive mixture when combined in suitable proportions with oxygen. Because they transport flammable products, pipeline companies go to great lengths to see that the public, their employees, and the environment are protected.
>
> Cooperating with technical societies and governmental authorities, the pipeline industry has carried out a continuing program of research designed to eliminate hazards--both to employees and the public. Every vessel, every pump, and every section of pipe and its fittings

have been designed with safety as the foremost consideration.

[71]National Transportation Safety Board. Special Study Prevention of Damage to Pipelines, Washington, D.C., 7 June 1973. NTIS, NTSB-PSS-73-1.

[72]Ibid.

[73]U.S. Department of Transportation. Research and Special Programs Administration. 1985. Annual Report on Pipeline Safety, 25, 28. It should be noted that "LNG facilities are exempted by regulations from filing written incident reports....[They are] not included in the statistical summaries presented in this annual report." p. 32.

[74]Ibid., 23.

[75]National Transportation Safety Board. Pipeline Accident Report Standard Oil Company of California (SOCAL) Pipeline Rupture, Los Angeles, California, 16 June 1976. NTIS, NTSB-PAR-76-8.

[76]National Transportation Safety Board. Brief of Accident - The Peoples Natural Gas Company, Pittsburgh, Pennsylvania, 31 July 1979. DCA-79-F-P-021.

[77]National Transportation Safety Board. Brief of Accident - The Texas Pipeline Company, Berwick, Louisiana, 2 January 1980. FTW-80-F-P002.

[78]National Transportation Safety Board. Pipeline Accident Report - Four Corners Pipe Line Company, Pipeline Rupture and Fire, Long Beach, California, 1 December 1980. NTIS, NTSB-PAR-81-4.

[79]National Transportation Safety Board. Pipeline Accident Report - Mid-America Pipeline System Liquefied Petroleum Gas Pipeline Rupture, West Odessa, Texas, 15 March 1982. NTIS, NTSB-PAR-84-01:

> ...the mobile home on Lot 8 encroached 15 feet into MAPCO's easement and was within 10 feet of the pipeline. Since the development of Block 43 of Chaparral Estates, roads have been graded over the pipeline, and numerous excavations have been made adjacent to the pipeline for installing buried telephone cables, septic tanks, and poles for electric power lines.
>
> When MAPCO learned that land adjacent to its pipeline was being developed for residential lots, additional markers were installed over the pipeline. Even though MAPCO was aware that its pipeline lay only 16 inches below the surface, that roads had been graded over the pipeline,

and that the high-pressure pipeline now would be exposed to additional risks which might endanger a significant number of people, no changes were made in the design or operation of the pipeline to increase protection for persons who would live close to the pipeline. No changes were required by 49 CFR Part 195 (Federal requirements for liquid pipelines).

Chapparal Estates, like many other land subdivisions, was planned without consideration of the hazards that might be posed to future residents by damage to pipelines transporting hazardous materials. Moreover, Ector County officials approved the plans for Chaparral Estates without consideration of the effect of the development upon the safety of MAPCO's pipeline and also without consideration of the possible hazard to future residents posed by the pipeline. Because neither the developer nor land planning officials recognized the location of the pipeline within the planned subdivision as a potential threat to the safety of future residents, 11 lots in Block 43 were allowed to be developed over the land occupied by MAPCO's pipeline easement. Dwellings could not be erected or placed on some of these lots without siting the dwelling over the pipeline. MAPCO's first knowledge of the development was provided by its aerial surveys when construction activity was noted.

[80]National Transportation Safety Board. Pipeline Accident Report, Texas Eastern Pipeline Company Ruptures and Fires at Beaumont, Kentucky, on 27 April 1985 and Lancaster, Kentucky, on 21 February 1986. NTIS, NTSB/PAR-87/01.

[81]Comments on GAO's Review of the Department of Transportation's Pipeline Safety Program by O. W. Krueger. 1984. Hearings Before the Subcommittee on Fossil and Synthetic Fuels, Committee on Energy and Commerce, House of Representatives, March 13:

The Department of Transportation administers the federal pipeline safety program using authority contained in the Natural Gas Pipeline Safety Act of 1979, as amended. This legislation makes the Department responsible for establishing and enforcing safety standards for both interstate and intrastate pipelines. States may assume responsibility for enforcing the safety standards for all or a portion of the intrastate pipelines located within their borders. Some states, acting as agents of the Department, also have been inspecting interstate pipelines. The states' participation in the program is strictly voluntary but participating states can obtain federal reimbursements for up to 50 percent of the costs incurred operating their programs.

The Department is responsible for (1) enforcing the standards (inspecting) for those pipelines the states do

not assume responsibility for and (2) monitoring the participating states to ensure that these states are adequately enforcing the federal safety standards. In 1983, Alaska and South Dakota were the only states that did not have a pipeline safety program. However, as of December 31, 1982, there were 32 states that had assumed jurisdiction over some but not all of the various types of intrastate gas operators that existed in those states.

[82]U.S. Department of Transportation. Research and Special Programs Administration. 1986. Pipeline Safety Regulations.

[83]Ibid.

[84]Ibid., 641-647.

The list of codes and standards includes design criteria established by the following: Aluminum Association; American Concrete Institute; American Gas Association; American National Standards Institute, Inc.; American Petroleum Institute; American Society of Mechanical Engineers; American Society for Testing and Materials; American Water Works Association; American Welding Society; Association of American Railroads; Bureau of Explosives; Compressed Gas Association, Inc.; Institute of Makers of Explosives; International Conference of Building Officials; International Organization for Standardization; Manufacturers Standardization Society of the Valve and Fitting Industry; National Bureau of Standards; and, the National Fire Protection Association.

[85]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance, 93, 98:

> Pipe made of various materials has been used for thousands of years for transporting water and sewage. While some of the projects were monumental in size and scope and represented great technological advances at the time, the quantities transported were small and the distances short when compared with those of today's pipeline industry. The pipe materials were not very strong. This was true even of the lead, copper, and cast-iron pipes that were used during the last few centuries....
>
> The use of wrought iron and steel for making pipe is a comparatively recent development. The discovery of petroleum in commercially significant quantities in 1859 was a great stimulus for progress in the manufacture of iron and steel tubular goods. The production, transportation, refining, and distribution of petroleum and its products have led to the development of different classes of tubular goods to meet the varying requirements of the industry.
>
> Processes for manufacturing wrought iron and steel with the properties and in the quantities needed by the

petroleum industry were developed just prior to and during the early stages of the oil age.

[86]Ibid., 29-30.

[87]Ibid, 98:

The strength of steel can be increased by changing its chemical content. Yield strength can be increased by cold working the steel. These methods have been used singularly and in combination to raise the yield strength of pipe, thereby increasing the allowable pressure rating. Cold working is usually achieved by making the pipe slightly smaller than its intended size. It is then expanded mechanically or by internal pressure that causes stresses in the pipe walls exceeding their yield strength. Where internal pressure is used, expansion continues until it is restrained by enclosing dies that stop the expansion when the proper size pipe has been reached....

Pipe properties other than strength such as ductility, elasticity, and grain structure of the steel need to be considered in some cases. Heat treatment can be used along with chemical formulation of the steel to obtain the desired properties and the pipe may be furnished as rolled, normalized and tempered, quenched and tempered, subcritically stress-relieved, or subcritically age-hardened.

[88]Ibid., 55:

Line pipe is subject to various forms of damage and deterioration during its movement from pipe mills to the pipeline right-of-way. Specifications intended to minimize this damage or deterioration may be implemented by including appropriate terms in purchase orders, shipping instructions, and arrangements for interim storage. Construction specifications usually provide in the job description that pipe will be available to the contractor at locations reasonably close to the right-of-way. These may be railway delivery points, barge terminals, ocean shipping ports, storage yards, pipe coating plants, or pipe mills. The contractor may be required to arrange for unloading from railroad cars or barges and truck transportation by properly licensed and authorized haulers from these locations to the right-of-way. The haulers also perform the construction operation of stringing the pipe. This operation consists of unloading individual lengths of pipe and placing them in an end-to-end arrangement along the right-of-way. Lifting the pipe from stringing trucks and placing it on the ground and supporting pads in such a manner that it will be properly placed for pipe paving operations, with proper spacing between lengths and without damage to the pipe or

its protective coating, requires skill and care on the part of pipe stringers.

[89]Ibid., 72-73:

Pipeline welding requires the exercise of arts and skills by the welder that can be acquired only by study and practice. Industry standards and governmental regulations require that welders demonstrate their skill and competence by making sample welds similar to those to be made on the project. These welds are examined and tested for strength, ductility, and other properties as part of a prescribed qualification procedure. API Standard 1104, Standard for Welding Pipe Line and Related Facilities, describes the qualification procedures that must be carried out before a welder is permitted to work on a project. the procedure provides for retesting of welders as needed and the maintenance of welder qualification reports.

API Standard 1104 provides for qualification of proposed welding procedures. The quality of sample welds made by the proposed procedure on pipe similar to that which will be used is determined by destructive testing. Methods of testing and examination as well as standards of acceptability are given.

