Disseminating Critical Pipeline Infrastructure Data with GIS

Authors: Samuel Hall, Amy Nelson, Dan Meehan, Jay Mukherjee

Abstract

The National Pipeline Mapping System (NPMS) is a GIS dataset owned by the U.S. Department of Transportation, Office of Pipeline Safety (US DOT OPS). It contains features and attributes representing hazardous liquid and gas pipelines in the U.S. The main challenge of this Federal program is protecting sensitive data while making it available to qualified parties for activities such as analysis and emergency response. The US DOT OPS and its contractor have designed an ArcIMS Web site displaying pipeline data with background layers such as quads, Unusually Sensitive Areas, High Population Areas, and Federally-owned property. Innovations on the ArcIMS site include the use of OpenGIS to display other agencies' data, granting users partial data access by password, advanced buffering and querying, and security features.

Introduction

The National Pipeline Mapping System (NPMS) is a geographic information system (GIS) created by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Pipeline Safety (OPS). The NPMS is the main tool available to the federal government to disseminate information about the United States' critical pipeline infrastructure. The NPMS consists of geospatial data, attribute data, public contact information, and metadata pertaining to interstate and intrastate gas and hazardous liquid transmission pipelines, liquefied natural gas (LNG) facilities, and hazardous liquid breakout tanks that are jurisdictional to OPS.

The Office of Pipeline Safety uses the NPMS as a tool to support various regulatory programs, pipeline inspections, and external customers. Prior to the terrorist attacks of September 11, 2001, the NPMS was available to the public. The terrorist attacks placed additional security concerns on the U.S. pipeline infrastructure. As a result, the Office of Pipeline Safety restricts access to the NPMS to federal, state, and local government agencies, including emergency responders. Pipeline operators are allowed access to their own pipeline data only. The NPMS is the only complete non-commercial source of transmission pipeline GIS data available to governmental agencies and pipeline operators. As such, the NPMS has become a critical piece of information for governmental agencies that are concerned with pipelines.

This paper will discuss five major points: 1) the NPMS data model; 2) operation of the NPMS National Repository; 3) the role of the NPMS at the U.S. Department of Transportation's Office of Pipeline Safety; 4) user access and data security; and 5) potential future direction of the NPMS.

NPMS Data Model

The NPMS is built from data submitted by pipeline, LNG, and breakout tank facility operators. Pipeline operators began voluntarily submitting data to the NPMS in March 1999. Since passage of the Pipeline Safety Improvement Act of 2002, transmission pipeline and LNG facility operators are required to submit mapping information to the NPMS and to update their submissions annually. Breakout tank operators submit data to the NPMS on a voluntary basis.

Attributes in the NPMS pipeline data layer include: OPS-assigned operator identification number; operator name; system name; subsystem name; diameter (voluntary data element); commodity; interstate/intrastate designation; operating status (in service, abandoned, retired); geospatial accuracy estimate. The NPMS does not contain information on interconnects, pump and compressor stations, valves, direction of flow, capacity, throughput, or operating pressure. In addition, distribution and gathering pipelines are not included in the NPMS. The nominal accuracy of data in the NPMS is +/-500 feet. Therefore, the NPMS should never be used as a substitute for contacting a one-call center before excavating.

Attributes in the NPMS LNG data layer include: OPS-assigned operator identification number; operator name; LNG facility name; operating status (in service, abandoned, retired); geospatial accuracy estimate.

Breakout tanks are mapped with points indicating tank farms. Using the Identify function on a tank farm allows the user to see attributes of individual tanks. These attributes include: company name and address; Facility Response Plan number; name and location of tank farm; name of individual tank; year tank was constructed; tank capacity; and tank commodity.

National Repository Operations

The National Pipeline Mapping System's National Repository is responsible for collecting and processing data for hazardous liquid and gas transmission pipelines, liquefied natural gas (LNG) facilities, and breakout tank farms. Operations of the National Repository are have been contracted to Michael Baker Jr., Inc since 1998.

The foremost duty of the National Repository contractor is to process submissions from pipeline and LNG operators. Submissions have four components: geospatial data, metadata, attribute data, and public contact information. Geospatial data arrives in many different formats (including paper maps, CAD files, and shapefiles) and is of varying quality. National Repository staff work with the pipeline operator to obtain acceptable data, and convert that data to append to the nationwide GIS layer. If data arrives as a paper map, the data is first digitized. Once appended, the data is uploaded to an ArcIMS site.

