6.0 Sampling

Samples were collected by drawing air through sampling tubes while passing over the ground surface above the pipeline. Air drawn through the sampler was directed through duplicate sampling tubes. Every sample collection was logged into a handheld computer. The computer assigned a unique sample ID number and stamped the record with the date. The operator then recorded the start time, sample type and the starting latitude and longitude for each sample. Also recorded were the serial numbers for each sample tube. The sampler was then passed over the pipeline right of way for a sampling interval. After 5 minutes, the operator recorded the ending time and the ending latitude and longitude for each sample. The operator also logged any additional information in the comment section of the sample log. At the end of the sampling interval the sample tubes were removed, tightly sealed and set aside for shipment to the Tracer Research Corporation laboratory in Tucson, Arizona. Two new tubes were affixed to the sampler and the procedure was repeated. At the end of each day, the sample tubes were packed and shipped via overnight carrier to the laboratory in Tucson. The sample log was transmitted electronically. When the samples were received by the laboratory, the serial numbers of the tubes were checked against the log and then analyzed.

For this investigation, two types of samples were collected; test samples and air blanks. Test samples were those collected above the pipeline and were used for tightness testing. Air blank samples are quality control samples typically collected at the resumption of sampling activities, if sampling activities had been stopped for any significant time period. Air blanks are samples collected for 5 minutes using the same apparatus that was used to collect the test samples. Air blanks were collected 50 to 200 feet up wind and away from the pipeline in a location where any tracer that was detected could not come from a leak in the pipeline. Results from the air blanks were used to determine the baseline level of tracer that was expected at the site. This baseline level of the tracer was the amount of tracer that was expected in each test sample that was collected above an interval of the pipeline that was not leaking. A release of 0.5 gallon or more of tracer labeled fuel during the test would have been detected.

6.1 Baseline Discussion

Many chemicals are present at measurable concentrations everywhere in the atmosphere. This ever-present level of the chemical can be referred to as the background level. If the chemical is being used as a leak-indicating tracer, the background level is referred to as the baseline level. The concept of using an elevated reading of a chemical as compared to its background level is commonly used by other leak detection methods. Helium is a gas that is commonly used as a leak indicator or tracer. For a leak to be detected using helium, the sensor must detect a level that is significantly greater that the worldwide background concentration or baseline level of 5 parts per million (ppm). The same concept has been applied by natural gas leak detection systems that use a combustible gas sensor to detect methane. In order for a natural gas leak to be detected, methane must be present at levels significantly greater than the background concentration or baseline level of 2 ppm. In the case of the tracers used for this investigation, the same principles apply, but the baseline levels are significantly lower than the cases mentioned above.

Tracer Research Corporation evaluated the baseline level of each of the tracers used in this investigation. The baseline level for Tracer E, the leak simulation tracer, was determined to be 2.4 picograms per sample (pg, a picogram is one trillionth of a gram) and the baseline level for Tracer R, the test tracer, was determined to be 0.9 picograms per sample (pg).

6.2 Discussion of Non-leak Related Tracer Detections

In conducting tracer tests that involve the analysis of leak-indicating chemicals at extremely low levels, it is possible to detect elevated levels of test tracer that cannot be associated with a leak in the pipeline. As the baseline level of the tracer chemical decreases, the possibility of accidental spurious tracer detections increases. When the baseline level for the tracer is 0.9 picograms, a few picograms deposited onto the sampling tube from any non-leak related source will produce the same signal as a small leak when the sample is analyzed. Spurious or non-leak related tracer that shows up in the sample analysis can be caused by site related tracer sources or non-site related tracer sources.