[90]Ibid., 91:

Hydrostatic testing is usually performed by construction contractors, but companies specializing in the work may perform it on subcontracts or on direct contract with the pipeline company. Such tests are used to prove that all parts of a pipeline are strong enough for the intended service. Internal test pressures may be subject to regulation by governmental agencies. Hydrostatic test procedures are usually described in considerable detail in specifications. Locations and lengths of individual test sections and applicable pressures are given.

[91]Ibid., 75:

Visual Inspection of welds and observation of welding operations are relied upon to some extent by welding foremen and company inspectors for detecting weld defects and indicating when further examination of certain welds is advisable....Radiographic examination is a nondestructive method of inspecting the inner structure of welds and determining or inferring the presence of defects. Radiographic pictures are made by binding film sensitive to X or gamma rays in close contact with a weld and allowing these rays to flow through the weld and adjacent pipe material. Sources of the rays may be X-ray machines or radioisotopes.

[92]Ibid., 123-124:

Covering metal with a waterproof, electrically nonconductive coating is an age-old method of corrosion control. Pipeline coatings need special properties. An industry of considerable size has grown up to develop, produce, and apply such coatings. It should be apparent to anyone familiar with the realities of pipeline construction that a completely waterproof, electrically nonconductive coating for an entire pipeline is a goal that may be approached but never fully achieved. Coating materials and application procedures are available that provide an acceptable degree of corrosion control.

[93]Ibid., 128:

At the beginning of this discussion of methods of corrosion control it was suggested that control could be achieved by making all parts of the pipeline cathodic. Cathodic protection does exactly that. It may be visualized as collecting all the anodes of all existing and potential corrosion cells and transferring them to a place of the pipeline operator's choosing. This is accomplished by creating and controlling the action of large corrosion cells. These cells are formed by connecting the negative terminals of direct-current power sources to the pipeline and connecting the positive terminals to expendable solid conductors buried in the ground....These solid conductors are called anodes and interconnected groups of them are often called ground beds. The electrical circuits are completed by current flowing through the soil from the anodes to the pipeline and along the pipeline to the current source.

[94]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.

[95]U.S. Department of Transportation. Research and Special Programs Administration. 1986. Pipeline Safety Regulations.

[96]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance.

[97]Ibid., 61.

[98]Ibid., 62:

The term clearing includes removal of above-ground obstacles to work such as trees, brush, crops, and boulders. It also includes removal of tree stumps and roots in the ditch line that would interfere with operation of the ditching machine. The term grading means leveling the ground surfaces as needed to permit transit and operation of vehicles and equipment and to permit placement of the pipeline at the desired elevation. This

involves cutting away the earth in some places and building it up in others. Construction of roads and bridges, diverting streams, stabilizing soil to support heavy equipment, and various other kinds of work are often needed. Generally, the right-of-way is cleared and graded to a width of 50 feet, but greater widths are not uncommon.

[99]Ibid., 54:

The course or path of the center line of the ditch should be described with respect to location of survey lines as shown on alignment maps and survey stakes showing locations of these lines. Most often the ditch centerline follows the staked survey line but may be offset to either side. Depth of ditch is usually defined as that required to provide the specified amount of cover when the ground surface is returned to its normal level. In some cases the depth of burial is governed by laws and regulations. The nature and use of the land has a bearing on the amount of cover needed.

[100]Ibid., 56:

Pipe laying consists of the operations required for joining individual pipe lengths, valves, and fittings into a continuous conduit for flow of fluids. Individual pipe lengths are bent as needed to conform with vertical and horizontal changes in direction of the ditch. The former practice of heating pipe to facilitate bending is no longer permitted because of the harmful effects of heat on most pipe metals. Bends should be made in a manner that avoids metallurgical and dimensional damage to the pipe and minimizes damage to protective coatings. Pipe ends are prepared for welding by inspecting them for damage, repairing damages, and cleaning by wire brushing or if necessary by abrasive grinding. A swab should be run through each pipe length just before it is placed in alignment for welding to insure removal of large objects, much of the loose dirt, and mill scale. Pipe with longitudinal welding seams should have these seams placed so that they will be kept above the center line of the pipeline. The seams in adjacent lengths should not be aligned.

[101]Ibid., 57-58:

Lowering consists of placing the completed pipeline in the ditch. It must be specified that lowering will be permitted only when an inspector is present. This permits the inspector to determine whether the pipe is ready for burial and whether the ditch is ready to receive it....The pipe must be placed in the ditch in such manner that preformed pipe bends will fit the corresponding bends in the ditch.

[102]Ibid., 58:

> Backfilling consists of covering the pipe with the earth removed from the ditch or with other specially prepared material and completely filling the ditch so that normal ground level is restored. The usual method is that of pushing or pulling the excavated earth back to the edge of the ditch and allowing it to fall in....
>
> Cleanup includes removal and disposition of refuse and surplus materials from the right-of-way. Rock blasted from the ditch can be a major cleanup item, especially in cultivate land areas. A common specification is that the contractor shall arrange for disposal sites, collect all rocks that would interfere with normal use of the land, and haul the rocks to the disposal sites. Also included in cleanup is leveling the right-of-way area by filling deep ruts and removing mounds of dirt. The degree of need for leveling and dressing the ground surface varies widely in different localities, and the appropriate one should be specified. Removal of temporary fence gates and bridges and restoration of fences, ground cover, and water courses are also included in cleanup.

[103]U.S. Department of Labor. Occupational Safety and Health Administration. Construction Industry. ([Washington, D.C.]: U.S. Department of Labor, Occupational Safety and Health Administration, 1987), 87, 200-210.

[104]Federal Register. 1987. April 15, Vol. 52, No. 72, 12288-12339.

[105]Code of Federal Regulations. 1988. 18 CFR CL 1, April 1, 300-313.

[106]U.S. Department of Labor. Occupational Safety and Health Administration. Construction Industry, 88, I-191-230.

[107]Comments on Pipeline Safety by C. H. Batten. 1984. Hearings Before the Fossil and Synthetic Fuels Subcommittee, Committee on Energy and Commerce, House of Representatives, March 13:

> Mr. Chairman, I am Charles H. Batten, Chief of the National Transportation Safety Board's Hazardous Materials and Pipeline Accident Division. With me is Mr. Henry M. Shepherd, who is a pipeline accident investigator within the Division. On behalf of the Safety Board, I am pleased to respond to the Subcommittee's request for Board comments concerning pipeline safety.
>
> Under the Independent Safety Board Act of 1974 as revised on November 3, 1981, the Safety Board is charged to investigate or cause to be investigated specific types of pipeline accidents to determine the facts, conditions, and circumstances, to determine the probable cause of

these accidents and to develop safety recommendations for reducing the probability of their recurrence. Since 1969, when the Board began investigating pipeline accidents and, with an average of only three investigators, we have investigated over 300 accidents and written 59 major accident reports and 148 other reports. Additionally, we have conducted seven major safety studies identifying safety improvements which should be incorporated into the Department of Transportation's pipeline safety program. We have issued a total of 741 safety recommendations, of which 165 were directed to the Department of Transportation's Research and Special Programs Administration (RSPA) or its predecessor organizations.

[108]U.S. Department of Housing and Urban Development, Office of Housing, Procedures for Approval of Single Family Proposed Construction Applications in New Subdivisions. ([Washington, D.C.]: U. S. Department of Housing and Urban Development, Office of Housing, 1981), 2.

[109]U.S. Department of Transportation, Research and Special Programs Administration, Pipeline Safety Regulations. ([Washington, D.C.]: U.S. Department of Transportation, Research and Special Programs Administration, 1986), 517-518.

[110]Ibid., 522, 535, 541, 550, 555, 556, 586, 587.

[111]Ibid., 517, 518.

[112]Ibid., 541.

[113]Ibid.

[114]Ibid., 521-526.

[115]Ibid., 544-549, 587, 605, 606, 624.

[116]Ibid., 622.

[117]Rich Hoffman, FERC, interview by author, 17 May 1989, Washington, D.C.

[118]Comments of the Reauthorization of the Natural Gas and Hazardous Liquids Pipeline Safety Grants-in-Aid Programs by W. J. Hernandez. 1984. Hearings before the Subcommittee on Fossil and Synthetic Fuels, Committee on Energy and Commerce, House of Representatives, March 9, p. 3:

> Since its enactment in 1968, the Natural Gas Pipeline Safety Grants-In-Aid Program...has proved to be a model of Federal-State cooperation in its efficient implementation of gas pipeline safety standards. As administered through the RSPA, the pipeline safety program

provides up to 50 percent in matching funds to assist participating States in enforcing gas pipeline safety regulations. The Federal-State cooperation for this program has worked effectively, but funding in the past has been insufficient to provide the full 50 percent matching funds authorized by law.

[119]Ibid., 8.

[120]U.S. Department of Transportation. Research and Special Programs Administration. 1986. Pipeline Safety Regulations, 517.