Custom programming plays an integral role in National Repository operations. Custom programs process common submission formats, such as CAD or comma-delimited text, into an ESRI GIS layer. Other custom scripts check for required attributes and build the attribute table of each submission. Additionally, custom programs handle metadata, attribute, and breakout tank submissions.

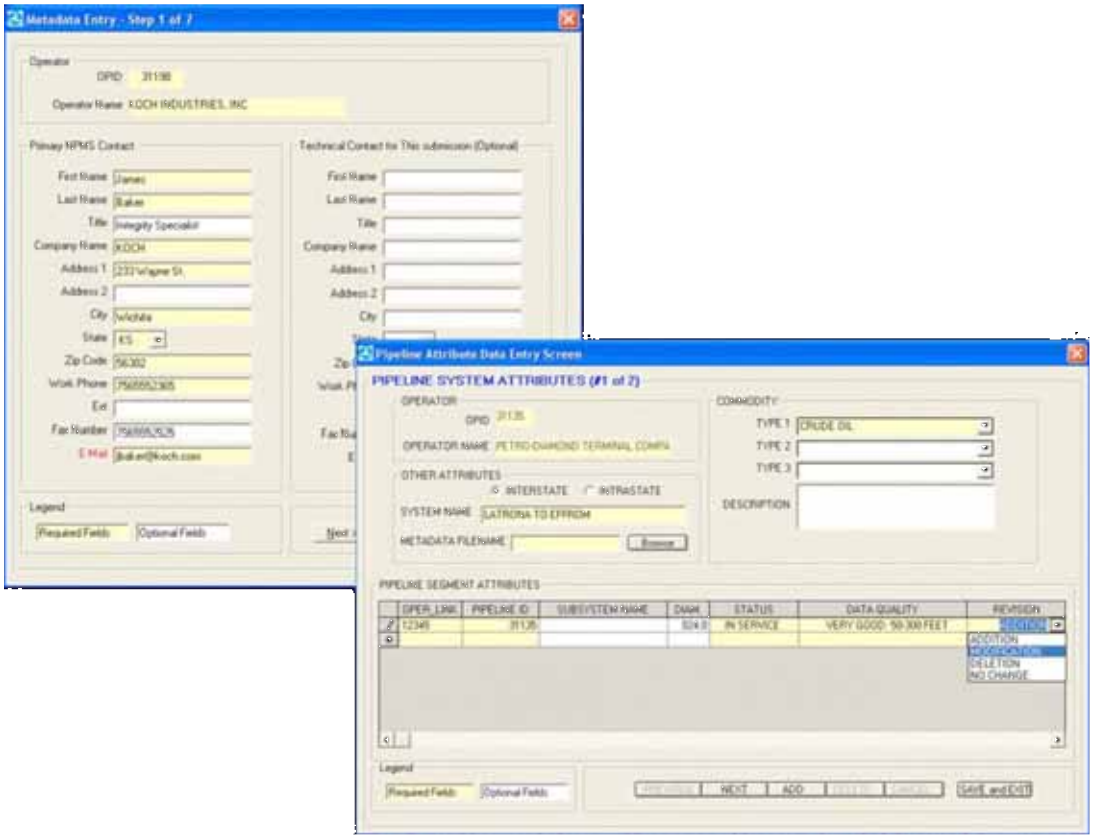

Figure 1: NPMS Metadata and Attribute template software.

The National Repository developed the code for look, feel, and functionality of the Pipeline Integrity Management Mapping Application (PIMMA), an ArcIMS site. The site permits users (who must have a username and password) to view pipeline, LNG, and breakout tank data. Users can conduct pre-selected queries, such as searching by various data layer attributes and performing simple spatial analyses. USGS topographic quadrangle maps and digital orthographic photos are available as background layers.

