Preliminary Assessment of Pipeline Contingencies and Associated Risk in the MISO Region

Executive Summary

Submitted to:
MISO

Submitted by:
ICF

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1. Executive Summary

As part of its ongoing efforts to assess and understand interrelationships between natural gas and power markets, MISO contracted ICF to perform a scoping review and assessment of the natural gas infrastructure supplying power generation facilities in MISO markets. The goals of the study included a review of historical gas infrastructure events and their impact on the MISO market and the development of a scoping tool capable of assessing potential impacts of a given gas infrastructure event on power generation facilities within MISO. Together, this historical analysis and scoping tool could be used to review interrelationships of natural gas infrastructure and power generation facilities in MISO, so as to identify areas warranting further review or study.

The ICF study is divided into three key parts:

- **Historical Review of Past Events** -- As a first step, ICF reviewed and evaluated historical data on observed gas infrastructure events based on pipeline informational postings. These events were assessed to determine the type of impact (e.g., pipeline, compressor, or receipt/delivery meter), the level of impact (e.g., 0 to 100 percent of associated capacity), and the duration of the impact (e.g., number of days). Summary statistics were developed to provide a perspective on the probabilities of events and associated magnitude and impacts of events.
- **Development of Gas Contingency Screening Tool** – ICF combined detailed data on key pipeline points and infrastructure components for natural gas systems serving the MISO region with MISO's database of power plants to establish a scoping tool for assessing potential impacts of a given outage on the interstate natural gas system on generation capacity within MISO.
- **Compilation of Detailed Pipeline / Power Plant Maps –** To assist in evaluating both historical and potential infrastructure events, ICF compiled a comprehensive set of detailed maps summarizing the interstate pipeline infrastructure in the MISO region with the power plants identified in the MISO database explicitly identified.

1.1. Review and Summary of Historical Pipeline Contingency Events

Background and Approach

Various factors can cause a natural gas infrastructure event. Events can be caused by normal wear and tear on equipment. They can be the result of natural disaster or severe weather, as in the case of flooding, landslides, or earthquakes. Or they can be man-made, for example, a backhoe operated by a third-party contractor can inadvertently rupture a pipeline. For the purposes of this study, ICF characterized historical infrastructure events based on the primary infrastructure component that failed or was affected by the event:

- Compressor events relate to instances where compressor stations or capacity is reduced or unavailable;
- Pipeline events relate to instances where lines are compromised (e.g., ruptures, blockages, pressure limitations, etc.); and

- Receipt/delivery meter events relate to instances where an interconnect or meter associated with receiving or delivering gas is compromised and unable to perform.

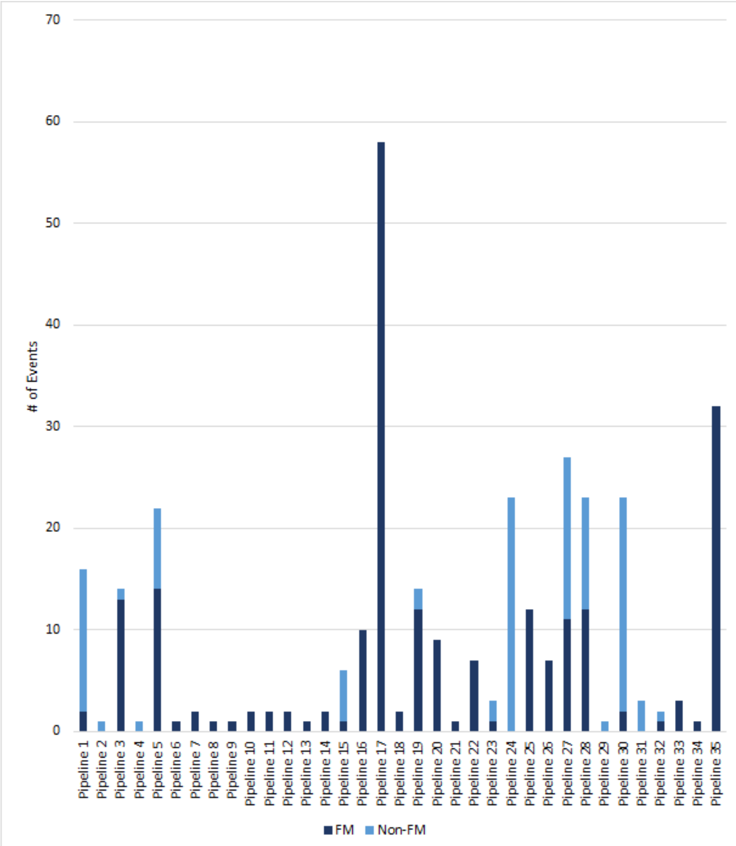
In order to assess causes and probabilities of events, ICF reviewed historical data on pipeline operations based on pipeline notices posted over the period January 1, 2013 through April 30, 2018. Interstate pipelines are required to maintain an electronic bulletin board with key information on their daily operations and tariff rules. These electronic bulletin boards (commonly referenced as "informational postings") include a section where pipelines compile notices regarding daily operations and other key information for market participants. Pipeline notices were compiled for key pipelines identified as supply resources in MISO. This information was reviewed, filtered, consolidated, and summarized into a single spreadsheet for reference, with each relevant incident summarized into a single data point for later aggregate analysis.

