Research and Developement of Oil and Gas Transmission Pipelines In Baton Rouge, Louisiana

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Disclaimer

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Abstract

This project is intended to supplement emergency response and planning for hazardous materials spills coming from transmission pipelines within the Baton Rouge, Louisiana vicinity. Over 688 miles of pipelines within the study area constitute a major source of oil spill emergencies. Assessment of digital petrochemical pipeline data is crucial for potential energy planning, environmental monitoring, disaster prevention, and emergency preparedness. Accurate pipeline maps and a Geographic Information System (GIS) compiled in this project will enable increased response efficiency by allowing emergency response teams to quickly assess the product, diameter, and operator of specific pipelines. In addition to oil, gas, and refined product transmission pipelines, chemical and other hazardous materials are transported by pipeline and have been included in the GIS. Emphasis was on transmission pipelines rather than on pipelines associated with gathering or distribution systems. Global Positioning System (GPS) point data were collected on pipeline crossings of public roads. These records contained accurate positional data, pipeline operator, emergency contact telephone number, and commodity transported by the pipeline. These data were compared to existing maps and digital pipeline data. Those data that did not conform to project guidelines were brought into compliance by comparisons with GPS point data and aerial imagery. Other pipeline data were developed with the imagery and point data. Source data research, field investigation

with GPS, remote sensing, and GIS analysis all provided a method for assessing the study area's pipelines and adjusting any spatially incorrect data.

1.0 Introduction

1.1 Background

This project is intended to supplement emergency response and planning for hazardous materials spills coming from transmission pipelines within the Baton Rouge, Louisiana vicinity. Over 688 miles of pipelines within the study area constitute a major source of oil spill emergencies. Assessment of digital petrochemical pipeline data is crucial for potential energy planning, environmental monitoring, disaster prevention, and emergency preparedness. Accurate pipeline maps and a Geographic Information System (GIS) compiled in this project will enable increased response efficiency by allowing emergency response teams to quickly assess the product, diameter, and operator of specific pipelines. In addition to oil, gas, and refined product transmission pipelines, chemical and other hazardous materials are transported by pipeline and have been included in the GIS. Emphasis was on transmission pipelines rather than on pipelines associated with gathering or distribution systems. Global Positioning System (GPS) point data were collected on pipeline crossings of public roads. These records contained accurate positional data, pipeline operator, emergency contact telephone number, and commodity transported by the pipeline. These data were compared to existing maps and digital pipeline data. Those data that did not conform to project guidelines were brought into compliance by comparisons with GPS point data and aerial imagery. Other pipeline data were developed with the imagery and point data. Source data research, field investigation with GPS, remote sensing, and GIS analysis all provided a method for assessing the study area's pipelines and adjusting any spatially incorrect data.

1.2 Objective

Any pipeline leak, large or small, can be dangerous to the public. These dangers include the obvious, such as volatile commodities exploding or inhalation hazards. Other hazards are not so obvious, such as small leaks that can seep through the porous Holocene alluvium that lies beneath the study area and into the southeast aquifer system. The resulting damage could be irreversible and detrimental to potable water supplies throughout the region. The data developed for this project can be used for emergency response as well as environmental and urban planning.

Creating a GIS of hazardous materials pipelines is detail intensive. The initial task was to determine the scope of data that existed in-house. Evaluating the existing digital and hard copy data submitted by pipeline operators was a time consuming task. Digital as well as traditional maps were intensively examined to determine spatial integrity. Third party data were useful in determining location and product of many pipelines. Most of the existing LGS pipeline data needed to be refined to conform to the digital mapping standards set forth by the Federal Office of Pipeline Safety, National Pipeline Mapping System (NPMS). This effort was completed with the use of Global Positioning System (GPS) technology. Field collection of point data where pipelines crossed public roadways was combined with digital orthophoto quarter quadrangle (DOQQ) imagery. This combination of data enabled the geographic adjustment of data to the federal mapping standard.

Some data were difficult to incorporate into a GIS for lack of adequate geographic control. The various types of data submissions, digital and hard copy, both displayed multiple problems. The focus of this study is to acquire Global Positioning System (GPS) point data of pipeline intersections of primary and secondary public roadways. We then compared these attributes to available digital pipeline data, other maps, and aerial imagery to develop a comprehensive pipeline GIS for the Baton Rouge metropolitan area.