Tracer Research Corporation has developed quality control strategies for dealing with both sources. To identify non-site related tracer depositions, duplicate samples are collected. To help identify site related sources, air blanks are collected

Before a sampling tube can be used to collect a test sample, all of the tracer material contained in the sampling tube must be removed. After the tracer is removed from the tube, the tube is sealed and shipped to the test location. After the sample is collected, the tube is sealed again and shipped to the laboratory. At the laboratory, the tube is analyzed and the amount of tracer contained in the tube is determined. Tracer deposited on the sampling tubes from non-site related sources tend to be distributed through the sampling tubes in random and unpredictable ways. It is unlikely a duplicate pair of sampling tubes will contain the same amounts of the same tracer chemical from non-site related sources. This is because the only significant tracer-depositing event they are likely to have shared completely is the duplicate sampling event. If neither of the tubes contains any tracer from any source other than the sampling event, then both tubes will have approximately the same amount of each of the tracers. If one of the sampling tubes contains significantly more of one of the tracers than the other then it is most likely that the extra tracer (in the tube with the elevated amount) came from some source unrelated to the sampling event. Therefore, if one of the duplicates shows an elevated amount of tracer (more than double the baseline level), while the other shows the expected baseline level, the result from the tube showing the higher level is thrown out. Whenever a result was discarded for this reason, the notation NST (non-site related tracer) is included in the data table.

If both of the duplicate samples show elevated levels of tracer, the tracer comes from the sampling environment. If elevated levels of any of the tracers are detected in the air blanks, there is a local or on-site source causing elevated levels of the tracer in the air. This will cause elevated levels of the tracer to show up in the test samples as well. When detected, on-site sources must be identified and eliminated if possible. Once the external source (a source external to the pipeline or a non-leak related source) has been eliminated, all samples from sampling intervals that showed elevated levels of the tracer must be re-collected. This is to confirm whether the source of tracer was from an external source or from a release from the pipeline. At the start of the test, elevated levels of the test tracer were detected in several of the test samples as well as in the air blanks. The non-leak related source was identified as the van that was being used by the on-site crew. Once the van was removed from the site, no subsequent samples, either air blanks or test samples, showed elevated levels of the test tracer. Further discussion of elevated tracer levels related to non-leak related sources of the test tracer at this site will follow in the Results section.

7.0 Analysis

Using state of the art laboratory instruments and techniques, all analyses were conducted at Tracer Research Corporation's Tucson laboratory. The instrument was calibrated with an external standard. Known masses of Tracer E and Tracer R were introduced on to a sample tube. This tube containing the external standard was then subjected to the same analysis as the samples. The detector response is directly proportional to the amount of tracer introduced to the analytical system. Using the known mass introduced and the measured response to the external standard, a mass response factor was calculated. The mass response factors from several calibration events were averaged to compute an average mass response factor. This average mass response factor was used to calculate the mass of tracer present in each of the samples.

When samples tubes were received by the laboratory, the serial number of each tube was first checked against the sample collection log that had been electronically transmitted the night before. Once the serial number on the sample tube had been confirmed from the sample log, it was analyzed for the presence of Tracer R and Tracer E. Each analysis was keyed to the sample log using the serial number of the tube and the date that the sample was collected. The results were entered into a spreadsheet generated from the sample log. All of the data, including analytical results, are tabulated in the appendices.

If results from both duplicates were available, then the results were averaged. If the result from only one of a set of duplicate samples was available, then that results was reported. If no result is available for a particular sample the notation NR (no result) is included in the data tables. Results were unavailable for a particular sample for a few possible reasons. These include: the sample tube was lost or damaged, the analytical instrument malfunctioned during the analysis of that sample, or the presence of an interference made the result undeterminable. If one of the duplicates shows an elevated amount of tracer (more than double the baseline level), while the other shows the expected baseline level, the result from the tube showing the higher level is thrown out. Whenever a result was discarded for this reason, the notation NST (non-site related tracer) is included in the data table.

8.0 Results

Appendix B contains only the validated test sample results. These are the results from which conclusions about the integrity of the pipeline can be drawn. The table is sorted by sampling interval. The first sample listed was collected at the upstream end of the test section of the pipeline that is 15 miles away from Fallon NAS. The next 109 samples (making a total of 110 samples) were collected from adjacent intervals moving toward the Kinder Morgan metering Facility on the Naval Air Station. In some cases, one test interval ends on one side of a river, canal, road or railroad crossing and the next sample in the spatial sequence begins on the other side of the obstacle. In each of these instances there is a corresponding gap between the end location for one sample and the start location for the next sample. The remaining 20 samples, listed at the end of the table, were collected at river, canal, road and railroad crossings. No significant levels of the test tracer, Tracer R, were measured in any of these samples.