[121]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.:

A high pressure pipeline is one which operates at a hoop stress of 20% or more of specified minimum yield strength (SMYS)...and is generally larger than six (6) inches in diameter.

[122]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.:

Generally, the MAOP for liquid pipelines can range anywhere from 600 to 800 psi. For natural gas pipelines, the MAOP may vary with the class locations, but in general the pressure ranges from 100-1700 psi.

[123]U.S. Department of Transportation. Research and Special Programs Administration. 1986. Pipeline Safety Regulations, 526-528, 563-564, 599, 625-626.

[124]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance, 107:

Valves, the second main type of pipeline fittings, are special fittings in that they are not static parts of piping systems but are means of providing various forms of control of the fluid being transported. The most common form of control is that of stopping flow completely in the portion of the pipe containing a valve by closing it or permitting flow with the least practical impedance by opening it. Many types of valves have been developed to provide this control, and different types will be discussed briefly. The latest edition of API Standard 6D, API Specifications for Steel Pipeline Valves, applies.

[125]U.S. Department of Transportation. Research and Special Programs Administration. 1986. Pipeline Safety Regulations, 589-593.

[126]Ibid., 562-563.

[127]Ibid., 562, 632.

[128]American Petroleum Institute. 1973. Oil Pipeline Construction and Maintenance, 143:

> The most common form of information gathering is done by aerial patrol on a weekly or biweekly schedule. During these patrols, the pilots watch for and report developments and changes on and adjacent to the right-of-way that may result in the need for maintenance. Often the first indication the patrol pilot sees is a spot of wilted vegetation. However, many changes are gradual and may take several years to reach stages that require maintenance work. Soil erosion, stream bed changes, weathering of pipeline markers, and signs of growth of brush and trees on the right-of-way are examples. Construction work adjacent to or approaching the right-of-way is noted and reported. Sometimes knowledge of such work is not received through other channels. Local pipeline managers investigate such activities and attempt to prevent possible damage by providing information as to locations of pipelines and arranging for their representatives to be present when excavation may result in exposure of the pipelines. Finding leaks, reporting their locations, and estimating their size and nature are prime responsibilities of air patrol pilots. Special flights are made to find leaks indicated by drops in pressure, meter readings, or other data.

[129]Ibid., 143:

> The employee classification of linewalker has been in existence almost as long as pipelines. While aerial patrol has taken over most of the linewalkers' work, they are still needed for certain places such as densely populated areas where minimum regulated flying heights do not permit adequate inspection from the air. Linewalkers also use means of transportation such as riding horses, motorcycles, swamp buggies, or boats as the occasion permits or demands. Covering the right-of-way at ground level is still required occasionally when emergencies occur during periods of darkness or bad weather that prevents aerial patrol.

[130]U.S. Department of Transportation. Research and Special Programs Administration. 1986. Pipeline Safety Regulations, 564, 631, 634.

[131]Ibid., 603, 610-611, 635.

[132]Ibid., 601, 608-610, 628-630.

[133]Ibid., 607, 628-632.

[134]Ibid., 630.

[135]Ibid., 629-630.

[136]Ibid., 641, 642.

[137]American Petroleum Institute. 1987. Publications and Materials, API 1987, 70-71. Offers some 100 critiques, discussion and research papers on policy analysis.

[138]National Response Team of the National Oil and Hazardous Substances Contingency Plan, Hazardous Materials Emergency Planning guide [Washington, D.C.]: National Response Team of the National Oil and Hazardous Substances Contingency Plan, 1987.

[139]National Research Council, Transportation Research Board, Pipeline Safety, [Washington, D.C.]: National Research Council, Transportation Research Board, 1985.

[140]U.S. General Accounting Office, Comptroller General of the United States, Need to Assess Federal Role in Regulating and Enforcing Pipeline Safety [Washington, D.C.]: U.S. General Accounting Office, Comptroller General of the United States, 1984.

[141]Witt, Elder. "The Tedious Chore of Preparing for Chemical Disaster Is in Lap of Local Government." Governing, April 1988, 24-30. The article presents a discussion of the Emergency Planning and Community Right to Know Act of 1986.

[142]A; Garnett, DOT, interview by author, 24 November 1987, Washington, D.C.

[143]A list of acts which require governmental regulation includes:

National Environmental Policy Act (NEPA) 42 U.S.C. 4321
Department of Energy Organization Act 42 U.S.C. 7101
Clean Air Act (1967 Act Amended) 42 U.S.C. 7401
Environmental Quality Improvement Act 42 U.S.C. 4317
Clean Water Act 33 U.S.C. 1251
Energy Supply and Environmental Coordination Act 15 U.S.C. 791
Safe Drinking Water Act 42 U.S.C. 300
NEPA Amendments 42 U.S.C. 4332
Toxic Substances Control Act 15 U.S.C. 2601
Naval Petroleum Reserves Production Act 42 U.S.C. 6244
Clean Water Act Amendments 33 U.S.C. 1251
Soil and Water Resources Conservation Act 16 U.S.C. 2001
Natural Gas Policy Act (NGPA)
Ground Water Protection Act of 1985
Public Utility Regulatory Policies Act of 1978

[144]The National Association of Regulatory Utility Commissioners is a nationwide organization of state and local government officials overseeing utilities.

[145]U.S. House of Representatives Committee on Energy and Commerce, Subcommittee on Fossil and Synthetic Fuels. The Reauthorization of the Natural Gas and Hazardous Liquids Pipeline Safety Grants-in-Aid Program. 9 March 1984.

[146]S. M. Marks, "Technical Hazardous Liquid Pipeline Safety Standards Committee Roster," Washington Pipeline Letter, no. 1 (1988): 5.

[147]Ibid., 6.

[148]National Environmental Policy Act of 1969, Federal Power Commission Order 415-C (issued December 18, 1972).

[149]Witt, Elder. "The Tedious Chore of Preparing for Chemical Disaster Is in the Lap of Local Government." Governing, April 1988, 24-30.

[150]Ibid.

[151]Ibid.

[152]Code of Federal Regulations. 1988. 18 CFR Ch. 1, April 1.

[153]American Petroleum Institute. 1984, ed. Facts about Oil, 19.

[154]Title III is intended for local level implementation. The TRB is looking at local policies and pipeline safety.

[155]Ralph Kubitz, DOT, interview by author, 11 August 1987, Washington, D.C.

[156]Fairfax County, Office of Public Affairs. 1986, rev. ed. Fairfax County Citizen's Handbook, 1.

[157]Ibid.

[158]Fairfax County, Office of Research and Statistics, Research and Analysis Branch. 1988. Standard Reports, 245-246.

[159]National Transportation Safety Board. Pipeline Accident Report, Washington Gas Light Company Natural Gas Explosion at Annandale, Virginia, 24 March 1972. NTIS-NTSB-PAR-72-4, 20:

WGL's leak record. In 1971, WGL received 85,756 leak reports, 50 percent of which turned out to be actual leaks. In addition to the leaks reported to WGL by people

outside the company, WGL also discovered the location of almost 1,000 leaks through its own surveys.

In its 1971 report to the Office of Pipeline Safety, WGL indicated that it repaired 11,608 leaks on its distribution system, 2,791 of which were caused by damage to WGL's facilities during construction activities. Although this represents an average of 54 damage-type leaks per week, the daily rate varied. One day, for example, 25 lines were damaged by construction activities.

[160]Ibid., 5-7:

The machine operator was taking light scoops to avoid breaking the 42-inch sewer. He did not realize that the gas main lay buried 3.14 feet below the surface of the street at that spot. At about 7:50, after making three passes with the backhoe, he realized that he had hit something 'very heavy.' He released the power and moved the bucket aside. The pipe was not broken where it was hit, but it was pulled....Although workmen generally guide the machine operator when he is near underground facilities, when the line was snagged no one was directing the operator's work....

The WGL crew arrived on the scene between 8:30 and 8:40 a.m., confirmed that a 2-inch main had been pulled and reported to their foreman by radio. After the foreman arrived on the scene, he was informed by the dispatcher that in order to shut off the affected area it would be necessary to close two valves to the east and two valves to the west of Magdalene Court.

When the crew arrived, the odor of gas was heavy, especially in the trench. The crew began to dig around the 2-inch main where it was snagged in order to confirm its size and to prepare to cut the line and place a 2-inch compression coupled valve on the end to stop the flow of gas. No attempt was made by the crew to check for the presence of gas in or around any of the nearby buildings or structures....

Shortly before 9 a.m., there was an explosion in the house. The woman, in the dining room at the time, picked up her infant son and attempted to leave the house from the kitchen door. The door was jammed shut and could not be opened. The front door was also jammed shut. She then saw an opening in the front wall near the front door caused by the explosion and was able to leave the house by squeezing through the opening. The house did not appear to be burning at that time.