1.3 Data Standards

The U.S. Department of Transportation, Office of Pipeline Safety created the National Pipeline Mapping System to "support the development of a reasonably accurate digital pipeline system" (www.npms.rspa.dot.gov). The standards for data submission created by the NPMS allow for no more than a 500 foot margin of spatial error for pipeline data. The Louisiana Geological Survey has adopted these guidelines for our pipeline GIS. The standards request that data be provided in digital format with accompanying metadata. If digital data are not available, then the operator may submit hard copy data. All submissions should contain geospatial data (location data), attribute data (descriptive information), and metadata (description of the content, quality, condition, and other characteristics of the submitted data).

The coordinate system used is based on the North American Datum (NAD) 1983. Unprojected data that employs a common projection, such as Universal Transverse Mercator (UTM), will be accepted. Digital data that do not employ real world coordinates cannot be accepted. These include CAD files that have origin points of 0,0. Measurement data can be metric or English units. Base maps used to develop the digital data should have scales of 1:24,000 to 1:1,200. The spatial accuracy of the digital data should be stated in the accompanying metadata.

The digital submissions should be of the following formats: ESRI's Arc/Info .E00 export files, ESRI's ArcView shapefiles (.shp), Intergraphs FRAMME and .DGN formats, MapInfo . mif files, and AutoCAD .dwg with required attribute data.

Hard copy data submissions are accepted, using appropriate base maps, in the formats listed below. USGS topographic maps, 7.5 minute/1:24,000 scale are the preferred base maps. Pipeline inventory and alignment sheets are acceptable if they have a scale between 1:24,000 and 1:1,200 and contain a minimum of four georeferenced control points per sheet. Also, any third party base maps can be used if the above scale and control parameters are followed. These third party maps must also include projection parameters, datum, and graphic scale.

2.0 Methods

2.1 Data Capture

The GPS point data were collected using Trimble Geoexplorer III GPS receivers and uploaded to computer via Trimble Pathfinder Office software. The field crew also documented the GPS point attribute data on field forms for a hard copy record. The collected spatial data were exported from Pathfinder Office in ArcView 3.2 shapefile format. Geographic parameters used are Universal Transverse Mercator (UTM) coordinate system, Zone 15, with the NAD 83 datum. The following is an outline of the methods employed during the project.

2.2 Outline of Methods

- I. Data Collection Route Planning
  - A. Study existing data for potential stops (design a route plan)
  - B. Examine aerial imagery for confirmation or other stops
  - C. Review traffic scenarios
- II. GPS data collection and compilation
  - A. Compile data dictionary
  - B. Complete route plan
  - C. Ensure all data is collected with the proper parameters and documented thoroughly
- III. Data projection and conversion
  - A. Upload GPS point data through Pathfinder Office
  - B. Export features as ArcView Shapefile
  - C. Load shapefiles into ArcView Project
- IV. Spatial feature GIS overlay and analysis
  - A. GPS point data theme
  - B. LGS digital pipelines theme
  - C. NPMS digital pipeline data
  - D. DOQQs and other themes from LaGIS CD to aid in analysis
- V. Assess spatial accuracy of digital pipeline data
  - A. Load digital point and linear pipeline data by operator into one view
    1. GPS point data shapefiles developed per operator
    2. Pipeline features, LGS and NPMS, per operator
    3. Analysis unique to each operator
  - B. Measure the distance between the GPS points and the corresponding crossing points, matched in terms of operator name
    1. Direct measurement using the measure tool in ArcView
    2. Select points by distance using “select by theme”
    3. Create buffers on pipeline features by operator
  - C. Create linear features for missing data utilizing DOQQs, GPS point data, and third party maps
- VI. Database normalization and quality assurance
  - A. Review digital attribute tables
  - B. Ensure database integrity (Quality Control)
- VII. Create CD and hard copy (report and maps)

