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O&M and Capital Cost Optimization Opportunities***

***Maximizing Safety and Organizational Profitability through  
Effective Asset Management***

David Richardson, P.Eng.  
QM4 Engineering Ltd.

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# ***Spatial Data Mining of Pipeline Data Provides New Wave of O&M and Capital Cost Optimization Opportunities***

## ***Maximizing Safety and Organizational Profitability through Effective Asset Management***

**David Richardson, P.Eng.**

QM4 Engineering Ltd.

4669 - 20 Street S.W.

Calgary, Alberta T2T 6G4

### **ABSTRACT**

Spatial data mining is the process of discovering interesting and previously unknown, but potentially useful patterns from large spatial datasets. Extracting interesting and useful patterns from spatial datasets is more difficult than extracting the corresponding patterns from traditional numeric and categorical data (spreadsheets) due to the complexity of spatial data types and spatial relationships. Efficient tools for extracting information from geo-spatial data are crucial to upstream oil and gas organizations which make decisions based on large spatial datasets, yet are not often applied to their fullest extent as the basis for creating valuable cost optimization opportunities.

This Paper highlights the cost optimization benefits of spatial data mining as applied to upstream oil and gas pipeline operations, including: a) Enhanced characterization and management of internal corrosion risk; b) Optimization of pipeline corrosion inhibition, pipeline inspections, pipeline corrosion monitoring costs; c) Identification of pipeline network hydraulic bottle-necks, prioritized based upon opportunity to achieve incremental production volumes through low-cost, routine pipeline pigging; d) Characterization and optimization of hydrate prevention; e) Optimization of drilling program site selection, and prioritization; f) Enhanced design basis for large capital projects; g) Enhanced ERCB compliance (D-066 / D-013 / D-071) and reduction of production-behind-pipe volumes.

The Paper places focus on how a quality-based compliant pipeline integrity management program can align to the overall business and operations plan for the owner company while delivering improvements to pipeline asset performance compared with industry performance standards, and how spatial data provides improvement of these programs.

## **INTRODUCTION**

### **Issues with Pipeline Performance in Upstream Oil and Gas Sector**

Pipeline failures attributed to internal corrosion continue to occur with increasing frequency each year throughout both the upstream (oil and gas producers) and the downstream (natural gas and liquids transportation) industry sectors in spite of the scheduling and execution of corrosion mitigation, corrosion inspection, and corrosion monitoring activities.

The Energy Resources Conservation Board (ERCB) pipeline performance statistics reported annually consistently demonstrate internal corrosion is the cause of 50 percent of all failure events and an upward trend of sweet and sour gas pipeline failures; consistent both in terms of magnitude and trend with reported pipeline performance from many similar operating sectors worldwide.

The unacceptable pipeline performance trends, particularly associated with internal corrosion deterioration, are occurring at a time when public and regulatory pressure for better control is increasing throughout all sectors. It is certain that corrosion mitigation expenditures designed to target internal corrosion are rarely, if ever, optimized, in terms of both dollar value and desired technical outcome. Pipeline performance trends suggest there are generally inappropriate characterization of the hazard state to which pipelines are exposed, and also the lack of commitment to a quality management model thereby preventing adequate recognition and response to changes that occur to the hazard state over the operating lifetime of the pipeline asset.

### **Role of Spatial Data within Pipeline Management Program**

To improve pipeline performance and regulatory compliance of the pipeline inventory requires the implementation of a formal pipeline integrity management (PIM) program that integrates information on physical inventory parameters, chemical analysis, chemical treatment, monitoring, and inspection data so notification of changes to the corrosion threat can be provided, and mitigated in a timely manner.

Spatial data systems (GIS) enables gathering operators to focus on asset maintenance and provides tools that work with existing operations workflows. With the modeling and mapping benefits of GIS, operators are afforded better decision-making tools, data support for integrity management, and the ability to quickly create accurate maps and detailed reports.

A GIS captures vital data and centralizes it for easy access. Using GIS, proactive maintenance, and integrity planning can reduce overall infrastructure downtime.

## **QUALITY PIPELINE INTEGRITY MANAGEMENT MODEL – *INTERNAL CORROSION***

### **Objectives of a PIM Program**

There is a substantial opportunity to optimize the total cost of pipeline operating and maintenance activities while delivering improvements to pipeline performance and regulatory compliance by implementing a formal Pipeline Integrity Management (PIM) program. A PIM program is the policies, practices and procedures, and standards which are implemented by the pipeline owner / operator to ensure the long term, safe, reliable and efficient operation of their pipeline assets.