When the explosion occurred at 4911 Magdalene Court, both the foreman for the gas company and the foreman for the Hopke Company called their offices on their radios, reported the explosion, and requested assistance. At exactly 9 a.m. the county emergency operation center received a call from a resident in the area. Nine

additional calls were received at 9:01. The foreman for the gas company ordered his men to turn off the gas meters at the houses on the Court and to evacuate the people. He had thought the meters were on the outside of the houses; however, they were on the inside.

A gas company employee and the machine operator ran into the court and were informed by the resident of 4911 that there was no one in the home except for her dog. They then attempted to evacuate the house at 4909. Finding the front door open, they entered the hallway and called to two children they saw in the basement, asking them if their mother was at home. The children, who were aged 3 and 1-1/2 years, did not seem to understand and did not move. The machine operator felt a rumble beneath his feet, turned around, and ran from the house. As he reached the sidewalk, the house exploded violently. The machine operator threw himself to the ground, but the WGL employee was thrown back out into the street with his clothing burning.

The house was almost completely destroyed by this blast. The only other occupant in the house at the time, the mother of the two children, was blown out of the back of the house.

[161]National Transportation Safety Board. Trans-continental Gas Pipe Line Corporation, 30 inch Transmission Line Failure Near Bealeton, Virginia, 9 June 1974. NTIS, NTSB-PAR-75-2.

[162]National Transportation Safety Board. Pipeline Accident Report, Colonial Pipeline Company Petroleum Products Pipeline Failures, Manassas and Locust Grove, Virginia, 6 March 1980. NTIS, NTSB-PAR-81-2.

[163]Angel O. Garcia, Petroleum Engineer, National Transportation Safety Board, March 28, 1984, letter to Raymond M. Moats, Office of the Fire Marshal, Fire and Rescue Services, Fairfax County.

[164]Columbia Gas Transmission Corporation, Transcontinental Gas Pipe Line Corporation and Washington Gas Light Company.

[165]Colonial Pipeline Company and Plantation Pipe Line Company.

[166]There are pipeline construction applications on file in Fairfax County Archives dating back to 1960.

[167]Fairfax County Code. Supp. No. 1, 12-77 Sec. 12.8.1, 30-132, 30-125, 30-133.

[168]Ibid., Chapter 63.

[169]Service line - a small pipeline leading to, or used as, a distribution line.

[170]A One-Call system is a centralized notification service which contacts all the utilities that have lines running through where a proposed excavation is to occur.

[171]Not all jurisdictions in Northern Virginia are members of MISS UTILITY.

[172]A test pit is the method used to locate a line by boring a small hole through the ground until it reaches the pipe.

[173]Fairfax County, Office of Comprehensive Planning, Development in Relation to Pipeline Locations (Fairfax, Virginia: Board of Supervisors, 5 October 1981), 15.

[174]Comprehensive Plan of the County of Fairfax Virginia. 1983 Edition. 478

[175]Ibid.

[176]Ibid.

[177]Ibid.

[178]Fairfax County, Office of Comprehensive Planning, The Proffer System in Land Use Regulation in Fairfax County, Virginia (Fairfax, Virginia: Board of Supervisors, 1 November 1985).

[179]Ibid.

[180]The group consists of members from Fire and Rescue, the Police Department, the Department of Environmental Management, the Department of Public Works, the Waste Water Treatment and Solid Waste groups, the Health Department, Risk Management, the Environmental Quality Advisory Council (a citizen organization) and the Office of Comprehensive Planning.

[181]The Northern Virginia Utility Committee is an informal discussion group, made up of utility operators and local jurisdictions, started in the mid-70's. The committee, which meets bi-monthly, addresses concerns, of both owners and governments alike, which relate to the safe operation and maintenance of utility lines. There are many notable accomplishments of the committee, such as the Damage Prevention Committee, a spinoff of the larger group, which is looking at ways to increase public awareness of the existence of underground lines. All of the transmission pipeline owners have representatives on the Utility Committee. The Heavy

Construction Contractors Association is the only private representative member of the committee.

[182]Fairfax County, Office of Comprehensive Planning, 1988 Annual Report on the Environment, 42.

[183]Mark Wendorff, Washington Gas Light Company, interview by author, 12 January 1988, Washington, D.C.

[184]Ibid.

[185]Fairfax County Code. Supp. No. 1, 12-77. Chapter 63.

[186]Ibid., 12.

[187]Patricia Davis and John Ward Anderson, "Break In Gasoline Pipeline Forces Evacuation in Fairfax," The Washington Post, 12 June 1987, Sec. A, 1.

[188]Ibid.

[189]Ibid.

[190]Mark Wendorff, Washington Gas Light Company,interview by author, 12 January 1988, Washington, D.C.

[191]Fairfax County, Office of Comprehensive Planning, Staff Report Application Number SE 84-S-049, Springfield District (Fairfax, Virginia: Board of Supervisors, 12 September 1984).

[192]Ibid.

[193]Ibid.

[194]Ibid., 1.

[195]Fairfax County, Office of Research and Statistics, Research and Analysis Branch. Standard Reports, 11.

[196]Fairfax County, Office of Comprehensive Planning. Staff Report Application Number SE84-S-049, Springfield District.

[197]Ibid.

[198]Ibid., 1.

[199]Ibid., 2.

[200]Fairfax County Code. Chapter 112.

[201]Ibid.

[202]Fairfax County, Office of Comprehensive Planning, Staff Report Application Number SE84-S-049, Springfield District.

[203]The County's proffer system allows developers to negotiate what type of zoning rules apply to its proposed project. It is called "conditional zoning."

[204]Fairfax County, Office of Comprehensive Planning, Staff Report Application Number SE84-S-049, Springfield District.

[205]Ibid., 2.

[206]G. J. Paisley, Baltimore Area Manager, Colonial Pipeline Company, December 17, 1986, letter to Tom Lovell, U.S. Home Corporation.

[207]Ibid.

[208]Statement by E. F. Gregory. Verbatim.

[209]567,000 gallons/hour equals 9,450 gals/min or 157.5 gals/sec.

[210]Ralph Kubitz, DOT, interviewed by author, 11 August 1987, Washington, D.C.: The maximum allowable operating pressure (MAOP) for this pipe is 657 psi. To allow for the detour of product to tank farm, Colonial has to lower the pressure in order to slow the travel of product so that it can be fed into the smaller lines which connect with the tanks. To shut-down the pipeline, a very accurate method or procedure must be followed in order to avoid creating a pressure surge, a sort of shock wave. Due to the physics of fluid hydraulics, if a stream of liquid completely stops its flow, a wave will be sent back down the stream. In this case, since the flow rate was at 9,450 gals/min in a 32" diameter pipe, it can be presumed that a pressure surge may have caused serious damage to the line at another point or increase the damage at the point of rupture. In order to prevent the possibility of this result, relief tanks must be opened to fill with product, pumps pushing the product must be shut down, then all the line valves closed.

[211]Ibid.

[212]Ibid.: Although a diesel engine works by air compression so there is no electric spark, there are ways that these motors can ignite gasoline vapor.

[213]Ibid.: A telephone, when the receiver is lifted, creates an electrical arc which can ignite a flammable gas. The U.S. Department of Transportation has reported this as a cause of an LNG (Liquified Natural Gas) explosion.

[214]Ibid.: The U.S. Department of Transportation (DOT) has reported that there have been cases where the electrical arc inside a light switch has caused the combustion of vapors. According to DOT, it is standard practice at natural gas facilities to have rules that state that, if gas odor is prevalent inside a building, no one is to use the telephone or turn on or off any lights.

[215]The driver, a resident of Singleton's Grove, later reported that he thought that it was only water. In this case, it has been speculated that, one, because the car was new, there were no spark plug wire electrical arcs and, two, that the engine must have been running "too rich" (the carburetor's gas-air ratio contained too much gas) so that it did not stall when entering or exiting the spray. If the latter had occurred, it can be presumed that the driver would have attempted to restart his engine, thus causing an electrical arc in the starter motor and possibly resulting in an explosion.

[216]Lead is a toxin which has been connected with illnesses such as paralysis.

[217]It was reported that gas vapors were detected one-quarter mile away.

[218]Because roads adjacent to the break were unpaved, truck units had to be situated farther away, on improved surfaces.

[219]Colonial personnel were prevented from entering the site until the Colonial supervisor contacted the emergency command center.

[220]Fairfax County, Office of Comprehensive Planning, Environmental Impact Evaluation, Design with Natural Systems (Fairfax, Virginia: Board of Supervisors, January 1980), 51.

[221]American Petroleum Institute. 1979, repr. 1986. Underground Movement of Gasoline on Groundwater and Enhanced Recovery by Surfactants, 5-8.

[222]Manually flushing the system and rain water flushing the system, respectively.

[223]American Petroleum Institute. 1980, 1st ed. Underground Spill Cleanup Manual, 23-30.

[224]Ibid., 11. Because water and gasoline have different properties, soil retains them differently.

[225]Ibid.

[226]American Petroleum Institute. 1979. repr. 1986. Underground Movement of Gasoline on Groundwater and Enhanced Recovery by Surfactants. Health and Environmental Sciences Department, Texas Research Institute. API Publication 4317, 8.