For the purpose of this study, focus was placed on events that affected a pipeline's ability to meet its firm obligations, generally defined as a force majeure ("FM") event. All FM related notices were included in the database. However, other notice types also appeared to have the potential to materially impact pipeline system performance. Given the sheer number of notices in these additional categories (>50,000), ICF employed a screening methodology to filter out notices that were out of scope from consideration. In particular, the filtering mechanism was applied to Capacity Constraint and Maintenance notices, which were determined to have the most relevant information. Alerts and other notice types were also considered, but ICF's review determined that significant events reported in these notice types were generally repeated and captured under the FM or Capacity Constraint / Maintenance notices.

Summary Results

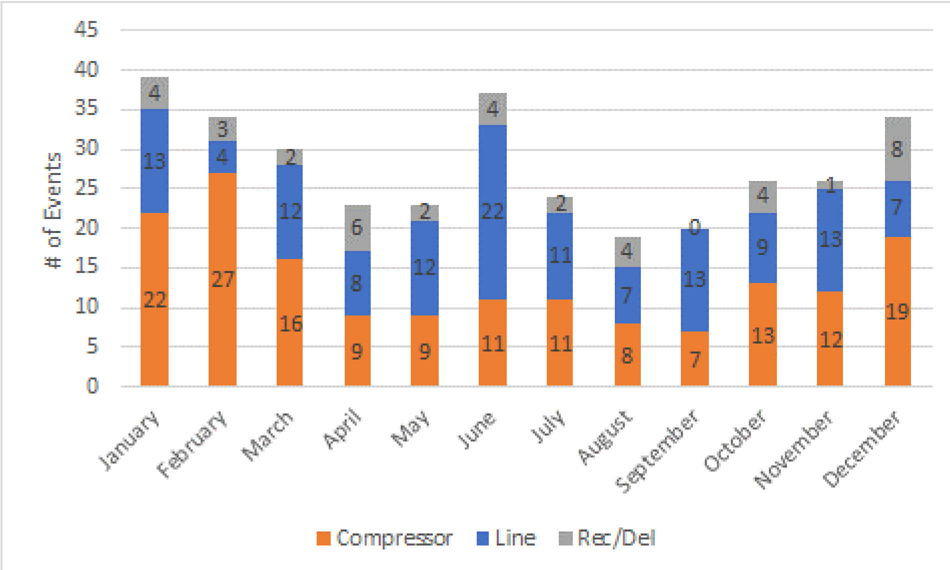
As summarized in Figure ES-1, 335 relevant events were identified in the historical data. Incorporation of the non-FM notice types (light blue bars) appears to fill in gaps where FM notices appear absent, both by adding events for a given pipeline and capturing events for pipelines not captured under strictly FM notices. However, the additional screening process still resulted in multiple pipelines not showing any relevant events. Of the 59 pipelines screened, 30 had FM events, and an additional five pipelines were captured with the broader screening process, leaving 24 pipelines showing no events. ***These results imply that nearly half of the study population did not experience or report any significant events over the 5 ½ year study horizon.***