Implementation of a formal PIM program enables operators to practice safe and environmentally friendly operating and maintenance programs that will ensure the long-term integrity of the pipeline corridors, prevent possible damages to adjacent human settlement, employees, the environment and production. A formal PIM program places structure around existing routine activities. Throughout the implementation of a PIM strategy, the activities carried-out in the field on a day-to-day basis are the same as present industry practices; however they are better focused because of an enhanced understanding of the hazard profiles throughout the pipeline network.

The success of any internal PIM program is directly related to: 1) The understanding the owner has of its pipeline system(s) with respect to deterioration mechanisms; and, 2) The company's ability to implement the appropriate mitigation, inspection, and monitoring programs with recognition and response to changes that occur to the hazard state.

### **Hazard Assessment is a Key Performance Requirement within PIM**

Throughout the implementation process, a formal PIM program places the priority on hazard assessment and scheduling of effective mitigation controls. These controls are typically continuous chemical inhibition, periodic pigging for removal of stagnant water accumulations, and batch application heavy-film-forming corrosion inhibitors between pigs as a supplement to continuous injection programs. Corrosion inspection and monitoring activities are scheduled to measure the effectiveness of the control activities to inhibit the measured hazards.

To address the root cause of pipeline failures, a formal PIM program must deliver the predictive and preventative tools necessary for the operating company to assess the impact of changing operating conditions on the internal corrosion hazard profile and provide them with the ability to make necessary adjustments to the chemical control program on an ongoing basis.

A formal PIM program incorporates an internal corrosion risk analysis model, has well-documented Corrosion Maintenance Plans, and an automated information collection and

data assessment software tool to facilitate ongoing day-to-day data collection and hazard assessment.

The data management to support an appropriate level of asset characterization is a challenge, given that all properties within an owner company portfolio requires the same level of consistent assessment, the same consistent technical basis for performing work, and for recognizing and responding to changes in the asset base and also with respect to measurement and reporting compliance to work schedules.

### **Benefits of a Quality PIM Program**

There are substantial benefits associated with implementation of a quality Pipeline Integrity Management program. A PIM program provides a consistent framework for evaluating and communicating the risks and hazards associated with the daily operation of a business unit to management, operations and the regulatory agency.

A PIM program minimizes the opportunity for the regulatory authority to become involved in the day-to-day operation of the business. Operators / owners who demonstrate they are actively seeking and implementing solutions in a proactive manner are less likely to have outside interference in operating and maintenance decisions.

Finally, an effective PIM program will result in long term reduced operating and maintenance costs, and improved pipeline performance because the focus of concern will be narrowed, allowing the scheduled mitigation controls and monitoring activities to be optimized based on the hazard profiles.

Following is a listing of benefits that have been realized through the commitment to the development and consistent application of a quality PIM program at an energy trust owner company:

#### Competitive advantage:

- Adoption of technological solution enhances efficiency of data access and work processes;
- Avoidance of hiring significantly more field staff (8) to achieve nominal level of compliance;
- \$1.2MM / year savings
- Provision of quantitative risk models for failure susceptibility and consequence characterization to support future acquisition strategies into traditional high-risk business sectors;
- Less expensive access to capital to grow value of reserves

#### Increased asset availability:

- Reduction in failure frequency of pipelines;
- \$6.0MM reduction in repair / remediation / year;

#### Reduced asset downtime:

- Reduction by 800 bbl / day nominally shut-in due to integrity issues;
- \$1.5MM / year

Reduced regulatory agency involvement in day-to-day activities

- Reduction from Major III status to no escalation;
- Elimination of compulsory ERCB audits on all operational disciplines.

Increased reserve value:

- 10% uplift in gross gas volumes achievable on 50% of wells (conservative estimate) through hydraulic flow optimization and de-bottlenecking of existing pipeline networks with no additional capital;

Leverage existing asset data:

- Consolidated fixed asset database provides single-point location for all historical field inspection / inventory data;
- Owner is positioned to apply consistent standards of operating and maintenance, and regulatory compliance across the entire asset base;
- Historical investment in field-proving / inventory of fixed operating assets is \$1.1MM per annum;

Improved employee retention & morale:

- Individual performance measurements are quantified and clearly communicated, measured and reported;
- Performance-based work contracts are effectively executed;
- Alignment of all activities provides confidence that all required activities for fully compliant program are identified to operations staff;
- Demonstrated direct alignment to the business model of all activities undertaken by each individual (office/ technical / administrative and field-based workers).

## **CRITERIA FOR ADOPTION OF GIS FOR PIPELINE MANAGEMENT**

A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions. GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a base map of real-world locations. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for managing pipeline information, and the relationship of the pipelines to features, land use areas, and populations.

