

BIOGRAPHICAL INFORMATION

Ron Brush
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Specific Responsibilities

Founded New Century Software in 1994 to provide GIS consulting, data conversion and software development expertise to the oil and gas and telecommunications industries. Responsibilities include strategic planning, management of company operations, consulting, business development, project management, and application development.

With over 15 years experience using and implementing GIS and CAD systems, the primary focus has been the development of enterprise GIS maintenance and mapping automation software, and GIS conversion software. Areas of expertise include GIS implementation consulting, system architecture, GIS database modeling and design, software application design and project leadership. Mr. Brush helped develop a core database model that is currently in use by major national pipeline companies to spatially enable corporate enterprise-wide facility database and GIS systems.

In 1998, Mr. Brush helped initiate the PODS Association, served as president in 2001 and is currently serving as Treasurer. As an active member of the association, he contributed to the early technical design and currently leads PODS training workshops.

Past Experience

Various positions with M. J. Harden Associates

Educational Information

B.S. - Mathematics, Colorado State University, concentration computer graphics

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APPLYING GIS TO THE NEW GAS HCA RULE

Presented by Ron Brush

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ABSTRACT

This presentation will review the Gas High Consequence Area (HCA) rule from a GIS perspective. We will review terminology included in the HCA rule and the application of spatial analysis to the identification of Gas HCAs. Discussion topics will include terms such as Potential Impact Radius (PIR), Potential Impact Zone (PIZ), Threshold Radius and application of the C-FER equation. Finally, this presentation will view examples of challenging cases that arise in its interpretation. These examples will illustrate different potential interpretations of the new gas rule.

Keywords: Gas HCA, Class Areas, C-FER, House Count, Sliding Mile

INTRODUCTION

The Gas Transmission Pipeline Industry is facing sweeping new changes in the area of pipeline integrity management requirements. These legislative changes will continue to affect many aspects of pipeline operations by requiring operators to improve operational and data management practices. One area of impact includes proposed regulations that require gas transmission operators to identify high consequence areas (HCAs) along their corridor. Unlike the liquid rule that requires operators to simulate releases from their pipeline into predefined HCA polygons, this rule requires operators to expand upon existing class locations to define HCAs based on additional criteria.

Because of the significant effort involved in performing these calculations manually, most operators are relying on GIS technologies manage this data and to perform the requisite analysis then field verify the results.

The purpose of this paper is to address the use of GIS analysis for the new Gas HCA rule December 15, 2003 – Pipeline Integrity Management in High Consequence Areas (Sec. 192.903 and 192.905). This paper was originally presented at the GITA Oil & Gas Conference, Houston, in September 2003. This original presentation described the proposed rule since the final rule had not been issued.

LEGISLATIVE BACKGROUND

On August 6, 2002, the U.S. Department of Transportation Research and Special Programs Administration (RSPA) released the Final Rule entitled “Pipeline Safety: Pipeline Integrity Management in High Consequence Areas.” (RSPA-2000-7666-161) This final rule was the first step in a two-step process to develop integrity management program requirements for gas transmission operators. In the second step, the Research and Special Programs Administration (RSPA) will propose requirements to improve the integrity of gas transmission pipelines located in these high consequence areas.

On December 17, 2002, President Bush signed the Pipeline Safety Improvement Act of 2002 into law (<http://www.tsi.dot.gov/divisions/pipeline/history/2002%20PSIA.doc>). This wide-ranging law incorporates many aspects of pipeline operations including one-call, NPMS, operator qualification, risk management, civil and criminal penalties, and public education.

On January 28, 2003, DOT RSPA issued a proposed rule entitled “Pipeline Safety: Pipeline Integrity Management in High Consequence Areas (Gas Transmission Pipelines); Proposed Rule.” (RSPA-2000-7666-167) This rule defines terms such as Moderate Risk Areas, Potential Impact Circle, Potential Impact Radius (PIR), Potential Impact Zone and Threshold Radius. Many of the definitions included in this proposed rule are now obsolete; however the Potential Impact Radius and Potential Impact Circle are included in the new rule.