Figure ES-1. Total Number of Events by Pipeline – Final Study Population



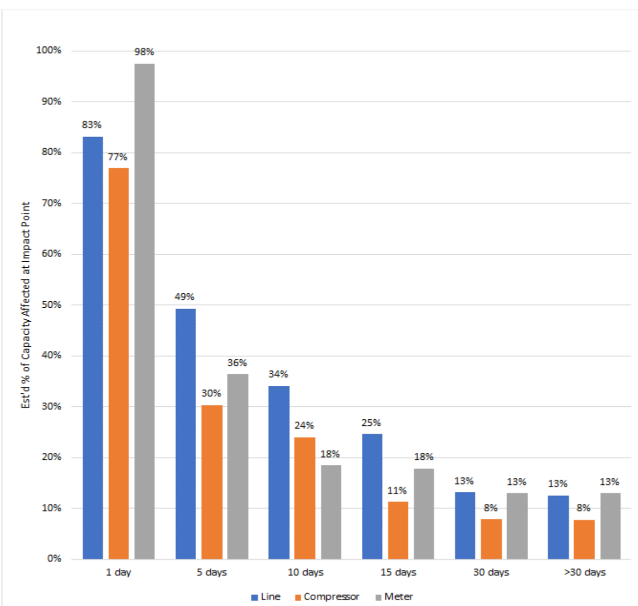
Of these 335 events, compressor station failures were the most common (164), followed by line events (131), and meter events (40). To assess if events are seasonal in nature, Figure ESES-2 summarizes the occurrence of historical events by month. There is a slightly higher occurrence of events in January and December (peak winter), and, in general, a higher average winter occurrence of events than during the summer (except June). However, the level of results does not suggest a dramatic seasonal difference. In fact, the reduced summer occurrence may be more indicative of events being reported as 'not affecting firm flows' due to lower overall flows during summer months (e.g., reporting bias) than actual seasonality of events.

Figure ES-2. Seasonality of Events



FigureES-3 summarizes the impact of an event on pipeline flows over time. As shown, the impact is generally very dramatic in the short term, with the first day impact exceeding 85 percent of the capacity of the affected point/equipment on average for line and meter events, and 75 percent for compressor events. However, while the typical event lasted more than two weeks, the level of impact over this period was non-uniform. As summarized in the figure, a significant portion of the impacts are concentrated to within the first 5 days of the event. Average impacts fall off dramatically thereafter, with impacts for line events falling below 37 percent by the 6-10-day window and compressor and meter impacts falling below 22 percent on those days.

Figure ES-3. Impact of Events on Capacity over Time[1]



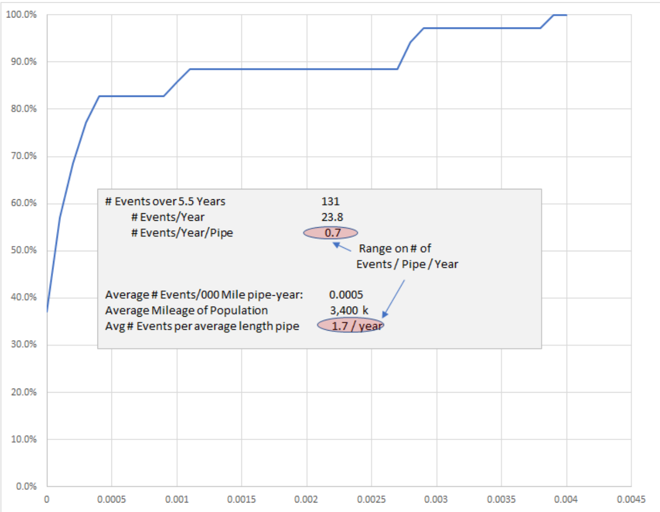
Measuring Probability of an Event

Measuring probabilities of events, particularly for a given pipeline or location, requires normalization of event data. For example, an extremely long pipeline will be more likely to incur a line event simply because its footprint increases likelihood of events, versus a shorter pipeline. Similarly, a pipeline with many compressors is more likely to experience a compressor event than one with few compressors. As such, ICF normalized event data by the relevant metric (i.e., miles of pipeline, number of compressors, and number of meters) to provide a more representative picture of the probability of an event, independent of each pipeline's characteristics. This produced the following summary statistics.

Line Events

As noted above, ICF's analysis revealed 131 line events in the historical period. As summarized in Figure ES-4 below, this implies slightly less than one event per year per pipeline. However, when normalized based on mile of pipeline and based on the average length of pipeline in the population, this implies roughly 1.7 events per pipeline per year.