[227]American Petroleum Institute. 1980, 1st ed. Underground Spill Cleanup Manual, 29-32.

[228]"Understanding The Underground: The First Step Toward Cleanup," Hazardous Waste Management.

[229]American Petroleum Institute. 1980, 1st ed. Underline Spill Cleanup Manual, 29-32.

[230]Ibid., 18.

[231]Ibid., 14-18.

[232]Ibid., 18.

[233]Ibid., 11.

[234]Ibid., 4-6.

[235]"Understanding The Underground: The First Step Toward Cleanup," Hazardous Waste Management Fall 1987.

[236]Ibid., 4-5.

[237]American Petroleum Institute. 1980, 1st ed. Underground Spill Cleanup Manual.

[238]Ibid., 11.

[239]"Understanding the Underground: The First Step Toward Cleanup," Hazardous Waste Management, Fall 1987.

[240]American Petroleum Institute. 1980, 1st ed. Underground Spill Cleanup Manual.

[241]Ibid., 23.

[242]Ibid.

[243]American Petroleum Institute. 1979, repr. 1986. Underground Movement of Gasoline on Groundwater and Enhanced Recovery by Surfactants.

[244]American Petroleum Institute. 1980, 1st ed. Underground Spill Cleanup Manual, 31-32.

[245]Fairfax County, Office of Comprehensive Planning, Gasoline Rupture in Centreville, (Fairfax, Virginia: Board of Supervisors, 15 June 1987), 6.

[246]Ibid.

[247]Fairfax County, Office of Comprehensive Planning, Prohibition of Transmission Line in Subdivision Lots, (Fairfax, Virginia: Board of Supervisors, 17 September 1976).

[248]Fairfax County, Office of Comprehensive Planning, Annual Plan Review, (Fairfax, Virginia: Board of Supervisors, March 1982), 44.

[249]Fairfax County, Office of Comprehensive Planning, Item in Countywide Plan Review Re. Pipeline Construction, (Fairfax, Virginia: Board of Supervisors, 28 June 1982), 6.

[250]Fairfax County, Office of Comprehensive Planning, Concern For Safety From Gas Explosions in The County, (Fairfax, Virginia: Board of Supervisor, 17 October 1983).

[251]Fairfax County, Office of Comprehensive Planning, Spilling of Jet Fuel in The County, (Fairfax, Virginia: Board of Supervisors, 23 July 1984).

[252]Fairfax County, Office of Comprehensive Planning, Relationship of Gasoline Pipeline to Subdivision Lots, (Fairfax, Virginia: Board of Supervisors, 19 November 1984).

[253]Fairfax County, Office of Comprehensive Planning, Pipeline Safety, (Fairfax, Virginia: Board of Supervisors, 14 January 1985).

[254]Local Government Information Network (LOGIN) request, September 15, 1987. County of Fairfax Virginia. No response to request for information on setback requirements in zoning ordinances or code provisions or regulations pertaining to transmission pipelines.

[255]Fairfax County Code. Supp. No. 1, 12-77. Chapter 112, 20-32, definition is "[t]hat which is built or constructed."

[256]This is an assumption of the author derived from the discussion by the Board on June 15, 1987, about the protection of County citizens from harm due to pipeline accidents. Board Summary, June 15, 1987.

[257]U.S. Department of Housing and Urban Development, Office of Policy Development and Research. Safety Considerations in Siting Housing Projects. [Washington, D.C.] U.S. Department

of Housing and Urban Development, Office of Policy Development, 1975.

Urban Development Siting with Respect to Hazardous Commercial/Industrial Facilities, Rolf Jensen, 1982.

[258]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.

[259]Al Garnett, DOT, interview by author, 17 July 1987, Washington, D.C.

[260]U.S. Department of Housing and Urban Development. Office of Policy Development and Research. Safety Considerations in Siting Housing Projects.

[261]Ibid.: The equation to calculate the flow rate is

$$\frac{U^2}{2} = \frac{G_c}{p} (P_2 - P_1)$$

where U = velocity of liquid flow in the pipe (ft/sec)
G_c = 32.2 poundal/lb. force
P_2 = pipeline pressure ($lb._f$/sq.ft.)
P_1 = atmospheric pressure ($lb._f$/sq.ft)
p = density of the liquid fuel-53lb/cu.ft.

This can be stated as:

$G - 77.68\ D^2\sqrt{-p-15}$

where G = liquid flow rate (gallons/sec.)
D = diameter of pipe (ft.)
p = pipeline maximum pressure (psi)

If using the Colonial pipeline incident as an example, 190 psi (the pressure at the time of the accident) into the above equation, with a 32-inch diameter (2.67 ft.)

$77.68\ D^2\sqrt{-P-15}$
$77.68(2.67)^2\ 190-15$
$77.68 \times 7.13 \times 13.23 = 7326$ gal.

The pipeline was not shut down for 10 minutes. (10 minutes = 600 seconds).

$600 \times 7326 = 4,395,849.6$ gallons

Note that the initial estimate of the spill at Singleton's Grove was 21,000 gallons. This difference is due to the fact that the ADL calculation is based on a complete guillotine break in the line, but the Colonial line was only punctured.

Also, the variable for pressure of blast, is calculated differently for gases than for liquids. For gases, the formula is to solve an equation for the "TNT equivalent" using

$$TNT_{eq} = \frac{RT \ln P_1/P_2}{A_{TNT}M}$$

Where TNT_{eq} = TNT equivalent ($lb._{TNT}/lb.$ gas or gm_{TNT}/gm_{gas})

R = molar gas constant = 1.987 cal/mole°K

T = final temperature = 300°K

P_1 = initial pressure at which rupture takes place (psi)

P_2 = final pressure - 14.7 psi

M = molecular weight of gas (lb./lb. mole or gm/gm mole)

A_{TNT} = work function TNT - 1120 cal/gm

[262]Fairfax County Code. Supp. No. 1, 12-77. Chapter 13. Fairfax County has many requirements for landscaping, and open space.

[263]American Petroleum Institute. 1979. repr. 1986. Underground Movement of Gasoline on Groundwater and Enhanced Recovery by Surfactants.

[264]Ibid.

[265]U.S. Department of Housing and Urban Development. Office of Policy Development and Research. Safety Considerations in Siting Housing Projects.

[266]Ibid.

[267]Ibid.

[268]The results of the calculation are, for Fairfax County, one fatality every 200 years and one injury every 30 years from a pipeline accident. In reality, in one twelve-year period there were four deaths. It can be speculated that if the product had ignited at Singleton's Grove, there would have been upwards of ten fatalities.

[269]Memo from J. Hamilton Lambert, County Executive, Fairfax County, June 14, 1984, to the Board of Supervisors.

[270]For 21,000 gallons spilled
Fire Width = 290 feet
Fire Height = 235 feet

Fire Area = 66,700 square feet
Fire Separation (People) = 975 feet
Fire Separation (Building) = 205 feet

This means that there should be no impact on people 975 feet away. But this assumes that all of the gasoline is contained in one area and that the fire is ignited immediately.

[271]U.S. Department of Housing and Urban Development. Office of Policy Development and Research. Safety Considerations in Siting Housing Projects, 61-68. If it is windy, then the fire may be blown in a direction farther than calculated.

[272]American Petroleum Institute. 1979, repr. 1986. Underground Movement of Gasoline on Groundwater and Enhanced Recovery by Surfactants.

[273]The trans-Alaskan pipeline route was studied and mapped for soil conditions, hydrology, topography, and geology to determine the best placement of the valving system in order to minimize the amount of oil spilled from a leak. Lloyd Ulrich, DOT. DOT, OPS Docket No. Pct. 74-12.

[274]Federal Register, February 10, 1984, 5100-5108. The Arthur D. Little, Inc., study along with the Rolf Jensen & Associates study is used by HUD to calculate setback safety distances for HUD-funded housing projects.

[275]Hazardous facilities are defined as storage facilities which contain 100 gallons or more of combustible liquids or "...substances of an explosive or fire prone nature." This also includes liquid propelled ICBM missile sites. Federal Register, February 10, 1984, 5103.

[276]The HUD rule is no closer than 10 feet to the easement of a pipeline.

[277]U.S. Department of Transportation. Research and Special Programs Administration. Pipeline Safety Regulations. ([Washington, D.C.]: U.S. Department of Transportation, Research and Special Programs Administration, 1986), 575-582. DOT's 50-foot setback applies to liquid lines, whereas FERC's applies to natural gas. It has been stated by federal authorities that the 50 feet is not based on any research or calculation. Al Garnett of DOT also has a calculation for a "dispersion distance" for Liquified Natural Gas facilities.

[278]U.S. DOT, Section 193. However, DOT personnel have suggested that the 220 yards is not based on research but is an engineering mapping scale.

[279]Daniel R. Mandelker, Land Use Law, 15-16.