2.3 GPS Data Integration

I. Data Collection Route Planning
   A. Study existing data for potential stops (design a route plan)
   B. Examine aerial imagery for confirmation or other stops
   C. Review traffic scenarios
II. GPS data collection and compilation
   A. Compile data dictionary
   B. Complete route plan
   C. Ensure all data is collected with the proper parameters and documented thoroughly
III. Data projection and conversion
   A. Upload GPS point data through Pathfinder Office
   B. Export features as ArcView Shapefile
   C. Load shapefiles into ArcView Project
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   A. Review digital attribute tables
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VII. Create CD and hard copy (report and maps)

2.4 GPS Setup and Export

The attributes entered into the data dictionary for GPS data collection include operator name, satellite geometry (automatically generated by the GPS unit), transported material, and diameter of the pipeline (if labeled). Collected data is exported from the Trimble Office software as shapefiles. The emergency telephone numbers were recorded on the hard copy field forms and added to the respective themes in the office, reducing data acquisition dramatically. A strong 95% of the recorded PDOPs (satellite geometry) throughout the field measurements were well within an acceptable range. Spatial data recorded by the GPS units eliminated the possibility of transcription errors that can occur with hard copy conversion from field forms. Hard copy transition is cumbersome and awkward, and can easily compromise data accuracy.

2.5 GPS Point Shapefile Analysis

Upon completion of field investigation, an analysis was performed on existing maps, digital pipeline data, and pipeline data received from the NPMS. This was accomplished by creating unique pipeline and GPS point attribute files per operator. Spatial accuracy of linear features was determined by three methods. The first method, simple but effective, utilized the measure tool directly within the view window of the project. GPS point distance from pipeline features were directly measured and compared to DOQQs.(See Figure 2.2.) This method is very useful when analyzing point data mostly in urban areas where pipeline clusters may inhibit auto analysis offered by GIS. This method was employed for LGS and NPMS digital pipeline data. All results of the analysis are found in the analysis section.

Secondly, under the Theme menu, "select by theme" allowed the selection of GPS point features in the active theme that were within a defined distance. Standards from the federal pipeline mapping initiative were used to define these parameters; 0-50 feet as excellent, 51-300 feet as very good, 301-500 feet as good, and over 500 feet as poor spatial quality. (See Figure 2.3.) This method was used for LGS digital data and NPMS pipeline data. As the distance was defined, the GIS software would highlight the points that fell within the defined parameters. Separate shapefiles were created for these selected points and compared to digital and hard copy pipeline data. This method proved useful for rural areas or areas where there were no clusters of pipelines. As previously noted, not all pipelines were recorded in the GPS. This was a result of pipelines being clustered and the resulting time required to log these as point features in the GPS. In the interest of efficiency, it was preferable to record each pipeline operator as one point feature, while writing the number of pipelines and the respective commodity on the field forms. Once in the office, these unique pipeline features were incorporated into the shapefile database.

The final method of spatial analysis involved using the "create buffers" option under the Theme menu. Buffers of 50 feet were created on each operator pipeline features. (See Figure 2.4.) These were saved as themes in a separate directory and analyzed against the pipeline features and GPS point data. Each GPS point and pipeline feature was reviewed for spatial accuracy. These methods were employed instead of a user created ArcView extension “Theme intersections to points” because of the nature of GPS point data collection. Not all points could be collected directly above the pipelines, resulting in phantom errors. It is difficult to incorporate an algorithm in an automated analysis routine that takes into account the noted offsets introduced by limited safe access to pipeline witness posts.

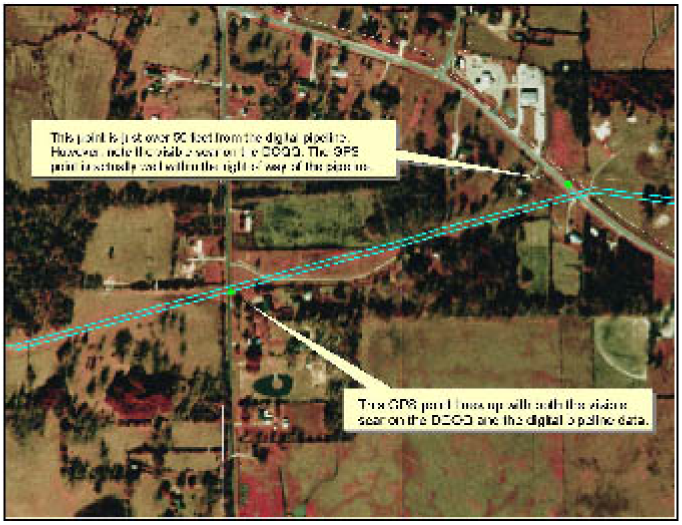

Figure 2. Using the measure tool in Arc View 3.2.