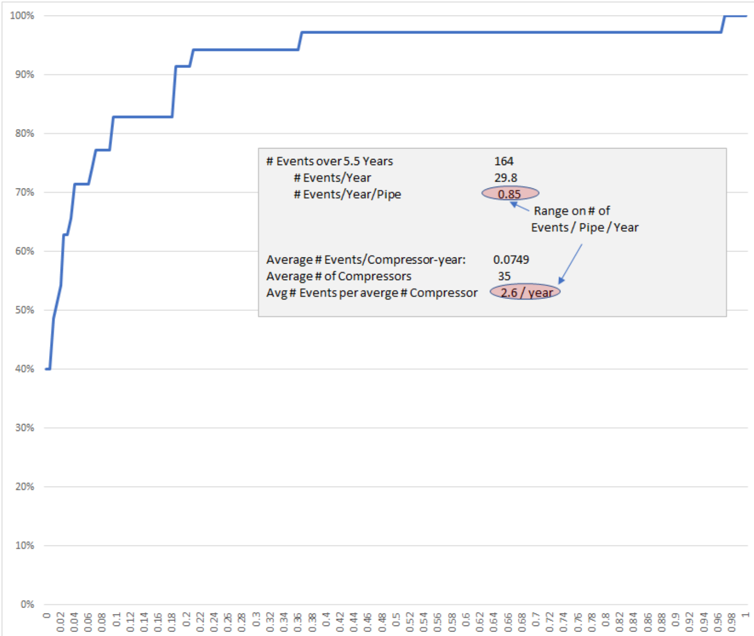
Figure ES-4. Distribution of Number of Line Events/Mile of Pipe-Year



Compressor Events

As noted above, ICF's analysis identified 164 instances of compressor events in the historical period. As summarized in Figure ES-5 below, this implies slightly less than one event per year per pipeline. However, when normalized based on the number of compressors per pipeline and based on the average number of compressors per pipeline in the population, this implies roughly 2.6 events per pipeline per year.

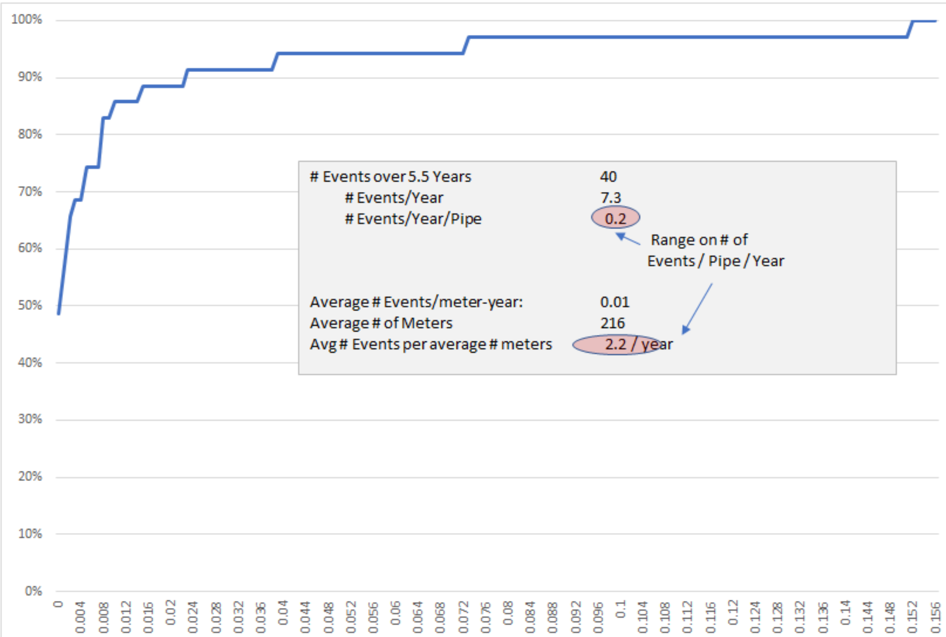
Figure ES-5. Distribution of Number of Compressor Events/Compressor-Year



Meter Events

As noted above, ICF’s analysis identified 40 instances of meter events in the historical data. This suggested an average of slightly under one-half an event per pipeline per year. However, when normalized based on the number of meters per pipeline and based on the average number of meters per pipeline in the population, this implies roughly 2.2 events per pipeline per year.