A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. It is typical that operating companies have an abundance of geographic data for analysis, and government pipeline, road, and drainage feature data is likewise available to compliment proprietary corporate data. Map file databases for pipeline data link with other corporate information systems, including well, and facility data, production data, and land use data.

The selection of an enterprise spatial data management platform for pipeline data is a significant business decision with long-term implications that increasingly drives or limits a company's future success. When selecting a platform, decision makers should consider factors including: 1) existing infrastructure and data management systems; 2) near and long-term business needs and desired functionality; 3) current and future product availability; 4) broad industry support; and, 5) short and long-term cost implications.

In many cases, a standard industry pipeline data model proves successful in balancing of the short and long-term needs of users with the cost of implementation. Common data management issues often faced by organizations include data redundancy, data segregation versus integration, multiple data formats and reference systems, labour intensive data maintenance, poor data quality control, limited security, and costly customization. An effective enterprise data management platform must be one that helps solve these issues while empowering an organization to effectively implement, maintain, and expand new technology.

Stakeholders, whether employees, owners, regulatory agencies, or the public at large, are increasingly demanding access to actionable information. Integrity management combined with increased public awareness presents the pipeline industry with new, evolving, and complex challenges.

This Paper concentrates on highlighting the individual data groups, and data conditioning processes necessary within a GIS solution for pipeline management.

## MANAGING PIPELINE DATA WITHIN A GIS DATA SYSTEM

Pipeline operators need to create integrity management plans that minimize the overall costs of pipeline operation and that address the consequences associated with a leak:

- Loss of life and property
- Environmental damage
- Business losses
- Damaged reputation.

To accomplish this, operating companies are required to manage ever-increasing amounts of pipeline data, including information necessary to characterize integrity threats, risks, and consequences of failure. Managing all of the data, and providing a database to support assessment, and reporting of the data, and analysis results, requires an integrated GIS solution.

The ability of a GIS system to provide spatial, as well as attribute information for pipelines is essential to position the owner with the appropriate analysis tools, positioning for regulatory compliance, and supporting the integrity management challenges, with consideration of the implications of production changes that occur each month throughout the pipeline systems.

### Key Components of a Pipeline Management GIS Solution

<b>Data Attribute</b>	<b>Present As-Is State of Data</b>	<b>Ideal State within GIS Solution</b>
Pipeline Positional Data	Pipeline spatial data is based upon a planned / hypothetical placement of the pipeline, often in a speculative nature at time of preliminary route selection;	Step 1: Corrected location based upon associated land title survey boundaries  Step 2: Pipeline data edit tools that allow for movement of pipelines to correct location, and with storage of location in GIS database
Pipeline Flow Direction	50% of all pipelines in public data source drawn with incorrect flow direction	Application of an algorithm in GIS database to correct flow direction attribute of pipelines

<b>Data Attribute</b>	<b>Present As-Is State of Data</b>	<b>Ideal State within GIS Solution</b>
Pipeline Data Attributes	Physical data within industry databases / spreadsheets is limited to a data specification provided within industry PL-100 (licence) files, and provides insufficient data to support a quality risk-based pipeline integrity management program	The combined GIS and database solution needs to support an expanded pipeline data definition, and provide a means for user-editing of the data
Pipeline Network Connectivity	Pipelines are not connected in any relational database structure to wells, facilities, or to other pipelines	<p>Application of a GIS tool that connects pipelines to wells, to pipelines, and to facilities based upon operating status, substance, proximity, ownership within the database</p> <p>Provision of user tools within the GIS system to permit editing of connections, and/or creation of new connections, including tie-in connections of wells, and pipelines along pipeline lengths</p>
Production Flow Apportionment throughout Connected Network	Operating companies are unaware of the production volumes being transported at any given time through their pipeline networks – making assessment of integrity, and maintenance programs challenging, and leads to over-expenditure on maintenance and inspection, and leads to inadequate pipeline performance	Application within the GIS database that apportions oil / gas / water throughout a connected network based upon diameters, substance, operating status, fluid separation at facilities
Interaction of Pipelines with Physical and Cultural Features	Within traditional spreadsheet (flat) data management systems, pipeline owners do not have the ability to adequately consider the implications of pipeline interactions with the surroundings in a manner that adequately supports risk assessment models	A pipeline GIS / database solution needs to provide analysis of pipelines with roads, land use,