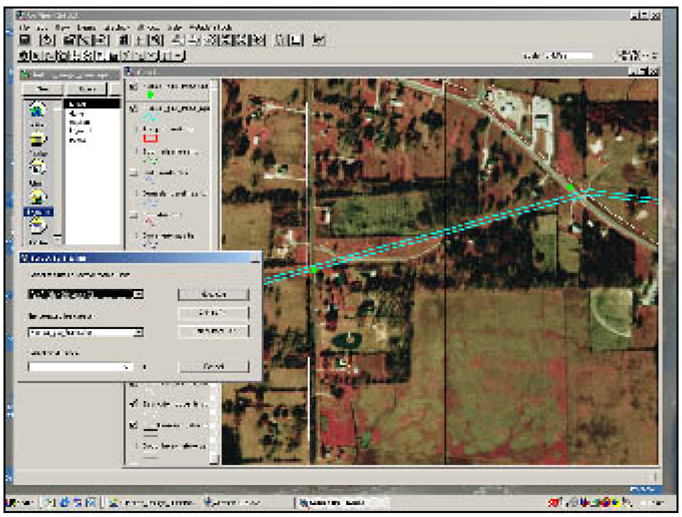

Figure 3. GPS point data selected upon defined distance from pipeline features.

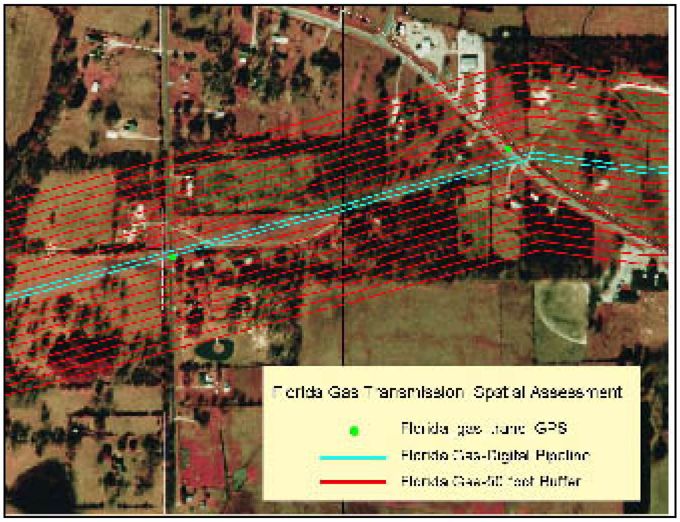

Figure 7. Tracing pipelines with the system name.

2.6 Evaluation of Analysis Techniques

Evaluation methods for spatial accuracy were developed for a standard analysis process. Each of the methods had their strong points. For example, direct measurement permits a spot check method for a quick ascertainment of data quality. Once a feature is found to have large error, further investigation using the buffer or select by theme method will show more feature displacement. Our data collection efforts were restricted by time and safety. Future efforts will incorporate real time differential GPS technology that will provide point accuracy to within one meter, but this may prove redundant and unnecessary. A more thorough analysis will come once every pipeline is logged into the GPS, allowing the researcher to quickly view all point data with no substandard file content. This method will require more data collection time, however, it will provide a more complete and accurate point data collection for detailed analysis.

Not all GPS point data were collected directly above pipelines. Sometimes offset positions were required. Most GPS point data were used for verification of existing pipeline data, hard copy or digital. Concern for the safety of the field crew and the time required to complete the point data collection were factors in the time spent at pipeline intersection locations. The collection of point data can be a time consuming task. Each point collected could take more than ten minutes to record digitally and document on hard copy forms. On occasion, poor satellite geometry or other interference would inhibit GPS data collection. This was most apparent when the point was surrounded by buildings, trees, or other obstructions. Multipath interference or the reflection of satellite signals off obstructions, could affect GPS point data quality. Post processing the GPS data reduced any multipath problems and allowed for an error budget of less than 10 feet. Sub-meter accuracy in point data collection is important where pipelines are clustered in groups of three or more. Locations with many pipelines were recorded per operator in the