On December 15, 2003, the Integrity Management for Gas Pipelines Final Rule was issued as expected. This rule is significantly different from the proposed rule described in the August 2002 rule but follows many recommendations made by industry.

CENTERLINE QUALITY

Centerline quality is an important factor in being able to automatically identify DOT HCAs. Because the centerline is used to create a buffered corridor around the pipeline within which structures and identified sites are identified, it is important to ensure the highest quality centerline from all available source information. Often as-built alignment sheets containing PI's and survey ties are used to route a *station aware* centerline. The as-built survey can be mathematically adjusted using survey techniques to better approximate the actual centerline and identify potential busts. Unfortunately, some GIS pipe centerlines were created by simply digitizing points from as-built drawings. This results in poor centerline quality and often requires expensive rework or field-based corrections.

Aerial photography, including one meter USGS DOQQ's (Digital Ortho Quarter Quads), and satellite imagery can be used to identify some pipeline right-of-way areas. This can also aid centerline quality.

Most pipeline operators do not have the luxury of GPS surveying their entire centerline. However, depending on budget resources, critical centerline locations may be GPS surveyed using sub-meter GPS equipment. These areas would include high-activity zone or population growth areas, locations that are not readily accessible along the right-of-way, and all new construction work.

As geo-inline inspection (ILI) tools become more available, operators will increasingly rely on ILI runs for an accurate centerline location and elevations of their piggable lines. Additionally, ILI above ground markers (AGM's), GPS'd close interval surveys and GPS'd pipe inspections can be used to incrementally improve centerline quality for non-piggable lines.

FIELD UPDATE PROCESSES

HCA Alignment Sheets

Some pipeline operators are using HCA alignment sheets to field verify HCAs. Typically, alignment sheets showing aerial photography, digitized structures and identified sites, and class locations are automatically generated from the GIS. These sheets are sent to field personnel for verification and markup. Redlined sheets are then returned to the main office, sometimes with GPS shots of structures and site perimeters. Updates are made to the GIS and HCA analysis is used for comparison with field observations. This process is typically repeated on an annual basis.

Line Patrols

Ongoing ground and aerial patrols provide an opportunity to update the DOT structures in the GIS on a regular basis. Field crews can monitor corridor activity and submit HCA change notifications to the GIS. Submissions can be paper and/or electronic.

GPS

GPS provides the ideal solution for collection the location of structures in the pipeline corridor. Using a laser range finder, technicians can quickly ‘shoot’ structures from a convenient distant location without having to occupy each structure location.

Field Laptops

Ruggedized laptop computers can be used by field personnel to continuously update the GIS. Using a technique called ‘disconnected editing’, technicians can review and update pipeline records remotely, without being directly connected to a centralized GIS. These changes can be posted back to a *staging* database for gatekeeper approval prior to being applied to the master production database. After posting the change, the laptop is refreshed with the most current data.

Digital Pictures

Because of the low cost of digital cameras, digital pictures of identified sites and important structures can also be included in the GIS. Trimble’s MediaMapper software enables pictures to be collected and easily integrated with GPS data.

POINT VS. POLYGON FEATURES

CFR 192.5 (Appendix A) defines gas transmission Class Locations. These features include the following:

Feature Type

<i>Type</i>	<i>Reference</i>	<i>Feature Type</i>
Building intended for human occupancy	192.5 (a) (2)	Point or Polygon
Well-defined area (playground, recreation area)	192.5 (b) (3) (ii)	Polygon
Four story building	192.5 (b) (4)	Point or Polygon
Building cluster	192.5 (c) (2)	Polygon

Identified Sites (CFR 192.903 – Dec. 15, 2003)