Figure ES-6. Distribution of Number of Compressor Events/Compressor-Year



General Conclusions

These results and the review of the pipeline notices imply several things about infrastructure events in the natural gas industry:

- In general, significant infrastructure events affecting firm capacity are infrequent
- Pipelines have substantial flexibility to work around events to preserve firm shipper rights. This includes utilizing line pack and secondary receipt points to preserve system flows for firm customers.
- To the degree such events occur during non-peak periods, it appears that many pipelines do not consider these FM events unless conditions exist to restrict a firm nomination.

Finally, while 335 events were identified, implying 1 to 2 events per year per pipeline, it is important to place this number in the context of the thousands of miles of pipeline capacity and hundreds of compressor stations and meters across the study region. An event at one location on a pipeline will not necessarily have a significant impact on up or downstream operations. In fact, pipelines can often adjust such operations to at least partially compensate for the immediate impacts of a given event. The specific implications depend on the location of the impact, nearby interconnectivity with other supply alternatives, the time of year and loads on the system, and related factors. As measured herein, the estimated percentage of capacity affected at the impact point is a measure specific to the incident and section of affected pipeline or equipment. It is not generally measured against the overall capacity of the associated pipeline.

1.2. Contingency Data Base

Background and Approach

ICF developed an analytical tool to identify how each power plant relates to the gas supply system with respect to pipeline capacity, compressor stations, and pipeline interconnects (e.g., major supply points including storage receipt points). The tool is scoping in nature, but also useful as a screening tool. In particular, the tool can assist MISO in identifying sections of its system that are particularly exposed to gas infrastructure events. In addition, the tool can also be used during an actual infrastructure event to help identify potentially affected generation units and assist in mitigation planning.

The tool was developed in four steps, as follows:

- **Step 1** -- MISO's initial data base of power plants and associated information was used as a starting point. It was used to identify all interstate pipelines that would be included in the study universe.
- **Step 2** -- For pipelines included in the universe, detailed data on key pipeline points and infrastructure components was compiled. ICF also developed a set of measurement metrics by which to evaluate the importance of each such point to the overall MISO system.
- **Step 3** -- ICF computed relational metrics to summarize the proximity of each power plant in the MISO database to each pipeline point / infrastructure component in the database.
- **Step 4** – The resulting plant / point data base was filtered to eliminate smaller points that would have an infinitesimal impact on power plant gas deliveries and produce a more workable set of data that would highlight key issues of interest to MISO.

In order to establish the potential significance of a given point to MISO operations, it was necessary to establish a metric reflecting the importance of each point that could be measured and compared across points on an analytical basis. To this end, ICF computed a numerical value deemed ***'Impacted Capacity'*** for each point. The Impacted Capacity is reflective of the potential gas flow quantity at risk of curtailment in the event of a contingency issue that impacts operations at that point. Impacted Capacity for the various point types was computed as follows:

- **Interconnect, Supply and Processing, and Storage points** – Flows over a five-year and one-year period for each point were calculated to determine the peak flow capacity of that point. The Impacted Capacity is a function of either the five-year or one-year absolute average flows, with the utilized time range used to determine the recent deliverability trends and current nature of flows on the pipeline system.

- **Compressors –** If compressor station throughputs were not reported (not metered), a throughput calculation was implemented based on a compression ratio input, which is a proportionality measure developed by the Energy Information Agency (EIA) that addresses the ratio of compressor horsepower to capacity.[2] Using this capacity figure, ICF developed an estimate for the potential lost deliverability on a pipeline system from an outage.

ICF established proximity relationships between each power plant and the various pipeline points of the upstream pipeline by relating the latitude and longitude of each plant to the pipeline point based on approximate locations leveraging county data for pipeline points. While approximate, this provides a reasonable representation of the proximity of a point to each plant.

Pre-packaged Report Tools

Several pre-packaged tools were incorporated into the final data base that may be used to review general operational exposures and specific operational incidents as they occur. The summarized information is meant to be used in combination with the supplemental resources (pipeline system and power plant descriptions and maps) included in the Appendix to the report.