GPS data collection unit, with each pipeline and commodity therein recorded on hard copy forms. This method reduced the time required to log each pipeline separately in the GPS. Imagine a location with 30 pipelines, as encountered on the west levee of the Mississippi River. The time to record each pipeline in the GPS data loggercould take 30 or more minutes. On the other hand, it takes less than ten minutes to record the name of the operator, note the presence of multiple features as one data point in the GPS data logger, and then write the commodities and other pertinent data on the field forms. The process of scrolling through the massive list of pipeline operators and commodities in the GPS datalogger is very time consuming. Efforts to narrow the operator or commodities lists proved very problematic. Omitted operator names or pipeline commodities can lead to confusion in point data compilation and analysis.

VIII. Results

The analysis of the LGS pipeline data revealed many problems with spatial data accuracy. The most notable problems were a result of inadequate data received from operators. Much of the data received prior to the implementation of the NPMS do not meet the standards for operator submissions. Most of the problems encountered were with maps of inadequate scale and detail level. Data digitized at less than 1:24,000 scale led to excessive cartographic displacement. In some areas, this spatial displacement was close to a mile. Also, linework representing pipeline features was often drawn with a very thick line (sometimes wider than the right of way in which the pipeline rested), introducing a large spatial error. Three categories of pipeline data were examined, adjusted or created with a thorough study of existing data.

Source data gathered by the LGS fell into three categories: large- scale or engineering diagrams with geographic control suitable for digitization, maps of small scale and poor geographic control that were not digitized (useful as reference material), and undocumented pipelines. While ensuring that all digital data were of the same geographic parameters, data were loaded and analyzed in ArcView 3.2.

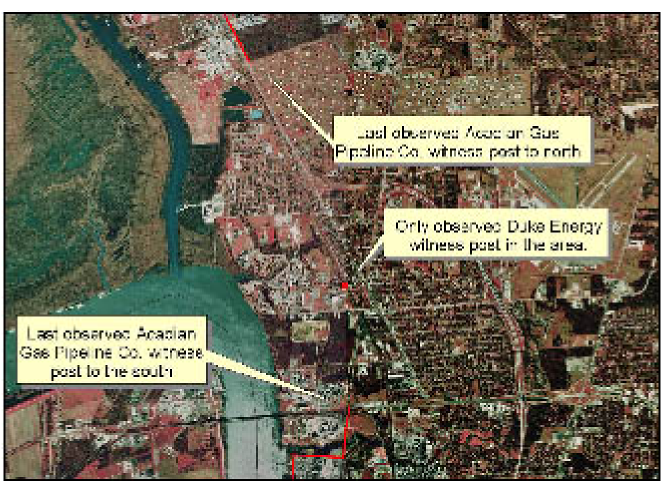

Figure 5. Segment of Acadian Pipeline disappears

IX. Digitally Developed Pipelines

The following operator data were developed with heads up digitizing technology utilizing DOQQs, GPS point data, and comparisons to third party maps (DTC Atlas). Trenching scars visible on the DOQQs were very useful for delineating the presence of pipelines. GPS point data indicated where pipelines crossed public roads.(See Figure 4.1.) Using a combination of third party map sources, GPS data, and DOQQs, pipeline features were developed for those operators who did not submit data to the NPMS or LGS. Pipeline features were created using ArcView 3.2 GIS software. Research showed that by following the trench and right of way features noticeable on the DOQQs and "connecting the dots" of GPS point features we could map pipelines with reasonable accuracy.