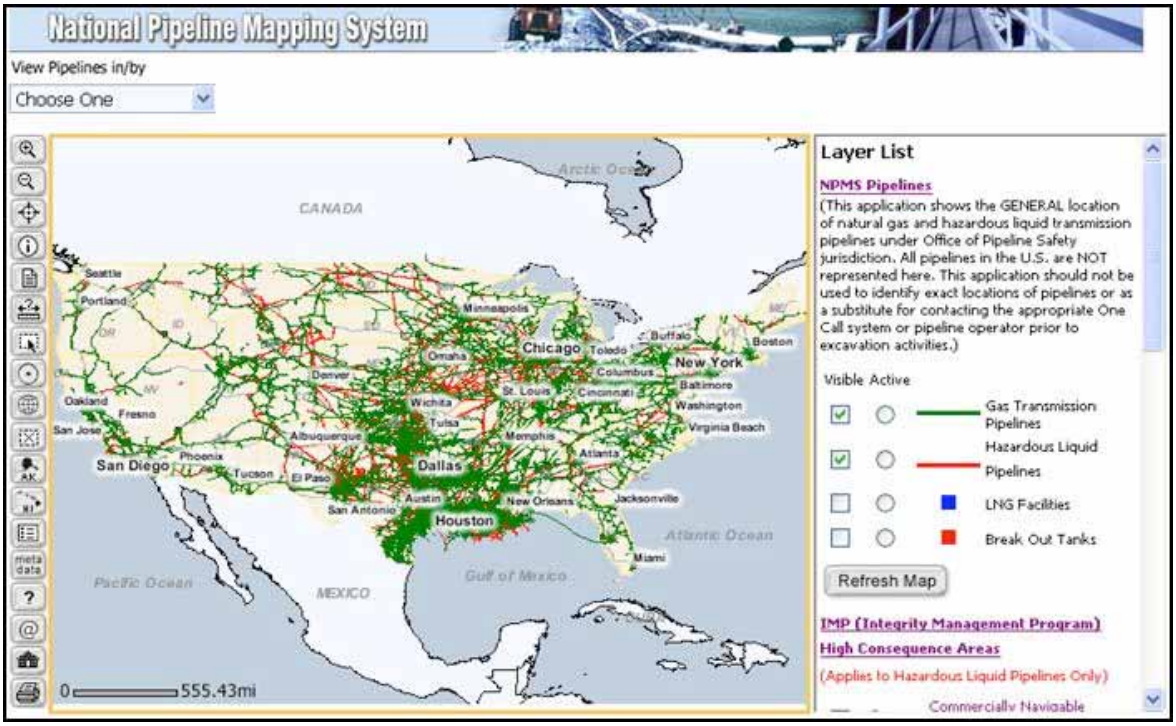

Figure 2: United States transmission pipelines, viewed through the NPMS PIMMA application.

Tracking existing and incoming submissions is part of the National Repository's duties. Submissions are tracked and records are maintained in Oracle databases. Oracle databases are also used for compliance efforts. Compliance tracking includes providing the Office of Pipeline Safety with reports on operators who have not submitted their data or who are not up-to-date with their submissions.

The National Repository functions as a help desk for operators who have questions about making an NPMS submission. Staff is available by phone or email. An operator standards manual that provides submission instructions and guidelines is available online.

The National Repository also provides onsite GIS support to the Office of Pipeline Safety. Onsite GIS analysts perform various GIS tasks, including map production, modeling, data analysis, statistical data generation, data distribution and web site maintenance. They produce maps in a range of scales. These maps include nationwide displays showing gas transmission and hazardous liquid pipelines, regional depictions of OPS district and field offices, and site-specific maps showing pipeline incidents and accidents. Additionally, thematic maps, displaying information such as nationwide pipeline densities by counties, are created using statistics collected from the NPMS.

OPS uses NPMS data to answer questions from the public and from Congressional overseers. Since the data is geographic in nature, information regarding miles of pipelines within states, counties, cities, and other areas of interest can be easily calculated. A wide range of statistical analyses have been performed by onsite personnel.

Examples include calculating the number of miles of pipelines within environmentally sensitive areas, analyzing total population and population density around pipelines, determining the number of accidents and incidents per county, and estimating the number of miles of pipelines found within federal areas, such as national parks. This information can then be used for a variety of purposes, such as to aid inspectors in making decisions about limited inspection resources, and for guiding policy makers in determining additional precautions needed to protect people and the environment.

The Role of the NPMS at the Office of Pipeline Safety

Decision Support

The mission of the Office of Pipeline Safety is to ensure the safe, reliable, and environmentally sound operation of the nation's pipeline transportation system. OPS's approach to fulfilling its mission has changed and expanded rapidly over the past several years. This change and expansion has been driven by several large pipeline incidents, including those in Bellingham, WA and Carlsbad, NM[1]. The change has required intense organizational introspection and review of data to promulgate effective regulatory and procedural changes. The NPMS has been an integral part of this process.