<i>Feature Type</i>	<i>Feature Type</i>
(a) Outside Area or Open Structure	
Playgrounds and other outdoor recreational areas	Polygon
Beaches	Polygon
Camp grounds	Polygon
Outdoor theaters and stadiums	Polygon
(b) High Occupancy Buildings	
20 or more persons, 5 days per week, 10 weeks per year	
Office buildings	Point or Polygon
Religious facilities and community centers	Point or Polygon
General Stores	Point or Polygon
Indoor recreational centers	Point or Polygon
(c) Building occupied by persons of impaired mobility	
Day-care centers	Point or Polygon
Hospital facilities	Point or Polygon
Retirement or assisted living facilities	Point or Polygon

Prisons	Point or Polygon
Schools	Point or Polygon

When defining these features for use in a GIS, sites can be stored as either a Point or Polygon. The GIS Point feature representing the building or identified site may identify the following (for example):

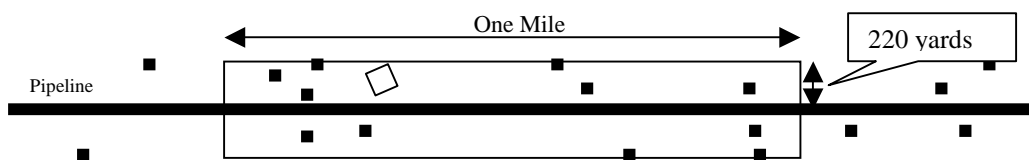
- a station and perpendicular offset from the pipeline without being more specific, or
- the centroid of the feature (as identified from aerial photography), or
- the point on the structure nearest the pipeline, or
- a point on the property boundary nearest the pipeline, or
- a point at the main entrance of the building (i.e. using GPS)

Polygons representing well-defined areas, buildings or identified sites may identify the following:

- a station and perpendicular offset from the pipeline without being more specific, or
- the footprint of the building or identified site, or
- the property boundary of the site (i.e. fenced area), or
- the property boundary of the site including parking and unfenced areas, or
- the entire property including undeveloped areas

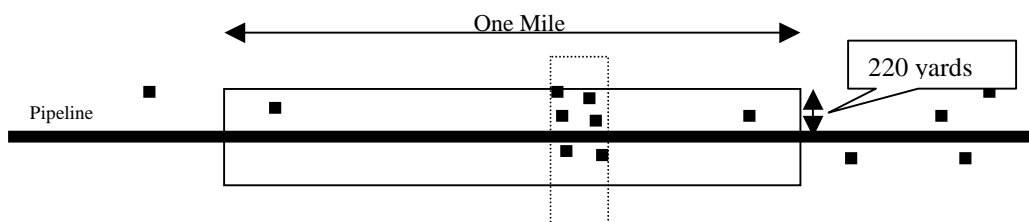
IDENTIFYING CLASS LOCATIONS

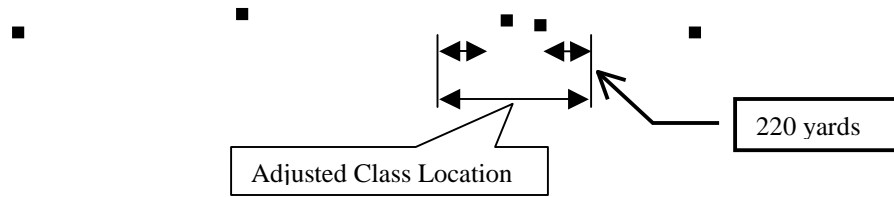
According to the regulations (Appendix A), a "class location unit" is an onshore area that extends 220 yards (200 meters) on either side of the centerline of any continuous 1-mile (1.6 kilometers) length of pipeline. Thus, in GIS terms a rectangular buffer around a continuous one-mile section of pipe with a width of 660 feet is slid along the centerline, counting the number of houses along the way. This sliding rectangle, without rounded ends, except at the endpoints of the pipeline creeps along the pipeline foot by foot.