Figure 1 is a graphical representation of the final test sample results. It clearly shows that there were no significant detections of the test tracer. The figure also illustrates how clearly the leak simulations are distinguishable from the baseline levels of the tracers. Note that the spike in the graph for leak simulation 4 appears wider than the other three. Leak Simulation 4 was located 8 feet from the end of a sampling interval. It is also 8 feet from the beginning of the next sampling interval. The leak simulation tracer was detected in both samples, making the spike from the leak simulation appear to be wider than the rest because elevated levels of the leak simulation tracer, Tracer E, show up in two consecutive samples. Figure 1 includes the results from the first 110 samples in Appendix B. The results from the samples collected from river, canal, road and railroad crossings are not included in Figure 1 because in some cases these additional samples were collected from locations in the middle of a sampling interval that is already included in the figure. The elevated levels (at the locations of the leak simulations) of Tracer E shown in Figure 1 and listed in Appendix B are the levels that were measured in the particular sample that was validated for that interval.

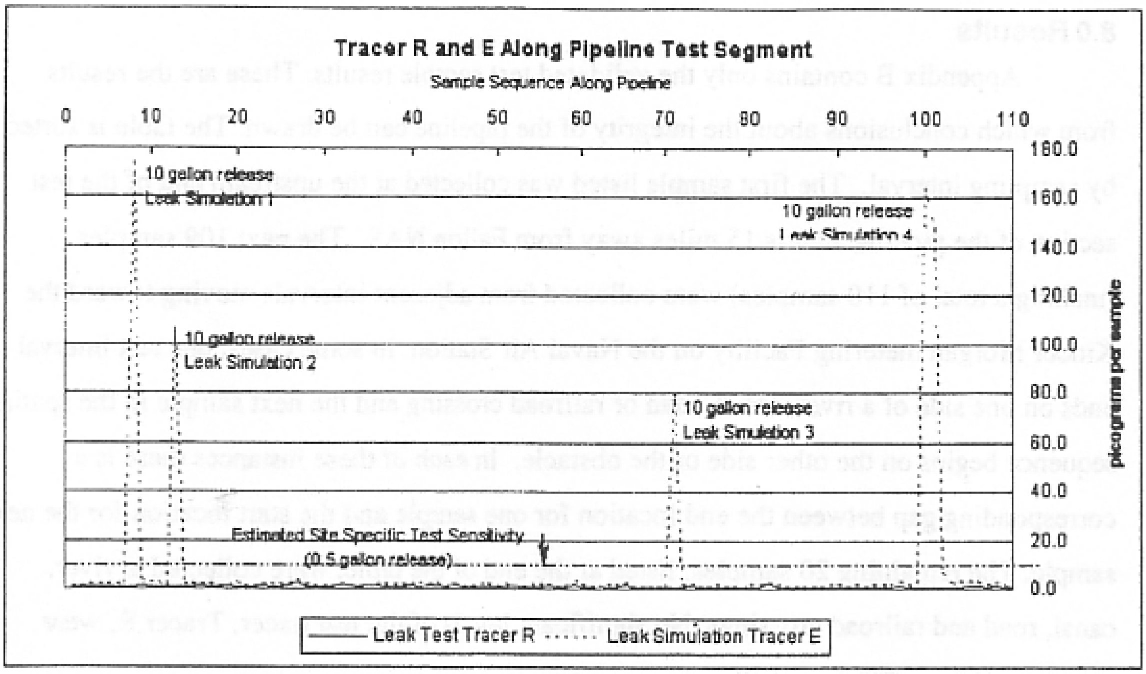

Figure 1. Tracer Amount versus Testing Interval Along the Test Segment. Tracer R was added to the jet fuel in the pipeline. Tracer E was added to leak simulation fluid (ethanol) that was released into the ground. Samples were collected above the ground along the pipeline right of way. Tracer amounts are listed as picograms in each sample (a picogram is 10^{-12} grams). All of the leak simulations were detected, no release from the pipeline was detected.