In 2001 and 2002, OPS pioneered a new approach to hazardous liquid pipeline safety with a set of rules known collectively as the "integrity management program" for hazardous liquid operators (49 CFR Part 195)[2]. These rules specify regulations to assess, evaluate, repair and validate the integrity of hazardous liquid pipeline segments that, in the event of a leak or failure, could affect High Consequence Areas (HCAs). HCAs are defined as populated areas, environmental and drinking water unusually sensitive areas, and commercially navigable waterways. OPS used the NPMS to delineate HCAs for use in the integrity management program. Pipeline operators and OPS's regulatory partners in the states use the NPMS to view pipelines in relation to HCAs and to develop and oversee operators' integrity management plans.

While GIS has allowed OPS to conduct trending and analysis designed to assist with implementation of regulatory programs, perhaps the most powerful use of the NPMS has been for simple mapping. The ability to visualize pipelines and the areas they traverse is a powerful tool for OPS. Government officials can now view pipeline incidents and accidents, the relationship between pipelines and environmentally sensitive areas, and the relationship between pipelines and the citizens they serve like never before. The ability to view these aspects of the pipeline system on a dynamic map has expanded OPS's ability to promote effective regulatory measures.

OPS Inspector Support

In addition to supporting the hazardous liquid integrity management rules and other regulatory initiatives, the NPMS supports various decision-making processes within OPS. For example, OPS uses the NPMS to generate statistical abstracts that are used for inspection planning. Because the NPMS can calculate pipeline mileage within any mapped geographic area, OPS can calculate pipeline mileage within HCAs, states, regions, water bodies, Congressional districts, and other areas. OPS uses these mileage

figures to help prioritize where limited inspector resources will be applied across the country.

OPS inspectors use the NPMS to aid inspection planning and as a visualization tool during inspections. Inspectors use two tools to access the NPMS. The first tool is the Offline Mapping Application (OMA), an ArcExplorer project disseminated on DVD to OPS's five regional offices. The OMA contains all of the NPMS data layers, High Consequence Areas, and various base data including roads, rail, and streams. The second tool is the Pipeline Integrity Management Mapping Application (PIMMA), an ArcIMS application that allows inspectors access to up-to-date NPMS data and pre-selected queries that are customized based on inspectors' needs.