CLUSTERS AND PREVALENT LOCATIONS

Section 192.5 (c) provides the ability to reduce class locations such that it ends 220 yards from the nearest building in a cluster as illustrated in the following diagram.





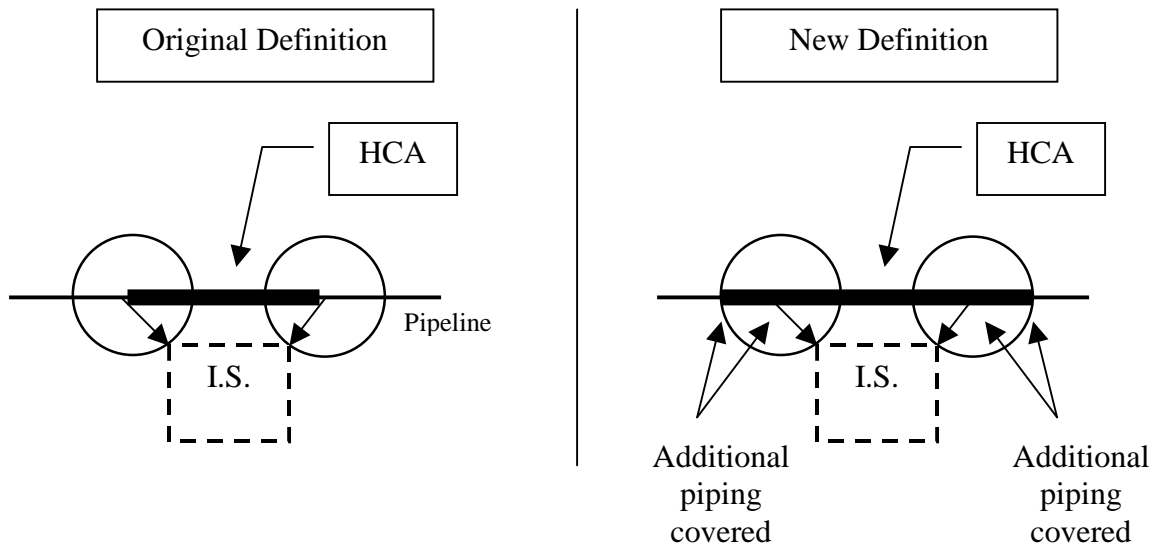
One challenge in automating the HCA identification process is defining and identifying clusters and prevalence of four story buildings. Several techniques are presented:

- manual identification of clusters – digitized polygons
- use a sliding circle to count the number of structures within the circle centered on the pipeline
- use a sliding rectangle to count the number of sites within the rectangle – the rectangle length might be one-half or one-quarter mile in length
- use two point features to represent a cluster – each point defining an boundary structure of the cluster

POTENTIAL IMPACT CIRCLE

The December 15, 2003 Final Rule defines the PIR (introduced as the C-FER equation) to be determined by the formula $r = 0.69 * (\text{square root of } (p*d^2))$, where “r” is the radius of a circular area surrounding the point of failure (ft), “p” is the maximum allowable operating pressure (MAOP) in the pipeline segment (psi) and “d” is the diameter of the pipeline (inches). A Potential Impact Circle means a circle with a radius equivalent to the PIR.

To account for gas jetting, the INGAA/AGA proposed modification (Appendix B) changes the definition of an HCA to the following:



GIS ANALYSIS

Using GIS linear referencing analysis of HCAs and class locations is fairly straightforward, but will likely require some customization of the GIS application to perform the specialized spatial searches involved. As is the case with math word problems, setting up the problem correctly is often the most challenging part of the problem. Likewise, getting a quality *station aware* centerline and data that represent the buildings and identified sites is critical, along with unambiguous descriptions of building clusters and building *prevalence*.