- **Plant and Point Information Sheet** – Allows a user to identify all pipeline points associated with a specific power plant. Upon selecting the power plant, the tab summarizes key summary data including the applicable pipeline, points on the pipeline, location of the points, distance category, point category (e.g., type of point), and the 1 and 5 year Impacted Capacity.
- **Pipeline Critical Point Identification** – Allows a user to select a desired pipeline and display all of its contingency points and the generating capacity associated with each point. The associated generating capacity is further categorized based on its distance from the various points.
- **Pipeline Point Information Sheet** – Allows a user to look at a single flow point and obtain all of the generation capacity associated with that point by distance category.

As an example of the application of the tool, the following table summarizes outputs generated from the Plant – Pipeline Point report for the Zeeland Generating Facility. As noted in Table ES-1, this facility is located in Ottawa, Michigan off the ANR pipeline and has a capacity of 1,247 MW. At this point on ANR's system the pipeline consists of three lines of pipe, meaning three parallel lines are 'looped' in this location. Table ES-1 provides the summary details that are generated by the report. This lists the various points on the ANR pipeline, their location and distance from plant, they type of point (e.g., throughput, compressor, interconnect), and the Impacted Capacity based on the historical 1 year and 5 year calculation.

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[2] Natural Gas Compressor Stations on the Interstate Pipeline Network: Developments Since 1996 - https://www.eia.gov/naturalgas/archive/ngcompressor.pdf

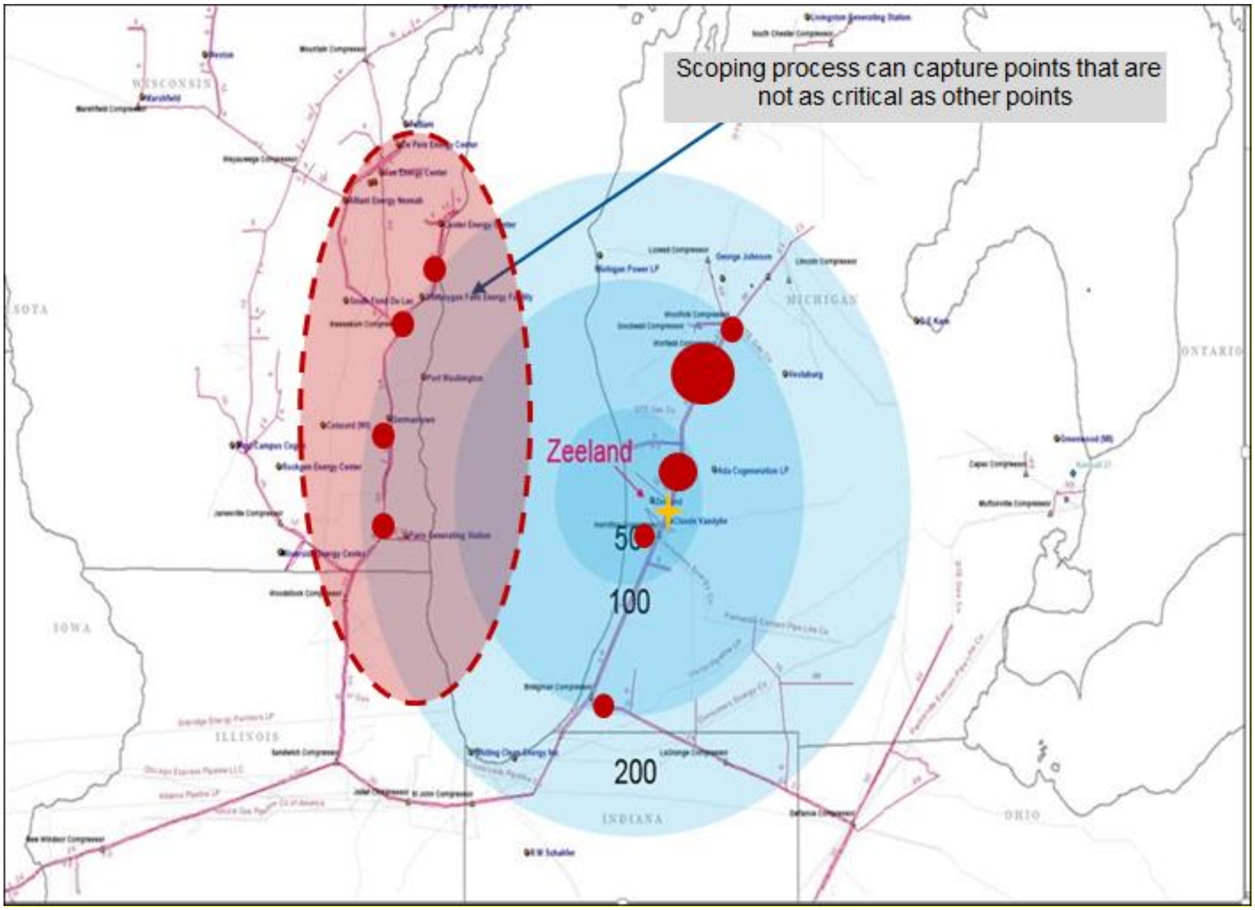
Table ES-1. Example of Plant – Pipeline Point Data Output