<b>Data Attribute</b>	<b>Present As-Is State of Data</b>	<b>Ideal State within GIS Solution</b>
<p>Access to Historical Operating Conditions for the Pipeline</p>	<p>Operating companies are not connected to historical well production data sources in order to adequately assess historical trends of non-producing periods which are essential when considering whether historical operating conditions may have contributed to the onset of internal corrosion, and which may present a greater threat than present conditions</p>	<p>Accurate analysis of pipeline condition requires access, and consideration of historical shut-in periods, frequency and duration of shut-in periods, onset and frequency of upstream acid stimulation projects, the magnitude of production “spikes” upon pipeline start-up, and the likelihood that detrimental materials from downhole may be delivered onto the pipelines upon transient production spikes</p>
<p>Access to Accurate DEM / Elevation Profile Models</p>	<p>It is typical that operating companies do not consider the topographical profile of pipelines in the consideration of corrosion hazard conditions caused by stagnant water film conditions, and if this is considered, only very coarse digital elevation data files, which are readily available from free-sources, are applied</p>	<p>Consideration of topographical profile of pipelines, and the onset of detrimental flow conditions is vital to an accurate corrosion hazard assessment, and this assessment requires high-density digital elevation data files</p>

## KEY COMPONENTS TO A PIPELINE GIS SOLUTION

### Pipeline Data Attributes and Editing within GIS

The GIS solution must provide access to an expanded database definition for pipelines, and provide the means for user-editing of the data. Examples of data within the expanded pipeline definition are:

Adjacent Land Use	Days to Repair Failure	Days to Detect Failure
Frequency of ROW Surveillance	Last ILI Inspection	ILI Qualitative Score
Pressure (kPa)	Temperature (C)	Years Operating Over 40
Water Separation (y/n)	Piggable (y / n)	Sibling Association
Flow Characteristics	Continuous Inhibition (L/day)	Pigging Frequency (days)
Batch Inhibition Frequency (days)	Batch Inhibition Volume (L)	Diluent Slug Volume (L)
Oil Density (API)	Chlorides (mg/L)	Oxygen Ingress Index
CO <sub>2</sub> (mol frac)	Bacteria Count (colonies/ml)	H <sub>2</sub> S (mol fraction)
Suspended Solids Index	Emulsified Fluids (y/n)	Parafin Deposition (y/n)

### Pipeline Network Connectivity within GIS

The GIS solution for pipeline network connectivity must consider well-to-pipe, pipe-to-pipe, pipe-to-facility, and facility-to-pipe connections, and provide for along-line-tie-in of well or pipeline to any pipeline segment. The connection rules must consider substance matches, flow direction matches, proximity of structures, status matches. Following, as Figure 4.0, are some examples of connectivity standards from within a GIS database:

## Production Flow Apportionment throughout Connected Network

Following are a sampling of rules that underpin the GIS / database allocation of oil / gas / water throughout the connected network:

Node Type	Facility Type	Production Volume Allocation Exiting Node		
		Oil / Hydrocarbon Liquid	Gas	Water
Well	None	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	Total all Water Arriving
Well	Separator	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	Oil / Hydrocarbon Liquid Volume X 2.5%
Well	Dehydrator	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	Nil
Field Junction / Header	None	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	Total all Water Arriving
Field Junction / Header	Line Loop Initiation	Allocate all Oil / Hydrocarbon Liquid Arriving Proportional to Cross Sectional Area of each Loop	Allocate all Gas Arriving Proportional to Cross Sectional Area of each Loop	Allocate all Water Arriving Proportional to Cross Sectional Area of each Loop
Field Junction / Header	Separator	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	Oil / Hydrocarbon Liquid Volume X 2.5%
Field Junction / Header	Compressor	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	0.00015 X Gas Volume (e3m3/d) = m3
Test Satellite - Oil (Group Line)	Satellite	Total all Oil / Hydrocarbon Liquid Arriving	Total all Gas Arriving	Total all Water Arriving
Test Satellite - Oil (Test Line)	Satellite	Gas from Upstream Well with Lowest Oil Production Volume	Oil / Hydrocarbon Liquid from Upstream Well with Lowest Oil Production Volume	Water from Upstream Well with Lowest Oil Production Volume
Central Battery - Oil (Solution Gas Line)	Battery	Nil	Total all Gas Arriving	0.00015 X Gas Volume (e3m3/d) = m3 Water
Central Battery - Oil (Sales Oil Line)	Battery	Total all Oil / Hydrocarbon Liquid Arriving	0.001 X Total all Oil / Hydrocarbon Liquid Arriving = e3m3/d	0.005 X Total all Oil / Hydrocarbon Liquid Arriving = m3/d
Central Battery - Oil (Water Disposal / Injection Line(s))	Battery	Nil	Nil	Total all Water Arriving

## **Interaction of Pipelines with Physical and Cultural Features**

The GIS solution for pipeline information management must incorporate consideration of pipeline interaction with other pipelines, roadways, and water ways. The spatial data assessment must accommodate point crossings, in addition to proximity buffers to account for potential interaction upon a spill event.