4.1 List of Pipeline Operations Developed Using GPS Point Data

This method was used to develop pipeline shapefiles of the following six operators:

British Petroleum Amoco (BP Amoco)
Equilon Pipeline Company LLC.
British Oxygen Company (BOC)
Louisiana Intrastate Gas Corporation
Cypress Gas Pipeline Company
Placid Refining Corporation

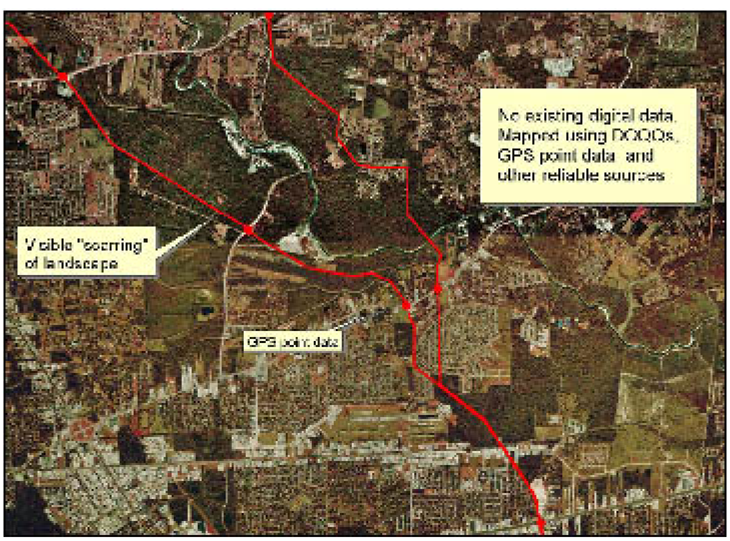

Figure 8. Pipeline features created for Equilon Pipeline Company.

X. Mississippi River Crossings

The most difficult part of this project is, by far, the collection and analysis of pipeline data for the Mississippi River. All data reviewed were very different. (See Figure 5.1.) Data submitted to the NPMS by ExxonMobil do not match any other source. The DTC Atlas has different pipeline commodities, operators, and spatial placement than the atlas published by the USACE. GPS point data collected on the levee in West Baton Rouge Parish and La 986 revealed few similarities to either of the aforementioned sources. This quandary resulted in a lengthy and confusing analysis. GPS point data were difficult to collect on the west levee because most witness posts face the river and are inaccessible. However, La 986 has many witness posts along the road. These data were collected and converted into a shapefile representing probable pipeline crossings. Further clarification of these crossings can only come from the pipeline operators.

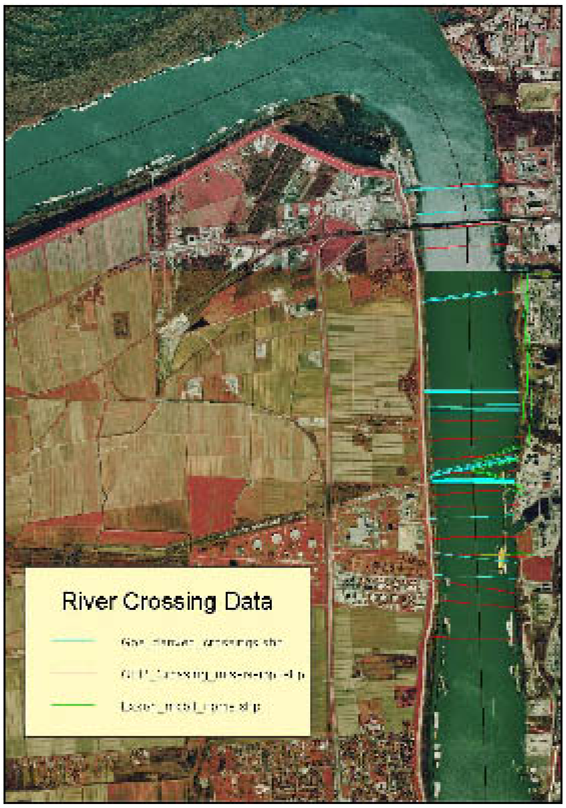

Figure 9. Contradicting data is confusing.

XI. Review of Directory of Petrochemical Directory

Research of the Mississippi River 1998 Directory of Petrochemical Industries, 1998 Homesite Company, has allowed for some confirmation of GPS point data and pipelines within the Baton Rouge study area. This publication contains a thorough review of the petrochemical industry along the river. Many of these plants use commodities produced from the ExxonMobil facility on Scenic Highway. These facilities have been contacted for pipeline data. No data have been received by the LGS for inclusion into the digital pipeline GIS. Most of these industries, however, do not operate their own pipeline systems outside of the plant property.