The amount of leak-indicating tracer collected above the releases of leak simulation fluid were more than 100 times greater than the baseline level. The amount of Tracer E in 0.5 gallons of the leak simulation fluid contained a quantity of Tracer E that was equal to the amount of Tracer R dissolved in 10 gallons of jet fuel in the test section of the pipeline. Suppose 0.5 gallons of the jet fuel that was labeled with Tracer R had leaked from the pipeline during the test period. The amount of Tracer R in that ½ gallon would have been one twentieth ($1/20^{th}$) the amount of Tracer E released into the pipeline trench at each leak simulation location. This fraction, $1/20^{th}$ is obtained by dividing 0.5 gallons (the hypothetical amount imagined to be released from the pipe for illustration purposes) by 10 gallons (the amount of jet fuel containing the same amount of test tracer equivalent to the amount of leak simulation tracer released). The tracers behave equivalently in the underground environment. If 0.5 gallons of jet fuel had leaked from the pipeline during the test period, the amount of Tracer R arriving at the ground surface would have produced a signal equivalent to $1/20^{th}$ the signals generated by the leak simulations. Since the leak simulations produced a tracer signal that was more than 100 times the baseline level, this hypothetical release of 0.5

gallons would have produced a tracer signal at least 5 times the baseline level (100 divided by 20). It is conservative to conclude that a tracer signal 5 times the baseline level would have been detectable and easily distinguishable from the background. This leads to the conclusion that, with a high degree of confidence, any release of tracer labeled fuel greater than 0.5 gallons during the test period would have been detected.

8.1 Non-leak Related Tracer Sources

Analytical results generated during the test was reduced in one of three ways depending on which one of three distinct categories the specific sample results belonged to. One category of samples showed baseline levels of tracer. A smaller category of samples contained varying amounts of one of the tracers from an on-site non-leak related source, namely the utility van. These samples were re-collected. The results from the re-collected samples showed only baseline levels of the tracers. These results were included in the validated data set. In the third category, there are a few samples that showed varying amounts of one of the tracers from an off-site non-leak related source. In these cases, the elevated result (anything more than double the baseline level) was discarded since the extra tracer in the one sample tube came from an off-site non-leak related source. Whenever a result was discarded for this reason, the notation NST (non-site related tracer) is included in the data table.

At the start of the test, elevated amounts of the test tracer appeared in air blanks as well as in some of the test samples. After additional sample collection, analysis and review, a pattern in the distribution of non-leak related elevated tracer amounts in the samples emerged. Each time that the sampling apparatus had been in the Tracer Research Corporation utility van for any extended period, the next sample (blank or test sample) contained elevated amounts of the test tracer. At other times, elevated amounts of tracer were detected whenever the sample was collected when the van was near. After the van was removed, on 15 July 2001, there were no more indications of an onsite source of the test tracer.

Appendix C contains the air blank sample data ordered chronologically. Figure 2 is a graphical representation of the analytical results from the air blank samples arranged in the order collected. This figure shows the effect the tracer-laden van had on the amount of tracer in the air blanks. The large variability in the amount of tracer in the air blanks is due to the effect of the dominant but uncontrolled variable, the proximity of the van. Since analytical equipment was not present on site, these early samples were collected before it was learned that the proximity of the van was an important variable. The reduction in the variability in the amount of Tracer R in the air blanks after the van was removed from the site on 15 July 2001 is a conclusive indicator of the fact that the van was the most likely non-leak related tracer source.