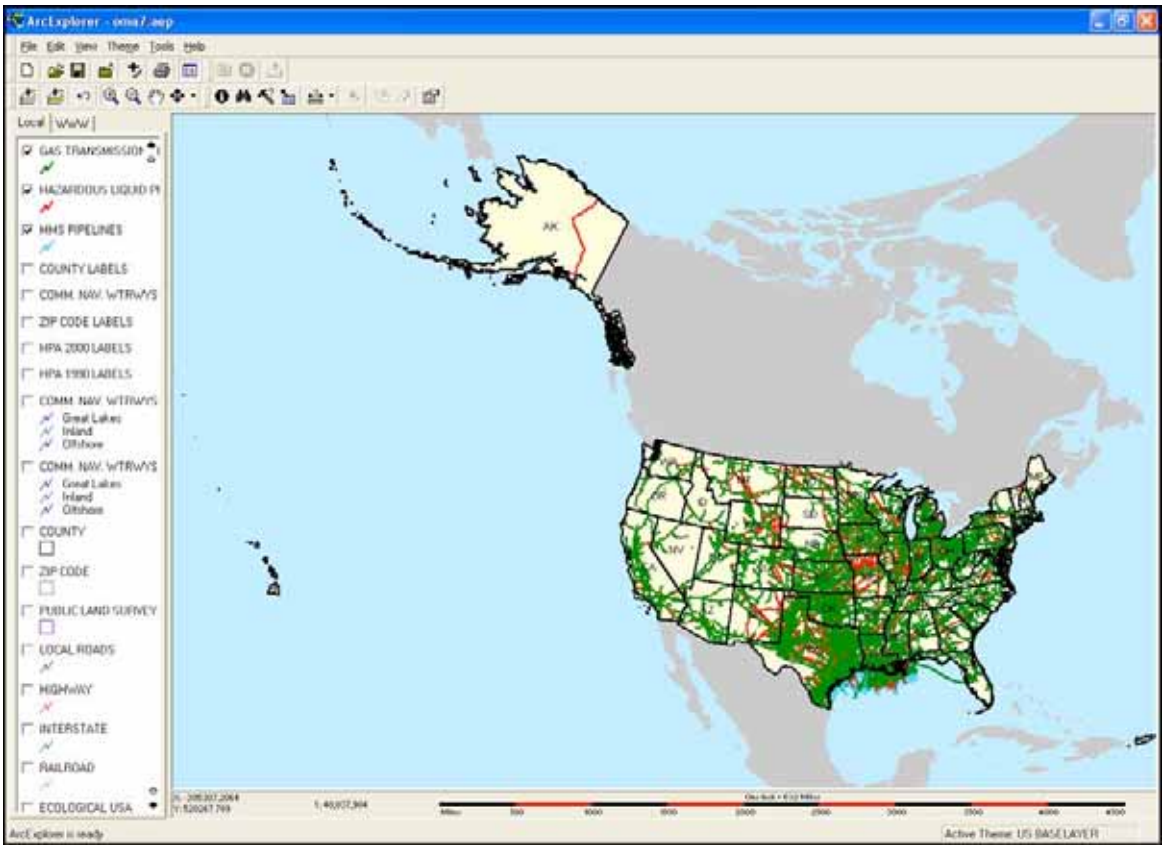

Figure 3: The Offline Mapping Application (OMA), an ArcExplorer project.

External Customer Support

External customers of the NPMS include federal, state, and local government agencies and pipeline operators. The NPMS serves customers such as the Department of Homeland Security, the Environmental Protection Agency, the U.S. Geological Survey, the Department of Defense, various state agencies including departments of environmental protection, and local emergency response organizations such as police and fire departments. These customers are allowed secure access to the NPMS through PIMMA and through NPMS GIS data. Customers use the NPMS for a variety of activities, including conducting security analyses, energy flow modeling, emergency

response planning, law enforcement, development planning, and environmental protection. OPS assists users with technical questions regarding the NPMS and attempts, to the extent practical, to develop applications to fit users' needs.

User Access and Data Security

Prior to the terrorist attacks of September 11, 2001, the Office of Pipeline Safety provided open access to NPMS data. Pipeline operators made submissions on a voluntary basis. At that time, about 70% of gas transmission and hazardous liquid pipeline mileage under OPS jurisdiction had been submitted to the NPMS. The general public was allowed to download all NPMS data directly from the web site. Unlimited access was also provided through an ArcIMS site administered by the National Repository.

The day after the attacks, all NPMS data were removed from the web site and access to the IMS application was discontinued. Since then, OPS has instituted policies that allow NPMS data access to government officials and pipeline operators only. Additionally, pipeline operators can only view data which they have submitted to the NPMS and not data submitted by other operators. To access NPMS data, a request must come from an employee of a government agency or pipeline operator. Government agencies and pipeline operators may share NPMS data with contractors, provided a confidentiality agreement exists between the two parties.

There are two ways qualified users can access the NPMS. The first way to access the NPMS is through the Pipeline Integrity Management Mapping Application (PIMMA), a password-protected ArcIMS site. Individuals seeking access to PIMMA are asked to complete an online application on the NPMS web site. Access is geographically limited to a user's area of interest. The second way to access the NPMS is through GIS data that can be incorporated into users' internal geographic information systems. Government access to the NPMS GIS data layers requires a formal written request on official government letterhead. Again, access is geographically limited to a user's area of interest.

Potential Future Direction of the NPMS

OPS is considering several changes to the NPMS that will enhance the utility of the program for both internal and external users. The first of the changes involves migrating to internal maintenance of NPMS data. Currently, the responsibility for keeping the NPMS up-to-date lies with pipeline operators. Operators are required to submit updates to the NPMS annually. This data maintenance model is redundant because much of the NPMS data is deleted and reprocessed every year. Going forward, OPS is considering a process by which pipeline operators simply notify NPMS of changes to their systems. This notification process is already largely practiced. OPS personnel would then work with pipeline operators and OPS regional inspectors to ensure that the NPMS reflects

conditions on the ground. Pipeline operators would have an annual responsibility of reviewing their data in the NPMS to ensure its completeness and accuracy, but they would no longer be required to make redundant data submissions on an annual basis.

OPS is also considering ways to integrate the NPMS with other in-house databases relating to operator compliance, incidents and accidents, and integrity management. Much of the data in these databases is geospatial in nature, but the data cannot be visualized because they are not integrated with the NPMS. Integration of the data would allow for much more robust analysis of OPS data.