Primarily, the ExxonMobil refinery has roughly 424,000 barrels of crude oil per day coming into the plant for production of a range of products, from light ends (LPG) to waxes and petroleum coke. GPS point data collected on the west levee of the Mississippi River and LA 986 show 30 petroleum pipelines operated by ExxonMobil that are active, and two idle pipelines crossing the river. The diameters of these lines vary and are not labeled upon witness posts observed at the crossing. Data submitted by the operator to the NPMS reveal no petroleum pipelines in this location. The only petroleum pipeline data submitted are the idle systems between the dismantled tank farm and active tank facility and one pipeline coming in from the south along LA 30. Further data are expected to be forthcoming from the operator. As mentioned, ExxonMobil has been very cooperative in supplying data to the pipeline mapping effort.

ExxonMobil Chemicals Americas' major function is steam cracking petroleum light ends and downstream separation of olefins. These commodities are then sent to other ExxonMobil locations or customers for production of plastics, rubber, and adhesives, among other products. GPS point data are not conclusive as to pipeline locations, and no data were collected within facilities.

ExxonMobil Plastics utilize ethylene and other additives for raw plastics production. GPS point data confirmed pipelines transporting ethylene from the refinery operations to this location. Data submitted by the operator list LPG as the commodity transported by the pipelines. ExxonMobil Resins produces petroleum resin streams for use in adhesives. Again, GPS point data confirm transport of these commodities from the refinery. Likewise, Paxon, part of ExxonMobil Chemicals Americas, produces high density polyethylene. Confirmation of ethylene pipelines to this facility lies in GPS point data.

The Alcoa (Reynolds) site north of Baton Rouge, produces calcined coke for use in aluminum reduction processing. Four large rotary kilns are in use at this facility, each burning natural gas. There are gas pipelines, operated by Cypress Gas Pipeline Company, leading to the facility.

Albermarle Corporation's facility next to ExxonMobil Chemical is shut down and partially dismantled. Pipelines to this facility would be considered within the plant and thus have no collected GPS point data.

Allied Signal, Inc. is involved in CFC and alternative refrigerant production. This process utilizes various hydrocarbons. No pipelines were confirmed through comparison. The MRDPI indicates various hydrocarbons entering the plant with no corroborating data from either GPS point data or the DTC Atlas.

Deltech Corporation produces specialty monomers. GPS point data revealed two pipelines leading from the ExxonMobil facility to the plant. These are reflected in the

Directory of Industry as benzene and ethylene. However, the witness post reveals a commodity of petroleum. Clarification of these and other pipeline commodities awaits data from the operators.

DSM Copolymer produces rubber for tire production. The pipelines for this facility are also considered in-plant because of their vicinity to ExxonMobil.

Entergy Corporation has a steam cogeneration plant next to the Mississippi River. The energy for this activity is supplied by five 10 inch natural gas pipelines operated by Cypress Gas Company (Monterey Pipeline Co.), or one 16 inch pipeline operated by ExxonMobil. All of these pipelines are submerged in the river. GPS point data collected on the levee are not explicit as to the destination of the pipeline.

There are several brine pipelines believed to be buried under the river. The MRDPI indicates that Formosa Plastics has a brine line coming in from Bayou Choctaw. This, and an ethylene pipeline also reflected here, is supported by the DTC Atlas and GPS point data.

The Ferro Corporation (Grant Chemical Division) facility produces specialty chemicals for a wide range of uses. There are several GPS point data that reflect unmapped ExxonMobil propane and petroleum pipelines. These appear to originate from the ExxonMobil Maryland tank farm. Although this farm is dismantled, the pipelines are believed to go through the premises. The DTC Atlas has no pipelines that reflect these findings. Further data acquisitions from the operator will clear any questions resulting from this study.

The Georgia Pacific facility in Zachary, La, produces both finished and baled paper products. There are no documented pipelines for this facility.

The LaRoche plant uses alumina for catalysts, abrasives, and fire retardants. No documented pipeline features were found for this facility. There are several natural gas pipelines in the vicinity of this plant that may supply an energy source for operations.