Plant Name			
Zeeland Generating Facility			
Location	**Pipeline Connections**	**Gas-Fired Capacity (MW)**	**Number of Loops**
MI-Ottawa	ANR	1247	3

Point	Point Location (State-County)	Distance Category - Mile	Point Category	1-Year Impacted Capacity (MMBtu/d)	5-Year Impacted Capacity (MMBtu/d)
IL to IN	IL-Will	200	Throughput	1104	813
Shelbyville-Rockies Express	IN-Shelby	Over 200	Interconnects	970	605
IL to WI East Leg	IL-McHenry	200	Throughput	676	680
Rover Westrick	OH-Defiance	200	Interconnects	595	111
Will-Alliance	IL-Will	200	Interconnects	585	594
Woolfolk Compressor	MI-Mecosta	100	Compressor	584	584
IN to OH North	IN-Adams	200	Throughput	568	881
Woodstock Compressor	IL-Mchenry	200	Compressor	508	508
Willow Run-Michcon	MI-Washtenaw	200	Interconnects	491	525
Defiance Compressor	OH-Defiance	200	Compressor	487	487
Anrpl Storage Facilities	MI-Otsego	200	Storage	468	371
Portland Compressor	IN-Jay	200	Compressor	460	460
Hamilton Compressor	MI-Allegan	50	Compressor	429	429
St John Compressor	IN-Lake	200	Compressor	425	425
Crystal Falls-Great Lakes	MI-Iron	Over 200	Interconnects	364	246
LaGrange Compressor	IN-Lagrange	100	Compressor	335	335
Bridgman Compressor	MI-Berrien	100	Compressor	300	300
Sandwich Compressor	IL-Kendall	200	Compressor	293	293
Mountain Compressor	WI-Shawano	200	Compressor	291	291
Will County-Northern Border	IL-Will	200	Interconnects	220	242
Goodwell Compressor	MI-Newaygo	100	Compressor	198	198
Farwell- Great Lakes	MI-Clare	100	Interconnects	197	249
Loreed Compressor	MI-Osceola	100	Compressor	170	170
Detroit A & B	MI-Mecosta	100	Storage	90	84
Lincoln Compressor	MI-Clare	100	Compressor	82	82

Figure ES-7 provides an illustration of this information. The blue concentric circles represent the distance categories from the plant (i.e., 0-100, 100-250, 250-500). Key points are identified with the red dots, with the dots sized based on their relative Impacted Capacity. The figure illustrates several large points that are in close proximity to the facility that would intuitively be very important to operational conditions at the plant. However, the tool is scoping in nature. So, as noted by the points on the left side of the figure circled by the dotted redline, the scoping review will capture some points that may have less relevance to the day-to-day operation of the facility. In this case the 250-500 distance category captures points that are associated with a separate ANR line located in Wisconsin.

Figure ES-7. Geographic Illustration of Plant – Pipeline Point Data Output



1.3. Opportunities for Strengthening the Power / Gas Infrastructure

The historical analysis developed in the report and an initial scoping assessment performed using the pipeline / plant contingency tool suggest that the upstream natural gas infrastructure supporting power plants in the MISO region is very robust and interconnected, providing for a highly reliable and flexible source of fuel. Moreover, with some exceptions discussed in the report, there appear to be limited clusters of gas-fired generation plants within the MISO market where a single natural gas infrastructure event would create a significant and extended disruption on MISO's system. However, there may be mitigation measures that MISO can influence that would act as preventive actions to address system vulnerabilities before issues arise. ***Regular review and consideration of these mitigation measures on a forward planning basis would minimize vulnerabilities over time.***