"The fifth amendment to the U.S. Constitution provides that "private property [shall not] be taken for public use, without just compensation." Most state constitutions contain similar clauses, and the fourteenth amendment makes the federal taking clause applicable to states. The taking clause raises the all-important taking issue in land use regulation. Local governments enact land use regulations under their police power, which does not require payment.

Compensation. When a land use regulation excessively restricts the use of land without compensation, the restricted landowner can argue that a taking of his land without compensation has occurred.

A strict reading of the taking clause would suggest that it does not apply to land use regulation, but only when a government entity takes or physically occupies land for a public use.

A land use regulation, as enacted, may be so restrictive that no application of its requirements can avoid a taking. An example might be an open space regulation that allows no substantial development of any kind. In this type of case the land use regulation may be a "facial" taking of property, and landowners can bring a facial challenge to its restrictions based on the taking clause.

Other land use regulations may not be a facial taking but may possibly be a taking "as applied" to a particular property. An example is a zoning ordinance dividing a community into land use districts. The ordinance may not be a taking as applied to some property, but may be a taking as applied to other property it covers. In this example, a landowner can argue that the zoning ordinance is a taking "as applied" to his property.

The judicial remedies available for an unconstitutional taking of property must also be understood. Read literally, the taking clause forbids the taking of property without compensation. It appears to require compensation when a land use regulation takes property without making compensation available. Despite this literal reading, the state courts do not provide compensation for an unconstitutional taking. They simply invalidate the land use regulation, although there are some exceptions to this rule in some states.

Cases also arise in which the landowner brings an "inverse condemnation" action to claim compensation for an unconstitutional taking. The action is inverse because the landowner rather than the government entity brings the action in court to claim compensation under the taking clause."

[280]Ibid.

[281]See note #254.

[282]Black's Law Dictionary, 5th ed. " stare decisis.

[283]Daniel R Mandelker, Land Use Law, 16-17.
An analysis of taking doctrine is complicated by the failure of most courts to clearly articulate their taking theory. Taking doctrine can be clarified by dividing taking cases into categories that distinguish the taking problems courts consider...
The following categories are one possible grouping, although they are not always easy to apply. They do reflect academic theories of the taking clause, which are discussed later and which sometimes appear in the court decisions...
The categories selected here include only those cases in which the property owner claims a "regulatory" taking of land through land use regulation. The "physical occupation" cases, in which a government entity physically occupies land, are excluded. An example is the case in which a government entity constructs a highway embankment that causes flooding on adjacent land. The courts usually find a taking in the physical occupation cases.

[284]Ibid. Sec, 8.19
Federal and state constitutions prohibit the taking of property without just compensation. In theory, this provision authorizes an award of compensation to a landowner when a court finds that her property has been "taken" by a land use regulation. A taking occurs when a land use regulation, such as a zoning ordinance, applies a classification to the landowner's property that a court finds unreasonable. Courts differ in the tests they apply to determine whether a taking has occurred. A commonly applied standard requires a finding that no reasonable use of the land is possible.
Inverse condemnation is a remedy implied from the Constitution and in most states is self-executing. The landowner bases his action for inverse condemnation directly on the Constitution, and a statute conferring the remedy is not required. Landowners may also bring inverse condemnation actions based on the federal taking clause in federal court.
The landowner's condemnation action is "inverse" or "reverse" because he claims that the municipality has taken his property through land use regulation, but has

not paid the compensation to which he is entitled. The landowner asks the court to compel an award of compensation for the property interest that has been taken.

Inverse condemnation is a remedy to enforce a constitutional obligation. This remedy does not independently provide constitutional protection for the property owner from excessive land use regulation. A landowner may bring an inverse condemnation action only if the court first finds that a taking has occurred."

[285]Ibid.

[286]Ibid., Sec. 8.26 and 8.27

Section 1983 of the federal Civil Rights Act of 1871 provides:

> Every person who, under color of any statute, ordinance, regulation, custom or usage, of any State..., subjects, or causes to be subjected, any citizen of the United States or other person within the jurisdiction thereof to the deprivation of any rights, privileges or immunities secured by the Constitution and laws, shall be liable to the party injured in an action at law, suit in equity, or other proper proceeding for redress. U.S.C. Section 1983.

The basic elements of a Section 1983 action require plaintiffs to prove a deprivation of rights secured by the Constitution or federal laws by a defendant acting under "color of law." Adickes v. S. H. Kress & Co., 398 U.S. 144 (1970). The "color of law" requirement in Section 1983 is usually coextensive with the state action requirement imposed under the fourteenth amendment. "Color of law" is present not only when officials act within the scope of their authority but also when they misuse authority conferred by a statute or ordinance. Monroe v. Pape, 365 U.S. 167 (1961). Under Monell, Section 8.25, a municipality is also liable for a constitutional deprivation based on a "policy statement, ordinance, regulation, or decision officially adopted and promulgated by that body's officers."

[287]Ibid., Sec. 8.33

A local zoning action that is clearly arbitrary can provide the basis for a Section 1983 action. In Wheeler v. City of Pleasant Grove, 664 F.2d 99 (5th Cir. 1981), the city revoked a building permit for an apartment complex after a local referendum showed overwhelming resistance to the project. The court upheld a finding

that a Section 1983 violation had occurred. It held that the ordinance revoking the permit was a 'confiscatory measure' that was a taking of property. Neither was 'the city's purpose in enacting the measure...rational.'

[288]The Comprehensive Plan of Fairfax County's policy statements regarding pipelines is located in the Environmental Policy section of the Plan.

[289]Daniel R. Mandelker, Land Use Law , 325.

Federal, state, and local governments have adopted a number of regulatory programs for the protection of environmental areas. These programs include wetland and floodplain regulation and zoning for the protection of agricultural land.

[290]Ibid.

Wetland regulation imposes restrictive controls in wetland areas to preserve their environmental function by keeping them free from development.

[291]Ibid.

Floodplain regulation imposes restrictive controls in floodways and adjacent floodplains. These controls restrict development in areas where flooding can cause loss of life and damage to property.

[292]Ibid., Sec. 12.8.

The cases have upheld floodplain regulations against taking objections. [10]. The prevention of flood damage serves well-established police power purposes and supports the constitutionality of restrictions on development imposed by floodplain ordinances.

Although not having quite the influence the Just case, Section 12.6 has had on wetlands taking cases, Turnpike Realty Co. v. Town of Dedham, Section 12.7, is an early leading case, upholding floodplain regulations against taking objections. The court upheld a floodplain ordinance prohibiting all developmental uses, even though the value of the restricted property was allegedly reduced from $431,000 to $53,000. The court held that floodplain regulation purposes...flood danger, protected other landowners from floodplain development, and protected the 'entire community from individual choices of land use which require subsequent public expenditures for public works and disaster relief.' The court also held that the property owner had not been deprived of all of the use of its land as a number of nonstructural uses were allowed. The court balanced the restrictions on the property 'against the potential harm to the community from

overdevelopment of a flood plain area.' It then applied standard taking law to find no taking even though there had been a substantial diminution in the value of the restricted property. [11].

A number of cases have emphasized flood dangers in rejecting taking objections to floodplain regulations. [12]. More recent floodplain taking cases, like the wetland cases, have also been influenced by the favorable holding in Penn Central. See Section 12.6 Krahl v. Nine Mile Creek Watershed Dist., 283 N.W.2d 538 (Minn, 1979), is a case in this category. A landowner denied a permit to construct a building in a floodplain brought an action challenging the floodplain regulation as a taking. The court observed that the filing necessary for the building would create a flood danger, noted that a number of nonstructural uses of the land were allowed, and applied a balancing test to uphold the regulation. The court also noted that the restrictions on the land were not permanent and would be modified once permanent flood control facilities were constructed. The court cited Penn Central for the proposition that 'this is not a case where a property owner is burdened with a restriction without receiving a reciprocal benefit in is favor.' (13).

An even stronger statement that the ecological purposes of floodplain regulation resolve taking questions appeared in Usdin v. State, 414 A.2d 280(N.J.L. 1980), aff'd, 430 A.2d 949 (N.J. App. Div. 1981):

> (A) proper balancing of ecology...is critically significant in determining whether a compensable taking has occurred. If the purpose of the restriction was to prevent an abuse and the restrictions are reasonably related to that end, the act of restricting is a proper exercise of the police power.

General approval of floodplain regulation, of course, does not preclude taking objections when a floodplain restriction is not supported by a finding that flood dangers exist on the restricted property. Sturdy Homes, Inc. v. Township of Redford, 186 N.W.2d 43 (Mich. App. 1971). (14).

[293]"Takings" by Land Use Regulations, Michael S. Horwatt, 1.: "The Court in First Church did not consider the flood control ordinance at issue actually constituted a 'taking.'"

Also see First English Evangelical Lutheran Church v. County of Los Angeles 55 U.S.L.W.1199.

[294]Slip Opinion. Nollan Et Ux v. California Coastal Commission, No. 86-133. (U.S. Supreme Court, decided 26 June 1987).

[295]Ibid., I.

[296]Ibid.

[297]Ibid., 15-16.