Finally, the NPMS is going to be integrated into a pipeline repair permit streamlining process mandated under Section 16 of the Pipeline Safety Improvement Act of 2002. Pipeline operators who voluntarily seek assistance with permitting of repairs will use the NPMS to notify OPS of segments that may need repairs in the future. Other federal, state, and local permitting agencies will then be able to view these segments and address resource issues in the geographic areas these segments traverse. With advance notice and precise mapping of pipeline segments to be repaired, it is anticipated that permitting agencies will be able to advise pipeline operators on pre-developed best practices for conducting repairs and therefore facilitate faster permitting.

Conclusion

The NPMS is a tool for disseminating information to governmental agencies that address the security or safety of hazardous liquid and gas transmission pipelines. A team of GIS professionals and government managers at the Office of Pipeline Safety work to ensure the NPMS conforms to legislative mandates and is available to the users that need it. Authorized users utilize the NPMS for a variety of purposes. The Office of Pipeline Safety uses the NPMS to carry out its regulatory programs. Other governmental agencies use the data for security planning, pipeline operator oversight, and emergency response planning. Future changes to the NPMS have the potential to increase the NPMS's utility for its authorized users and to improve internal regulatory oversight at OPS.

Appendices

Appendix 1: Pipeline Attribute Table

Field Name	Field Type	Field Length	Short Description	Full Description	Acceptable Values (UPPERCASE)	Required Field
OPER_LINK	I	8	Unique Link ID	Link between the geospatial elements (pipeline segments) and their respective attribute records. Assigned by the operator or the operator's software package (i.e., COVER-ID, MSLINK_ID, etc.). Note the OPER_LINK and the PLINE_ID may be identical.	Positive integer	Y
OPS_ID	I	5	Operator Number (OPID)	Accounting number assigned by OPS to the company that physically operates the pipeline system. If you do not know your firm's OPID, check with your accounting department or the NPMS Web site.	Positive integer	Y
OPER_NM	C	40	Operator Name	The company name that physically operates the pipeline system.	Character	Y
SYS_NM	C	40	System Name	Assigned by the operator. The operator's name for a functional grouping of pipelines.	Character	Y
SUBSYS_NM	C	40	Sub System Name	Assigned by the operator. A unique name for a smaller sub-section of a pipeline system. A subset of SYS_NM.	Character	N
PLINE_ID	C	20	Pipeline ID	Assigned by the operator. This is an identifier for a specific section of pipeline within a pipeline system.	Character	Y
DIAMETER	R	5	Diameter	Nominal diameter of the pipeline segment, in inches (two decimal places, ##.##).	Real Number	N
COMMODITY1	C	3	Commodity Category 1	Abbreviation for the primary commodity carried by the pipeline system. HG=hydrogen gas, CRD=crude oil, LPG=liquid petroleum gas, NG=natural gas, PRD=product, AA=anhydrous ammonia, CO2=carbon dioxide, NGL=natural gas liquids, HVL=highly volatile liquid, NIT= nitrogen, EPG=empty gas, EPL=empty liquid, OTL=other liquid, OTG=other gas.	HG, CRD, LPG, NG, PRD, AA, CO2, NGL, HVL, NIT, EPG, EPL, OTL, OTG	Y
COMMODITY2	C	3	Commodity Category 2	Abbreviation for the secondary commodity carried by the pipeline system. HG=hydrogen gas, CRD=crude oil, LPG=liquid petroleum gas, NG=natural gas, PRD=product, AA=anhydrous ammonia, CO2=carbon dioxide, NGL=natural gas liquids, HVL=highly volatile liquid, NIT= nitrogen, EPG=empty gas, EPL=empty liquid, OTL=other liquid, OTG=other gas.	HG, CRD, LPG, NG, PRD, AA, CO2, NGL, HVL, NIT, EPG, EPL, OTL, OTG	N
COMMODITY3	C	3	Commodity Category 3	Abbreviation for the tertiary commodity carried by the pipeline system. HG=hydrogen gas, CRD=crude oil, LPG=liquid petroleum gas, NG=natural gas, PRD=product, AA=anhydrous ammonia, CO2=carbon dioxide, NGL=natural gas liquids, HVL=highly volatile liquid, NIT= nitrogen, EPG=empty gas, EPL=empty liquid, OTL=other liquid, OTG=other gas.	HG, CRD, LPG, NG, PRD, AA, CO2, NGL, HVL, NIT, EPG, EPL, OTL, OTG	N
CMDTY_DESC	C	40	Commodity Description	Descriptive information of the commodities carried by the pipeline system. For example, "NATURAL GAS" or "PROPANE."	Character	N
INTERSTATE	C	1	Interstate Designation	(Y)es / (N)o designator to identify if the pipeline system is an interstate pipeline. Y=Interstate, N=Intrastate. (Use OPS definition; see glossary).	Y, N	Y
STATUS_CD	C	1	Pipeline Status Code	Identifies the current status of the pipeline segment. I=in service, B=abandoned, R=retired.	I, B, R	Y
QUALITY_CD	C	1	Data Quality Code	Operator's estimate of the positional accuracy of the submitted pipeline segment. E=excellent: within 50 feet, V=very good: 50–300 feet, G=good: 301–500 feet, P=poor: 501–1000 feet, U=Unknown.	E, V, G, P, U	Y
REVIS_CD	C	1	Revision Code	Identifies this pipeline segment as an A=addition to the NPMS, or a M=modification to or D=deletion of a previous submission.	A, M, D	Y
META_NAME	C	12	Metadata File Name	1 Character type of file code + 5 digit OPID + 4 digit file number.	File name	Y