## **Access to Historical Operating Conditions for the Pipeline**

For proper consideration of pipeline integrity, the GIS spatial database must provide assessment of historical well operations upstream of each pipeline segment. Examples of the nature of the historical well production queries necessary to support a complete pipeline assessment with a spatial / GIS data management system are:

Unique Well Identifier	Count-of-On-Off Events
Production Source Date	Count of Days with Production
Count Days with No Production	Current Oil
Current Gas	Current Water
Count of Days Following Last Producing Day	Producing Hours for Current Month
Average Daily Oil Production	Average Daily Gas Production
Average Daily Water Production	Count Days with Daily Oil Exceeds "Average Daily Oil Production" by 3X
Count Days with Daily Gas Exceeds "Average Daily Gas Production" by 3X	Count Days with Daily Water Exceeds "Average Daily Water Production" by 3X

## **Access to Accurate DEM / Elevation Profile Models**

Accurate digital elevation models are required to be generated within the spatial GIS data model to support accurate determination of water film characteristics in support of a quality assessment of internal corrosion likelihood distribution throughout a connected pipeline network system.

## **Monthly Data Update Process**

It is vital the spatial data system, and database easily accommodate monthly update of pipeline inventory data, connectivity, flow apportionment, crossings, and risk so that Operations staff have a modern assessment from which to management integrity programs, mitigation, and compliance. These processes are illustrated in Figures 7 and 8.

A typical monthly update summary from a spatial data, GIS pipeline management system follows:

## **CASE STUDY – APPLICATION OF SPATIAL GIS TO SUPPORT PIPELINE MANAGMENE**

### **HIGH-RISK NON-COMPLIANCE ENFORCEMENT:**

- Extensive sour gas gathering system in highly populated corridor
- Operational commitment to Pipeline Integrity Management program
  - Chemical injection / pigging / batching (\$2,500,000 / yr)
- History of extensive In-Line Inspections
  - 104 ILI Projects in previous 36 months (\$6,000,000 direct costs)
- History of Internal Corrosion pipeline failures on relatively short-life pipeline segments
- ERCB Issues a High-Risk Enforcement Memo Subsequent to Inadequate Failure Event Response:
  - Challenge from ERCB
    - Demonstrate a “Systems Understanding” as the basis for future operational competency
    - Develop a strategy to shift from a reactive mode to a forward-looking / proactive pipeline management mode
    - 30-day completion window

### **RESPONSE UTILIZING SPATIAL DATA TECHNOLOGY**

- Commission a 20-day Spatial Data GIS Project
- Perform an enhanced internal corrosion risk assessment
  - Incorporating pipeline spatial GIS data
  - Include characterization of water film transport properties
- Integrate all historical data into spatial database
  - Daily well production, mitigation activity, ILI inspection data, and risk assessment data
- Visualize GIS data in map to examine trends contributing to corrosion
- Publish Integrity Management Plans for each pipeline based upon assessment
- Create and implement a predictive integrity management plan based upon an enhanced “GIS-based systems understanding”

**RESULTS HIGHLIGHTED TRENDS IN WELL OPERATIONAL DATA AND HISTORICAL PIPELINE FAILURE EVENTS & POSITIONED OWNER WITH “SYSTEMS UNDERSTANDING”**

- IC predictions aligned with actual ILI data
  - No corrosion predicted on “clean” segments
  - IC predictions within average of 1.7 metre of actual ILI defects
- All pitting corrosion damage occurs ONLY in “**RED**” segments immediately downstream of “**HONKING WELLS**”
  - Well start-up at rates > 5X normal production
  - Delivery of highly corrosive fluid / solids into susceptible pipelines

Existing mitigation strategy is effective for “**RED**” pipeline segments, provided they are not directly fed with high cycling
- IC Risk Assessment re-aligns of pigging & batch inhibition schedules
  - Only one-of-25 susceptible segments being batch inhibited
  - *\$500,000 chemical cost savings for 2009*
- Five (5) candidate segments identified for immediate ILI inspection
  - Based upon common history with failed pipeline segments
  - *\$2,000,000 ILI savings compared with 2009 plan*

## **CONCLUSION STATEMENT**

The key to a quality, compliant pipeline management model is complete inventory characterization and determination of failure susceptibility profiles through application of appropriately rigorous data standards as the basis for triggering optimized activity and task schedules.