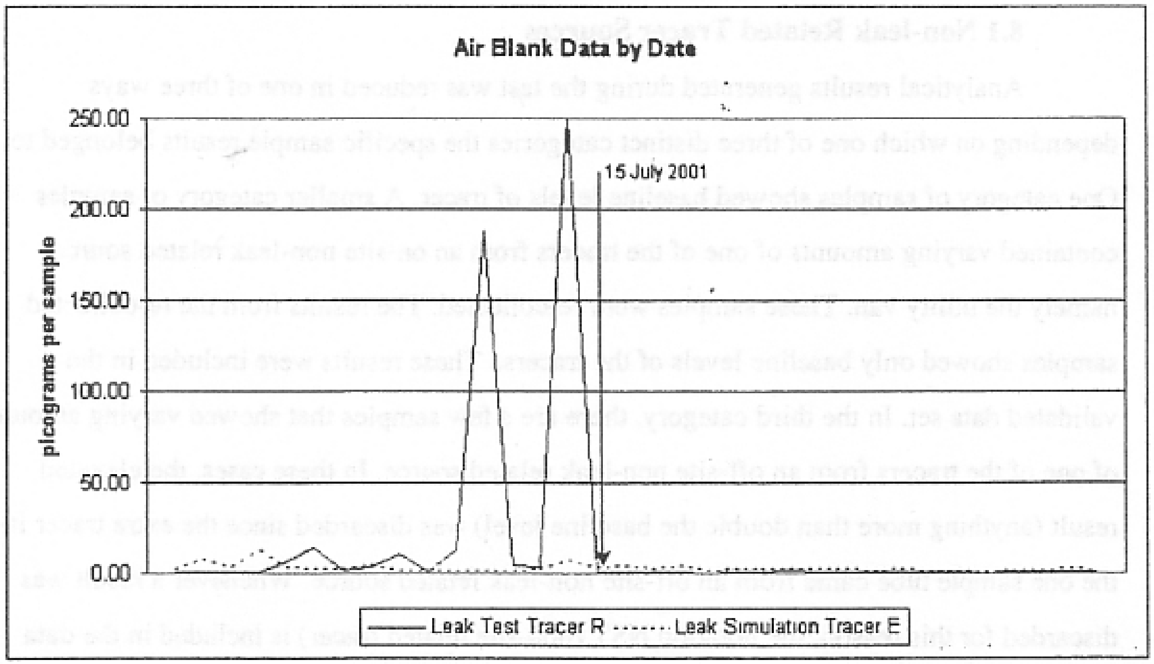

Figure 2. Tracer Amount in Air Blanks Collected Plotted in Chronological order. The van, which was removed from the site on 15 July 2001, was a significant source of Tracer R, the tracer that was added to the jet fuel in the pipeline. Tracer E was added to leak simulation fluid (ethanol) that was released into the ground. Air blanks were collected 50 to 200 feet upwind of the pipeline.

The analytical results associated with the test samples can be found in Appendix D. The results are listed in this table in the order in which the samples were collected. The sample identification number, the date and time the sample was collected and the validated analytical results for Tracer R and Tracer E are included in the table. For some samples the designator "NR" is listed as an analytical result. The designator "NR" signifies "no result." The "no result" outcome may have one of four causes: a duplicate sample that was not analyzed because it was not needed, a malfunction of the analytical instrument, a chemical interference in the sample or, in one case, a lost sample tube. In each case, the pertinent sample was re-collected if needed (see Appendix E).

Figure 3 is a graphical representation of all the analytical results from the test samples plotted in the order collected. Note the difference in the graph while the van was on site and after it was removed on 15 July 2001. Also note that the leak simulation tracer, Tracer E, was detected each time that a test interval that included the location of one of the leak simulations was re-sampled.