Some may assume that this analysis involves simply building a buffer around the pipeline and selecting the Identified Sites that are contained within the buffer. This is incorrect. The correct algorithm involves sliding a Potential Impact Circle each foot down the pipeline and determining if the circle contains an identified site or 20 or more buildings. Using this simplistic approach, assuming processing takes 1 second per foot, for a medium size pipeline of 5,000 miles this amounts to 7,333 hours of processing time, or 305 days processing 24/7. Clearly better processing algorithms will improve performance substantially.

CONCLUSION

After the *Pipeline Integrity Management in High Consequence Areas* proposed rule (January 2003) was issued, operators and service providers struggled to understand and apply the new HCA definitions. The new rule resolves many of these ambiguities and simplifies some things for the operator. Fortunately the new rule expands upon existing Class Location definitions with relatively simple and proven formulas and build upon well-understood and long-standing industry practices.

Now that the Gas Transmission pipeline industry has the final rule, many operators are working to capture and manage identified sites and determine their HCAs prior to the December 17, 2004 deadline. Although many operators expected this new rule and were proactively ensuring that they have the data that will be required to perform analysis and data integration required by the new Gas Pipeline Integrity Management Rule, other operators took a wait and see approach and are now faced with the challenge of meeting the requirements in a short timeframe.

GIS continues to play an integral role in the oil and gas pipeline industry for storing, assembling, analyzing and integrating data as the demand for more and better data increases.

APPENDIX A

CFR 192.5 Class Locations.

- (a) This section classifies pipeline locations for purposes of this part. The following criteria apply to classifications under this section.
 - (1) A "class location unit" is an onshore area that extends 220 yards (200 meters) on either side of the centerline of any continuous 1-mile (1.6 kilometers) length of pipeline.
 - (2) Each separate dwelling unit in a multiple dwelling unit building is counted as a separate building intended for human occupancy.
- (b) Except as provided in paragraph (c) of this section, pipeline locations are classified as follows:
 - (1) A Class 1 location is:
 - (i) An offshore area; or
 - (ii) Any class location unit that has 10 or fewer buildings intended for human occupancy.
 - (2) A Class 2 location is any class location unit that has more than 10 but fewer than 46 buildings intended for human occupancy.
 - (3) A Class 3 location is:
 - (i) Any class location unit that has 46 or more buildings intended for human occupancy; or
 - (ii) An area where the pipeline lies within 100 yards (91 meters) of either a building or a small, well-defined outside area (such as a playground, recreation area, outdoor theater, or other place of public assembly) that is occupied by 20 or more persons on at least 5 days a week for 10 weeks in any 12-month period. (The days and weeks need not be consecutive.)
 - (4) A Class 4 location is any class location unit where buildings with four or more stories aboveground are prevalent.
- (c) The length of Class locations 2, 3, and 4 may be adjusted as follows:
 - (1) A Class 4 location ends 220 yards (200 meters) from the nearest building with four or more stories aboveground.
 - (2) When a cluster of buildings intended for human occupancy requires a Class 2 or 3 location, the class location ends 220 yards (200 meters) from the nearest building in the cluster.

APPENDIX B

CFR 192.903 High Consequence Areas.

The *High consequence area* definition was modified to allow an operator two methods to identify the areas.

In method (a) high consequence areas are—

1. Current Class 3 location;
2. Current Class 4 location;
3. Any areas outside a Class 3 or 4 location where the Potential Impact Radius is greater than 660 feet (200 meters), and the area within a Potential Impact Circle contains 20 or more buildings intended for human occupancy. However, if the radius of the Potential Impact Circle is greater than 660 feet (200 meters), the operator may identify a high consequence area based on a prorated number of buildings intended for human occupancy within a distance 660 feet (200 meters) from the centerline of the pipeline until December 17, 2006. If an operator chooses this approach, the operator must prorate the number of buildings intended for human occupancy based on the ratio of an area with a radius of 660 feet (200 meters) to the area of the Potential Impact Circle (*i.e.*, the prorated number of buildings intended for human occupancy is equal to $[20 \cdot (660 \text{ feet [or 200 meters]}) / \text{Potential Impact Radius in feet [or meters]}]$ 2)).
4. The area within a Potential Impact Circle containing an identified site.