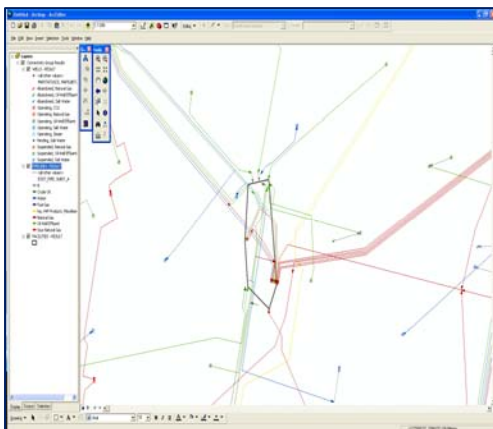
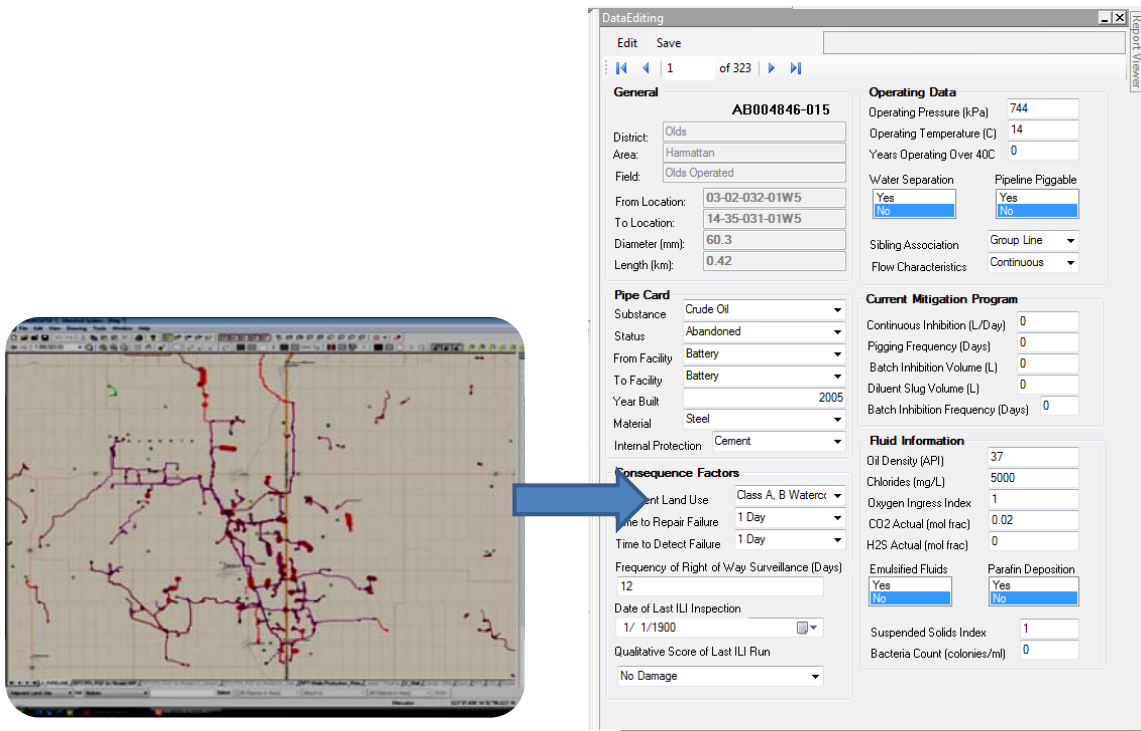
Complete dedication to the implementation of a quality pipeline management model includes the inherent ability to recognize and respond to changes that continually occur to the hazard state throughout the operating life cycle of the pipeline asset, and the ability to measure and report operational compliance to the prescribed work schedules.

A quality-based compliant pipeline integrity management program aligns well to the overall business and operations plan for the owner company (production volumes, worker and public safety, environmental stewardship, and operating expenses) while delivering improvements to pipeline asset performance compared with industry performance standards.

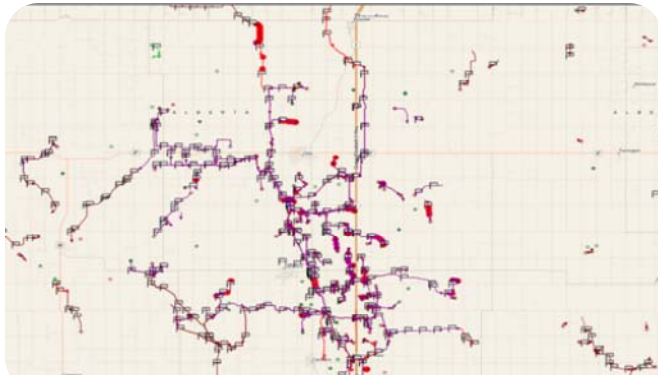
Spatial data / GIS technology provides a platform to support a successful pipeline integrity management program.