[298]Fairfax County Office of Research and Statistics. The average value of a single family home in Fairfax County is $203,000.

[299]An acre is 43,560 square feet. Therefore, a perfectly square acre would have sides of 208.7 feet each.

[300]208.7 ft. x 50 ft. = 10,435.5 square feet

[301]10,435.5/43.560 = .24 or approximately 25 percent.

[302]A mile = 5,280 feet

[303]5,280 ft. x 50 ft. = 264,000 sq. feet
264,000/43,560 = 6.0 acres
out of 25.3 acres

[304]5,280 ft. x 660 ft. = 3,484,000 sq. feet
3,484,000/43,560 = 80.0 acres

[305]151 miles x 5280 ft. = 797,280 feet
797,280 ft. x 100 ft. (50 ft. on each side of the easement) = 79,728,000 sq. ft.
79,728,000/43,560 = 1,830.3 acres

[306]U.S. Supreme Court has been using a heightened scrutiny in analysis of land use regulations. And the court, as one legal observer has noted, is finding more on equitable, or fair, ground rather than technical. Professor Joseph Broudis, George Mason University Law School.

[307]Grayson P. Haynes, "Litigating a Zoning Case." Virginia Bar News, June 1987, 17.
Dillon Rule is followed in Virginia. The rule is that localities cannot create any laws nor act in any function unless that power has been specifically conferred on it by the state.

[308]Daniel R. Mandelker, Land Use Law, Sec. 8.23.:

> The exercise of zoning and planning functions is held to be a governmental activity for which no tort liability attaches under the historical rule that local governments are immune from liability for damages arising out of the

exercise of governmental activities. Practically all states have now abolished governmental immunity in tort and have enacted statutes or adopted judicial doctrine imposing tort liability on municipalities. Under these statutes and judicial doctrines, municipalities usually remain immune for the performance of discretionary as distinguished from ministerial functions, a category that includes most land use control responsibilities.

[309]Ibid., 7.:
The Supreme Court has recognized absolute immunity for federal, state, and regional legislators when acting in a legislative capacity. Lake Country Estates, 440 U.S. at 404. It has not ruled on the immunity of purely local legislators. Id. at 404 n.26. However, most circuits have extended absolute immunity to local legislative officers. E.g., Aitchison v. Raffiani, 708 F.2d 96 (3d Cir. 1983); Kuzinich v. County of Santa Clara, 689 F.2d 1345, 1349 (9th Cir. 1982); Hernandez, 643 F.2d at 1193; Gorman Towers, Inc. v. Bogoslavsky, 626 F.2d 607, 613 (8th Cir. 1980); Bruce v. Riddle, 631 F.2d 272, 279 (4th Cir. 1980).

[310]Ibid.:
The enactment of zoning and land use regulations is a legislative action. See Kuzinich, 689 F.2d at 1349 (enactment of general zoning ordinance legislative act); Hernandez, 643 F.2d at 1191 (mayor's veto of re-zoning ordinance legislative act); Gorman Towers, 626 F.2d at 613 (passage of zoning ordinance legislative act); Bruce, 631 F.2d at 279-280 (voting on ordinance and meeting with partisans of challenged ordinance legislative activities).
However, actions that are more specific than enactment of general zoning ordinances may be administrative or executive in nature rather than legislative. See Cutting v. Muzzey, 724 F.2d 259 (1st Cir. 1984) (imposition of conditions on granting of specific permit administrative act); Kuzinich, 689 F.2d at 1350.

[311]Fairfax County Code. Supp. No. 1, 12-77. Sec. 2-414.

[312]U.S. Department of Transportation. Research and Special Programs Administration. Pipeline Safety Regulations.

[313]Fairfax County Code. Supp. No. 1, 12-77. Chapter 112.

[314]U.S. Department of Housing and Urban Development, Office of Policy Development and Research. Safety Considerations in Siting Housing Projects. ([Washington, D.C.]: U.S. Department of Housing and Urban Development, Office of Policy Development

and Research, 1975), 29. Chlorine is transported by rail. The evacuation area for a spill may be measured in miles.

[315]Hot Zone is a Fire Department term meaning the exact point or location of an emergency condition, and its immediate vicinity (i.e., the place from which fire department personnel must use equipment to quell or subdue an actual or potential fire).

[316]Fairfax County 1988 Public Facilities Manual.

[317]In the southwestern portion of Fairfax County, one easement contains a 36-inch Columbia and a 30-inch Washington Gas natural gas transmission pipeline alongside a 6-inch Plantation hazardous liquid transmission pipeline.

[318]In 1980, when Colonial laid its 36" line, no special exception applications or building permits were required because these types of pipelines need only to have a Planning Commission, Code of Virginia Title 15.1-456, public hearing for approval.

[319]U.S. Department of Housing and Urban Development, Office of Policy Development and Research, Safety Considerations in Siting Housing Projects.

[320]Fairfax County 1988 Public Facilities Manual.

[321]The turning path radius for larger vehicles, as specified in the American Association of State Highways and Transportation Officials (AASHTO) Manual titled "A Policy on Geometric Design of Highways and Streets," is 45 feet.

[322]Fairfax County 1988 Public Facilities Manual.

[323]At Singleton's Grove, the site plans show that the proposed New Braddock Road will run parallel and immediately adjacent to the north side of the Colonial easement. This street would fulfill the suggested restricted approach swath requirements on one side of the pipeline.

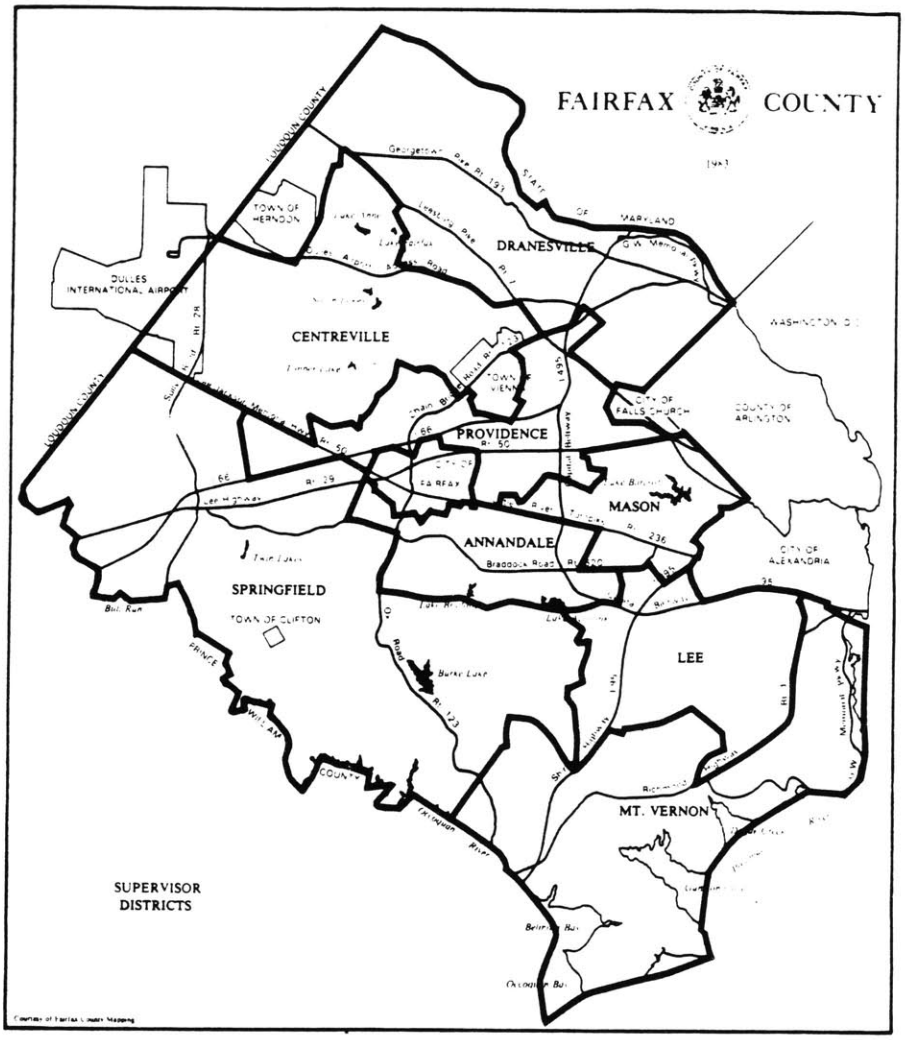
[324]On a visit to the Singleton's Grove site, it was observed that the pipeline easement was being utilized as a storage area for a large steam shovel and the wooden A-frames for some of the homes under construction. It is within Colonial's purview to allow such activity, but this would clearly impede vehicular movement if the easement were needed as a fire equipment ingress/egress maneuverability corridor. Also, mounds of dirt had been piled up on top of the easement and pipeline markers had been knocked down.