Appendix 2: LNG Attribute Table

Field Name	Field Type	Field Length	Short Description	Full Description	Acceptable Values (UPPERCASE)	Required Field
OPER_LINK	I	8	Unique Link ID	Link between the geospatial elements (points) and their respective attribute records. Assigned by the operator or the operator's software package (i.e., COVER-ID, MSLINK_ID, etc.). Note the OPER_LINK and the LNG_ID can be identical.	Positive integer	Y
OPS_ID	I	5	Operator Number (OPID)	Accounting number assigned by OPS to the company that physically operates the LNG facility. If you do not know your firm's OPID, check with your accounting department.	Positive integer	Y
OPER_NM	C	40	Operator Name	The name of the company that physically operates the facility.	Character	Y
LNG_NM	C	40	LNG Facility Name	Assigned by the operator. The operator's name for the LNG facility.	Character	Y
LNG_ID	C	20	LNG Facility ID	Assigned by the operator. This is a unique identifier for a specific facility.	Character	Y
STATUS_CD	C	1	LNG Status Code	Identifies the current status of the facility. I=in service, B=abandoned, R=retired.	I, B, R	Y
QUALITY_CD	C	1	Data Quality Code	Operator's estimate of the positional accuracy of the submitted facility data. E=excellent: within 50 feet, V=very good: 50–300 feet, G=good: 301–500 feet, P=poor: 501–1000 feet, U=Unknown.	E, V, G, P, U	Y
REVIS_CD	C	1	Revision Code	Identifies this facility as A=addition to the NPMS, M=modification to or D=deletion of a previous submission.	A, M, D	Y
META_NAME	C	12	Metadata File Name	1 Character type of file code + 5 digit OPID + 4 digit file number.	File name	Y

Appendix 3: Breakout Tank Attribute Table

Field Name	Field Type	Field Length	Short Description	Full Description	Acceptable Values (UPPERCASE)
COMPANY	C	40	Company Name	Name of the company that physically operates the tank or tank farm.	Character
FIRSTNM	C	20	Contact First Name	First name of the person to contact for information regarding the tank or tank farm.	Character
LASTNM	C	20	Contact Last Name	Contact person's title.	Character
TITLE	C	20	Contact Title	Contact person's title.	Character
PHONE	C	20	Phone Number	Primary telephone number for the contact person including area code. Please do not include dashes or parentheses.	Character
FAX	C	20	Facsimile Number	Primary fax number for the contact person including area code. Please do not include dashes or parentheses.	Character
EMAIL	C	40	Email Address	Contact person's email address.	Character
ADDRESS	C	40	Address	Street address of the contact person.	Character
CITY	C	20	City Name	Name of the city or town.	Character
STATE	C	2	State Name	Standard two-letter postal abbreviation for the state.	Character
ZIP	C	10	ZIP Code	Postal ZIP code (+4 if available).	Character
FRP	I	4	RSPA Facility Response Plan Number	Tracking number assigned by RSPA corresponding to the facility response plan (FRP) for the tank/tank farm. The FRP number is usually maintained by the operator's Environmental Health and Safety contact or an operations manager.	Positive Integer
SUBDATE	I	8	Date of Data Submission	Two-number month, two-number day, and four-number year of data submission (i.e. MMDDYYYY).	8-Digit Date
FACNAME	C	40	Facility Name	Assigned by the operator. The operator's name for a functional grouping of tanks (e.g. tank farm, tank hotel, etc.).	Character
FACCITY	C	20	Facility City Name	Name of the city in which the tank/tank farm resides.	Character
FACSTATE	C	2	Facility State Name	Standard two-letter postal abbreviation for the name of the state in which the tank/tank farm resides.	Character
FACOWNR	C	40	Facility Owner	Name of the owner of the tank/tank farm.	Character
TANKID	C	20	Tank ID	Assigned by the operator. This is an identifier for a specific tank within a functional grouping of tanks.	Character
CNSTRYR	I	4	Construction Year	Four-digit year of facility construction (e.g. "1990").	Positive Integer
TANKSIZE	I	3	Size of Tank	Nominal size of the tank (bbls x 000).	Positive Integer