## APPENDIX -- FIGURES

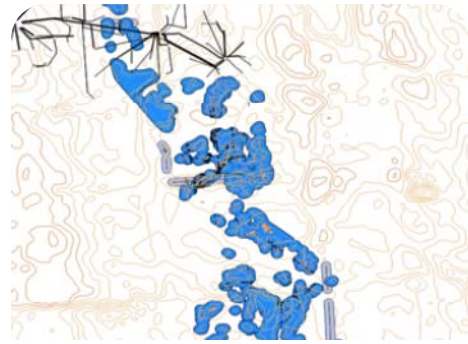
**Figure 1.0: Pipeline Data Editing within GIS Application**



**Figure 2:  
Resulting Network Connectivity of  
Facility within GIS System**



Road Crossing Sign Inventory (*map & report*)



Interaction with Potential Receptors  
(*crossings & down-dip proximity*)

**Figure 3: Interaction of Pipelines with Spatial Data – Roadways and Waterways**

**Figure 4.0: Pipeline Network Connectivity Rules within GIS Data Application**

**Well-to-Pipeline Connection Rules**



**WP.1. Well Matches Pipeline, All Attributes**

- Well Substance = Pipeline Substance
- Well Surface LSD = Pipeline “From” LSD
- No Alternative Pipeline – Start at Well LSD
- Pipeline Direction-of-Flow Away from Well
- Well Status = Pipeline Status



**WP.2. Well Matches Pipeline, Except for Substance**

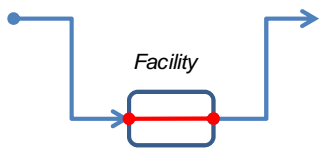
- Well Substance <> Pipeline Substance
- Well Surface LSD = Pipeline “From” LSD
- No Alternative Pipeline – Start at Well LSD
- Pipeline Direction-of-Flow Away from Well
- Well Status = Pipeline Status



**WP.3. Well Matches Pipeline, Except for Flow Direction**

- Well Substance = Pipeline Substance
- Well Surface LSD = Pipeline “To” LSD
- No Alternative Pipeline – Start at Well LSD
- Pipeline Direction-of-Flow Towards Well
- Well Status = Pipeline Status

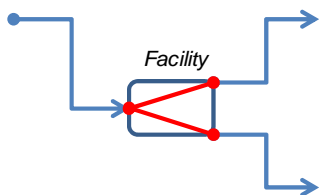
**Pipe-to-Facility Connection Rules**



*Connect Matching Pipeline – End to Pipeline - Start*

**FP.1. Single Pipeline – End with Single Pipeline – Start, All Attributes Match**

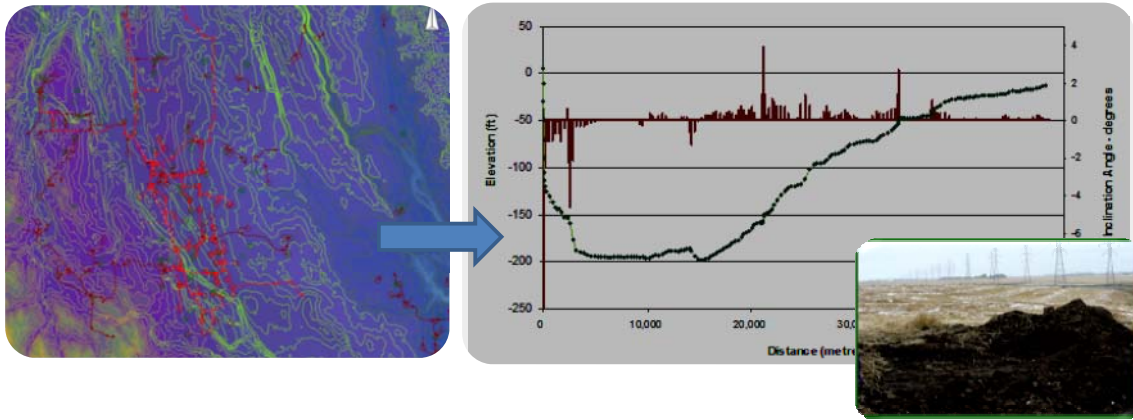
- Single Pipeline – End LSD = Facility LSD
- Single Pipeline – Start LSD = Facility LSD
- Pipeline – End Status = Pipeline – Start Status
- Pipeline – End Substance = Pipeline – Start Substance