[325]Virginia Citizens Planning Association. 1984, 2d ed., Community Planning Series, Vol 5., The Language of Planning. Virginia Cooperative Extension Service and Virginia Department of Housing and Community Development, Richmond, Virginia, 11:

> The transfer of property rights from private to public ownership. Land so conveyed to the local government may be used for streets, schools, parks, utilities, etc. The governing body must formally accept the dedication for the transaction to be complete.

[326]Ibid., 17.

APPENDIX I



Fairfax County At A Glance

County Formed	**June 19, 1742**
Net Area	**399 square miles**
Population, January 1985	**668,290**
Number of Public Schools 1985-86	**158**
Special Education Centers	**20**
School Membership 1985-86	**125,516**
Highest Land Elevation	**580 feet**

Because postal addresses use place names without regard for actual boundaries, many residences and public facilities which actually are in Fairfax County have postal addresses suggesting that they are in the Cities of Fairfax, Falls Church or Alexandria.

In this handbook, supervisor districts, planning districts or neighborhood names such as Groveton and Franconia have been substituted for mailing addresses in many instances to clarify the locations of County facilities.

APPENDIX II

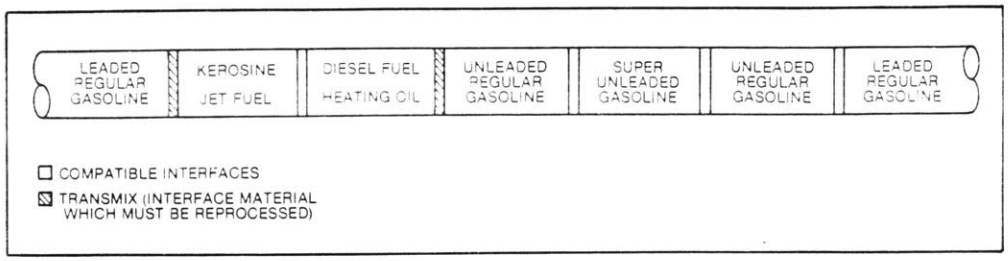


Figure 6.3. A typical products cycle of a products pipeline system (*Courtesy of the Association of Oil Pipe Lines*)

appearance of the product serves to verify the change from one shipment to another.

In transport, gasolines and distillate fuel oils are handled on a fungible or segregated shipment basis. At the present time, kerosines are shipped only on a fungible basis (i.e., confined with other kerosine having essentially the same properties with deliveries being made from any portion of the combined stream). This process allows shippers to tender smaller volumes (25,000 barrels minimum) than would be required for a segregated shipment (75,000 barrels minimum).

Figure 6.3 is a schematic representation of a typical cycle of batches. The sequence of products shown varies according to the types of products offered for shipment. The drawing represents a situation that might exist at any given time on a products line. It should be pointed out that it is not drawn to scale. For example, an interface might range from a few barrels to perhaps 15,000 barrels, while a batch of products might comprise a million barrels.

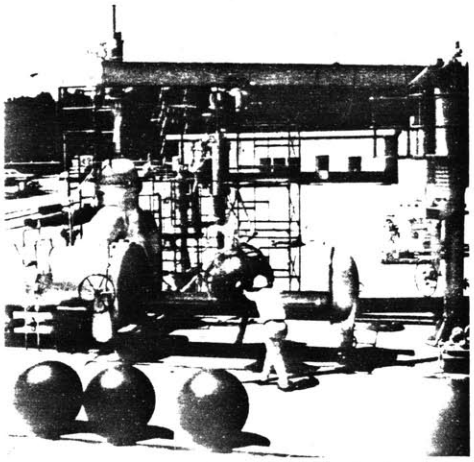


Figure 6.4. A sphere is used to clear water and sediment from a pipeline. (*Courtesy of the Association of Oil Pipe Lines*)

Batch Separators and Scrapers

Segregation of shipment occasionally (although not normally) is achieved via use of batch separators. In most cases, no separator is required since products move in turbulent flow regimen and the commingling of products at interfaces between shipments is tractable.

A common use of line scrapers or spheres is for pipeline cleaning (fig. 6.4). Regular scraper runs will remove water and sediment from the pipeline, thereby preserving product quality.

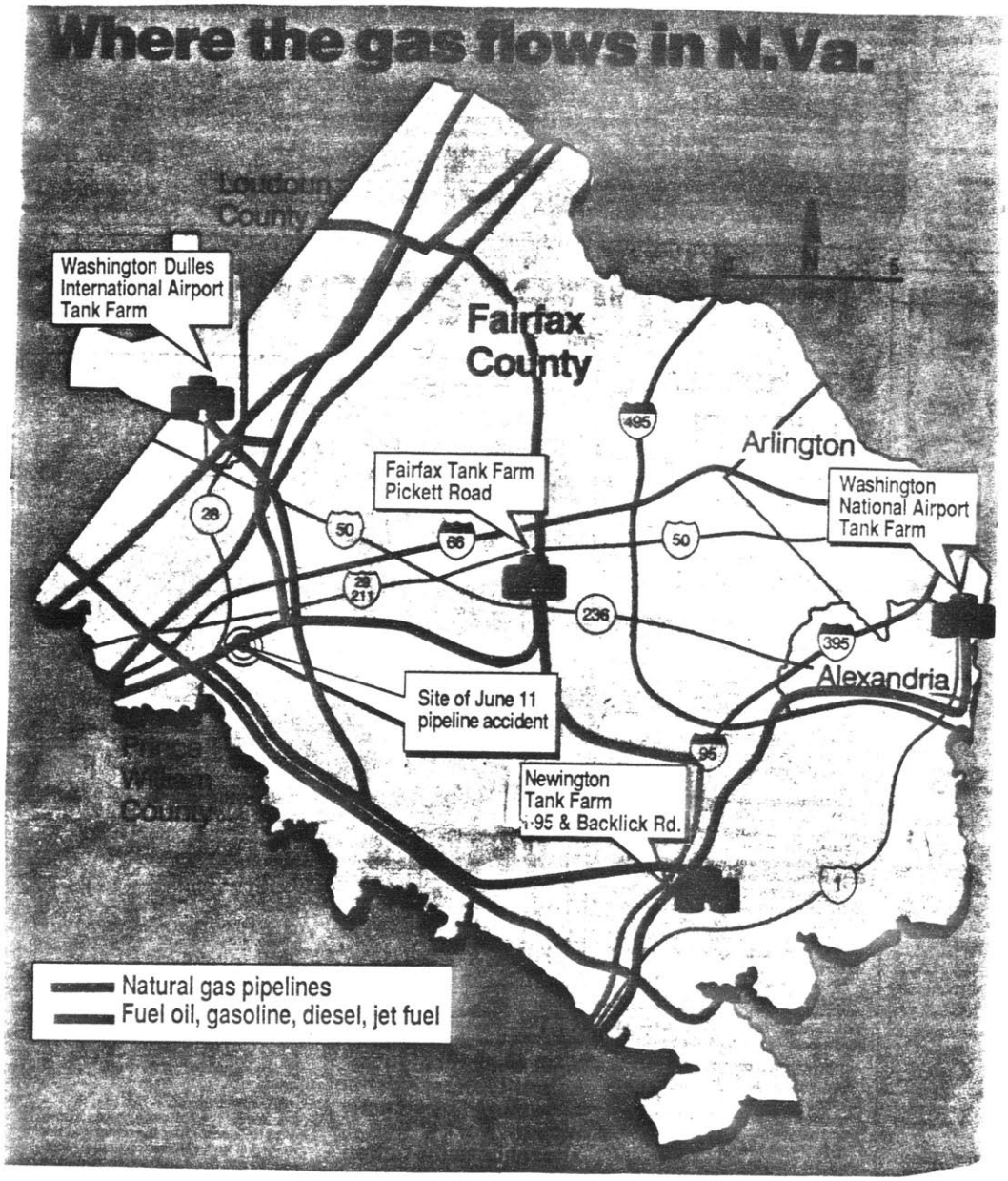
Booster stations along the line are designed to automatically pass the scrapers and spheres. Input stations, junctions, termini, and points where line diameter changes are normally equipped with receiving or launching traps for retrieving spheres and scrapers from the line or inserting them into a line leaving the station.

Product Measurement

Practically all measurements are made either by turbine meters (fig. 6.5) or positive-displacement meters (fig. 6.6). Conventional tank gauging of volumes may be resorted to in unusual situations.

Meter readings taken before and after deliveries are utilized to determine the volume of throughput. Meters are typically equipped with transmitting, remote-reading, and printout accessories to facilitate the delivery of correct product volumes and for preparation of delivery tickets. Often the data are transmitted to remote locations by various communications media (fig. 6.7).

APPENDIX III


Where the gas flows in N.Va.
Loudoun County
Washington Dulles International Airport Tank Farm
Fairfax County
Fairfax Tank Farm Pickett Road
Arlington
Washington National Airport Tank Farm
Alexandria
Site of June 11 pipeline accident
Newington Tank Farm I-95 & Backlick Rd.
Prince William County
495
50
66
29
211
236
395
95
1
Natural gas pipelines
Fuel oil, gasoline, diesel, jet fuel