In method (b) high consequence areas are—

1. The area within a Potential Impact Circle containing 20 or more buildings intended for human occupancy, (unless the exception described above in method (a) applies);
2. The area within a Potential Impact Circle containing an identified site. When a Potential Impact Circle is calculated under either of the methods to establish a high consequence area, the length of the high consequence area extends axially along the length of the pipeline from the outermost edge of the first Potential Impact Circle that contains an identified site or 20 or more buildings intended for human occupancy to the outermost edge of the last contiguous Potential Impact Circle that contains either an identified site or 20 or more buildings intended for human occupancy. Appendix E, Figure E.I.A gives a graphic representation. The identified site component of the high consequence area definition was also modified to distinguish between rural buildings and outside open areas and to simplify the identification process. An identified site is an area meeting one of three criteria—
 1. An outside area or open structure that is occupied by twenty (20) or more persons on at least 50 days in any twelve (12) month period (the days need not be consecutive). Examples included in the definition are beaches, playgrounds, recreational facilities, camping grounds, outdoor theaters, stadiums, recreational areas near a body of water, or areas outside a rural building such as a religious facility, or
 2. A building that is occupied by twenty (20) or more persons on at least five (5) days a week for ten (10) weeks in any twelve (12) month period (the days and weeks need not be consecutive). Examples included in the definition are religious facilities,

office buildings, community centers, general stores, 4-H facilities, and roller rinks.

3. A facility occupied by persons who are confined, are of impaired mobility, or would be difficult to evacuate. Examples included in the definition are hospitals, prisons, schools, day-care facilities, retirement facility and assisted-living facilities.

Determining High Consequence Area

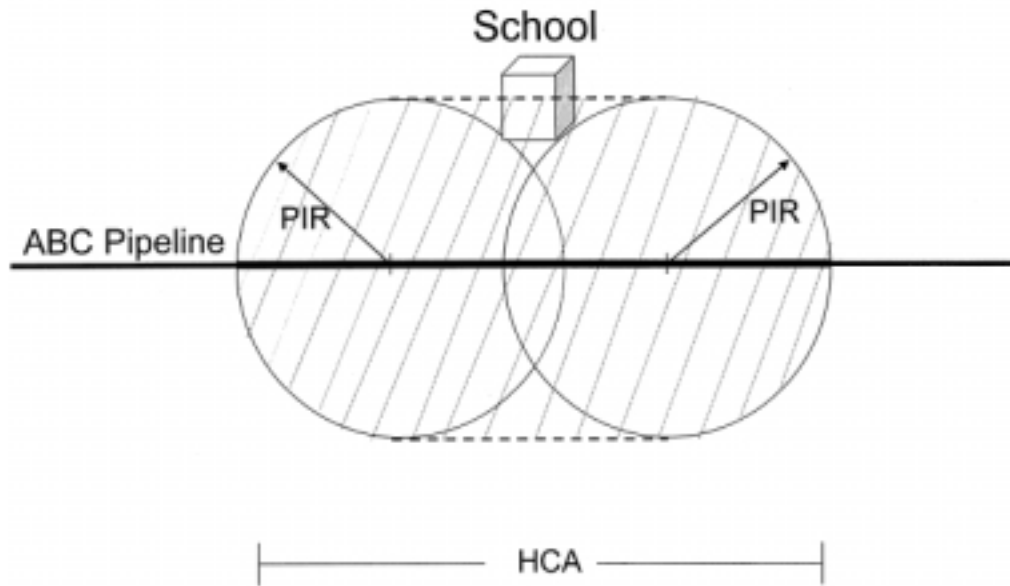


Figure E.I.A