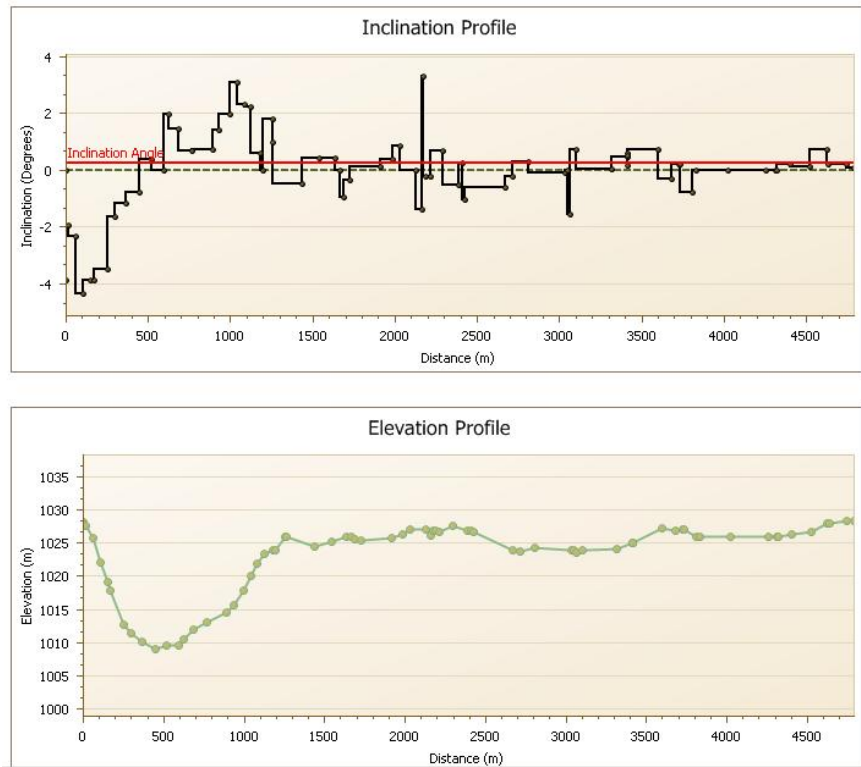
*Connect Single Pipeline – Ends to each Pipeline - Start*

**FP.2. Single Pipeline – End with Multiple Pipeline – Starts, All Attributes Match**

- Single Pipeline – End LSD = Facility LSD
- Multiple Pipeline – Starts LSD = Facility LSD
- Pipeline – End Status = Pipeline – Starts Status
- Pipeline – End Substance = Pipelines – Start Substance



**Figure 5.0:**  
**Use of Spatial Data Technology to Support Creation of Accurate Elevation Models for Pipeline Risk Assessment**



**Figure 6.0: Digital Elevation Profiles Stored in Spatial GIS Database**

**Figure 7.0: Summary of Spatial GIS Pipeline Data Update Process**

### **PIPELINE UPDATE ACTIVITY SUMMARY**

<b>Date Complete:</b>	<b>November 25, 2009</b>
<b>Daily Production Date:</b>	<b>October 31, 2009</b>
<b>Public Monthly Production Date:</b>	<b>August 1, 2009</b>
<b>IHS GIS Pipeline Data Date:</b>	<b>August 31, 2009</b>
<b>IHS GIS Well Header Data Date:</b>	<b>September 22, 2009</b>
<b>New Pipelines Added:</b>	<b>162</b>
<b>Pipelines Removed:</b>	<b>75</b>
<b>Reports Printed:</b>	<b>3590</b>
<b>Maps Printed:</b>	<b>781</b>
<b>Pipelines with Risk:</b>	<b>3330 (72%)</b>
<b>Pipeline Qualified for Risk:</b>	<b>4612</b>
<b>Pipelines Total Count:</b>	<b>8041</b>
<b>Pipelines Total License Length:</b>	<b>10274.59 km</b>

**Notes:**

- 1) All new pipelines added have had the following assessment completed:
  - Extended Attributes Added
  - Defaults pipeline attributes calculated
  - Assignment of hierarchy
  - Elevation profile processed
  - Crossings created
  - Initial connectivity with existing pipeline network
  - Flow apportionment
  - Risk and Mitigation engineering assessment
- 2) The removal of pipelines is determined by the Operator field (A reflection of licence) in the public data set. If the pipeline is no longer listed as licensed by a proprietary corporation it will be completely removed from the database
- 3) The GIS data date is provided from the most recent GIS Data CD provided.
- 4) All maps are printed in *pdf* with layer control functionality. These maps are available on the Report Atlas
- 5) Reports are printed in both *xls* and *pdf*. Report may be accessed on the report Atlas.

**Figure 8.0:**  
**Monthly Pipeline Update Process within a Spatial GIS Data Management System**