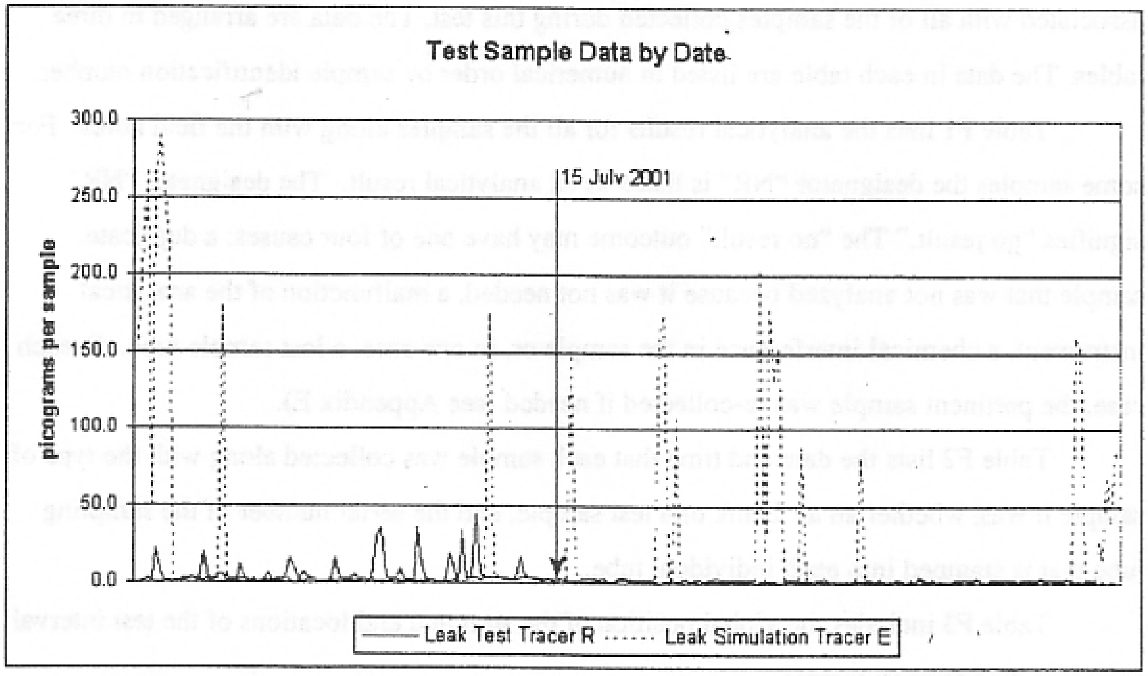

Figure 3. Tracer Amount in Test Samples Plotted in Chronological Order of Collection. The van which was removed from the site on 15 July 2001 was a significant source of Tracer R in the test samples. Tracer was added to the jet fuel in the pipeline. Tracer E was added to leak simulation fluid (ethanol) that was released into the ground.

After the non-leak related tracer source was discovered and then removed, a new sample was collected over each test interval for which the initial sample had shown elevated amounts of the test tracer.

The table in Appendix E includes data associated with the test samples that were collected over each of the test intervals for which the initial sample contained elevated amounts of tracer. The data associated with both the initial sample and each of the subsequent samples is included in the table. For each test interval the initial test result in question is listed first, followed by the results associated with the subsequent samples. For each test interval, the analytical result for the last sample collected over that interval shows only baseline levels of the test tracer. For some samples the designator "NR" is listed as an analytical result. The designator "NR" signifies "no result." The "no result" outcome may have one of four causes: a duplicate sample that was not analyzed because it was not needed, a malfunction of the analytical instrument, a chemical interference in the sample or, in one case, a lost sample tube. In each case, the pertinent sample was re-collected if needed.

Appendix F , entitled Complete Data, contains tables that include all of the data associated with all of the samples collected during this test, The data are arranged in three tables. The data in each table are listed in numerical order by sample identification number.

Table F1 lists the analytical results for all the samples along with the field notes. For some samples the designator "NR" is listed as an analytical result. The designator "NR" signifies "no result." The "no result" outcome may have one of four causes: a duplicate sample that was not analyzed because it was not needed, a malfunction of the analytical instrument, a chemical interference in the sample or, in one case, a lost sample tube. In each case, the pertinent sample was re-collected if needed (see Appendix E).

Table F2 lists the date and time that each sample was collected along with the type of sample it was, whether an air blank or a test sample, and the serial number of the sampling tube that is stamped into each individual tube.

Table F3 includes the global position of the start and end locations of the test interval corresponding to each sample.

9.0 Conclusion

The last 15 miles of the Kinder Morgan pipeline that supplies JP-8 jet fuel to the Fallon Naval Air Station was tested using a very sensitive **Tracer Tight®** line tightness test. The sensitivity of the test, estimated from the results of 4 simulated leaks and the baseline level of the test tracer, was sufficient to detect any release of fluid from the pipeline of 0.5 gallons or more during the test period. None of the data collected during the test contains any evidence of a release from the pipeline.