A closed loop of acid pipelines exists between the ExxonMobil refinery and the Rhodia Acid facility north of US 190. Spent acid from refinery alkylation units is sent to Rhodia via pipeline, processed with sulfur, and returned via pipeline to the refinery. GPS point data supports the closed loop finding in the MRDPI. However, only one GPS point location is not sufficient for mapping pipeline features. Further data is needed from the operator.

7.0 Untraceable Pipeline Point Data

There were few GPS point data that were not attributable to documented pipelines, digitally mapped or hard copy. Most notably are clusters of ExxonMobil pipelines in the Scotlandville area (see ExxonMobil, 3.2.3, above). An attempt to map these pipelines is reflected in the theme layer "ExxonMobil_additional." This layer is a supplement to the

NPMS data and is incomplete for lack of supportive data. Also, in the same area, there are two witness posts that indicate acid pipelines. After investigation, these lines are believed to lie between the ExxonMobil refinery and Rhodia. Due to the limited GPS point data and the nature of the industrial area, these pipelines were not represented as linear features in the pipeline GIS.

Included in this category are two undocumented Scurlock Petroleum Company points and one ExxonMobil GPS point that are all in the Perkins Road, Siegen Lane area. Neither third party sources, existing digital data, DOQQs or field investigations were helpful in locating these pipelines. However, it is believed that the pipelines are part of a gathering system originating in the Siegen oil field. (See Figure 7.1.) It is possible that the Scurlock Petroleum pipeline, although not clearly marked in the study area, leads to the Scurlock Petroleum Wharf in St. Gabriel, Iberville Parish.

Finally, there is a point for Humble Petroleum Company on River Road, near the sewerage treatment facility. The witness post for this point is very old and illegible. The DTC Atlas shows no pipeline for this company or commodity in this area. It is very possible that this company no longer exists, has been incorporated into another operator, or is abandoned.

Figure 10. Untraceable pipeline witness posts.

Some data were difficult to incorporate into a GIS for lack of adequate geographic control. The various types of data submissions, digital and hard copy, both displayed multiple problems. The focus of this study is to acquire Global Positioning System (GPS) point data of pipeline intersections of primary and secondary public roadways. We then compared these attributes to available digital pipeline data, other maps, and aerial imagery to develop a comprehensive pipeline GIS for the Baton Rouge metropolitan area.

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8.0 Conclusions

The compilation and spatial analysis of digital pipeline data for the state of Louisiana is a complex process that will take years to accomplish. The quantity and quality of data sources and the unique geographic parameters of each inhibit the rapid production of a full scale pipeline GIS for the state. Assessment of digital data, field investigations, and the development of undocumented data are important to the statewide implementation of a pipeline GIS. This project has pointed to deficiencies in data collected over the years. The most prominent problems are spatial accuracy. Most of the digital data, either digitized by the LGS or submitted by the operators, were incorporated into the GIS with few problems. However, many questions regarding data content can only be clarified by those who developed the data. This is most evident with the ExxonMobil data received by the NPMS.

The data developed through this and future pipeline mapping projects will eventually provide a comprehensive pipeline GIS for the state of Louisiana. As more operators develop and submit pipeline data and as the LGS and cooperative partners develop a metropolitan pipeline GIS, we will have a comprehensive GIS.

Suggested future research efforts should focus on logging all pipelines within the GPS datalogger. This will be accomplished with the Trimble Beacon on a Belt real time differential GPS technology. These point features will be accurate to within five feet and can be used in future pipeline research efforts.

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The use of GPS technology is very useful in pipeline mapping. Eventually, with this and other pipeline mapping efforts sponsored by OSRADP, the puzzle of pipelines in Louisiana will be put together.

9.0 Appendix

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The data developed through this and future pipeline mapping projects will eventually provide a comprehensive pipeline GIS for the state of Louisiana. As more operators develop and submit pipeline data and as the LGS and cooperative partners develop a metropolitan pipeline GIS, we will have a comprehensive GIS.

Suggested future research efforts should focus on logging all pipelines within the GPS datalogger. This will be accomplished with the Trimble Beacon on a Belt real time differential GPS technology. These point features will be accurate to within five feet and can be used in future pipeline research efforts.

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The use of GPS technology is very useful in pipeline mapping. Eventually, with this and other pipeline mapping efforts sponsored by OSRADP, the puzzle of pipelines in Louisiana will be put together.

10.0 References

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