(continued on following page)

Field Name	Field Type	Field Length	Short Description	Full Description	Acceptable Values (UPPERCASE)
CMDTY1	C	3	Primary Commodity Code	Abbreviation for the primary commodity stored in the tank. LNG= liquefied natural gas, CRD= crude oil, G= gasoline, K= kerosene, JF= jet fuel, DF= diesel fuel, HO= heating oil, AA= anhydrous ammonia, CO2= carbon dioxide, HVL= highly volatile liquid, OTH= other.	LNG, CRD, G, K, JF, DF, HO, AA, CO2, HVL, OTH
CMDTY2	C	3	Secondary Commodity Code	Abbreviation for the secondary commodity stored in the tank. LNG= liquefied natural gas, CRD= crude oil, G= gasoline, K= kerosene, JF= jet fuel, DF= diesel fuel, HO= heating oil, AA= anhydrous ammonia, CO2= carbon dioxide, HVL= highly volatile liquid, OTH= other.	LNG, CRD, G, K, JF, DF, HO, AA, CO2, HVL, OTH
CMDTY3	C	3	Tertiary Commodity Code	Abbreviation for the tertiary commodity stored in the tank. LNG= liquefied natural gas, CRD= crude oil, G= gasoline, K= kerosene, JF= jet fuel, DF= diesel fuel, HO= heating oil, AA= anhydrous ammonia, CO2= carbon dioxide, HVL= highly volatile liquid, OTH= other.	LNG, CRD, G, K, JF, DF, HO, AA, CO2, HVL, OTH
LONG_DIR	C	1	Longitudinal Direction	The compass direction of the longitudinal coordinate (e.g. "N").	Character
LONGITUDE	N	9	Longitudinal Coordinate	The longitudinal coordinate in decimal degree format (e.g. ###.######).	Number with 6 Decimal Places
LAT_DIR	C	1	Latitudinal Direction	The compass direction of the latitudinal coordinate (e.g. "W").	Character
LATITUDE	N	9	Latitudinal Coordinate	The latitudinal coordinate in decimal degree format (e.g. ###.######).	Number with 6 Decimal Places
SUB_TYPE	C	1	Submission Type	Identifies this tank/tank farm as an A= addition to the NPMS, or D= deletion of a previous submission.	A,M,D

End Notes

1. More information about the Bellingham and Carlsbad incidents can be found at the OPS web site at http://ops.dot.gov.

2. More information about the Integrity Management rules can be found at http://primis.phmsa.dot.gov.

References

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Author Information

Samuel Hall
GIS Manager
U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration
Office of Pipeline Safety
400 7th St. SW
Washington, DC 20590
Phone: 202-493-0591
Fax: 202-366-4566
Email: Samuel.Hall@dot.gov

Amy Nelson
Deputy Project Manager, NPMS
Michael Baker Jr., Inc.
3601 Eisenhower Avenue
Alexandria, VA 22304
Phone: 703-317-6294
Fax: 703-960-9125
Email: anelson@mbakercorp.com

Jay Mukherjee
GIS Analyst, NPMS
Michael Baker Jr., Inc.
3601 Eisenhower Avenue
Alexandria, VA 22304
Phone: 202-366-0667
Fax: 202-366-4566
Email: jmukherjee@mbakercorp.com

Dan Meehan
GIS Analyst, NPMS
Michael Baker Jr., Inc.
3601 Eisenhower Avenue
Alexandria, VA 22304
Phone: 703-317-3069
Fax: 703-960-9125
Email: dmeehan@mbakercorp.com