Evaluation of the EnviroSIR (Version 1.0) Statistical Inventory Reconciliation Method for Single and Manifolded Tanks

Final Report

Prepared For:

EnviroSIR, LLC

October 20, 1998

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P.O. Box 52565
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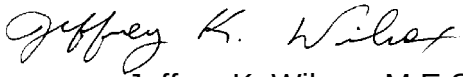
Preface

An independent, third-party evaluation of the EnviroSIR (Version 1.0) Statistical Inventory Reconciliation Method was conducted by Ken Wilcox Associates, Inc. The test procedures used in this evaluation were taken from the United States Environmental Protection Agency (EPA) evaluation protocol "Standard Test Procedures for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods," (EPA Document Number EPA/530/UST-90/007, June 1990." Additionally, this evaluation used procedures outlined in the U.S. EPA National Work Group on Leak Detection Evaluations (NWGLDE) test protocol "Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations, November 14, 1996."

The EnviroSIR Method, developed by EnviroSIR, LLC, includes a fully automated software package for conducting leak detection testing. The software contains leak detection algorithms for analyzing inventory, sales, and delivery data to conduct leak detection testing for both Monthly Monitoring (0.2 gal/h leaks) and Annual Tightness Testing (0.1 gal/h leaks). For this evaluation, Ken Wilcox Associates was provided with a copy of this software and its user instructions. Ken Wilcox Associates independently operated the EnviroSIR software without the presence of the vendor to determine the results of this evaluation. Additionally, Ken Wilcox Associates, Inc obtained the inventory data used in the evaluation directly from the tank owner/operators. Data from both single and manifolded tanks systems was used in the evaluation.

This report has been prepared by Mr. Jeffrey K. Wilcox, Ken Wilcox Associates, Inc. Technical questions regarding this evaluation should be directed to Mr. Sam Berjaoui, EnviroSIR, LLC at (318) 233-2383, e-mail: sberjaoui@worldnet.att.net.

KEN WILCOX ASSOCIATES, INC.



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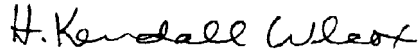

H. Kendall Wilcox, Ph.D.
President

October 20, 1998

Table of Contents

1.0 Introduction

EnviroSIR, LLC has developed a Statistical Inventory Reconciliation (SIR) Method for conducting leak detection on underground storage tanks. This report presents the results of an independent evaluation conducted by Ken Wilcox Associates, Inc. on the EnviroSIR Method.

The United States Environmental Protection Agency (EPA) regulations for underground storage tanks require owners and operators to check for leaks on a routine basis using one of a number of detection methods.[1] To ensure the effectiveness of these methods, the EPA set minimum performance standards for equipment used to comply with the regulations. All Annual Tank Tightness Test methods must be capable of detecting a 0.10 gallon per hour leak with a probability of detection of at least 95% and a probability of false alarm of no more than 5%. Similarly, all Monthly Monitoring procedures must be capable of detecting a 0.20 gallon per hour leak with a probability of detection of at least 95% and a probability of false alarm of no more than 5%.

To assure that tank testing methods meet these performance standards, the EPA requires that each method be evaluated using prescribed protocols.[2] The procedures for methods which involve a statistical analysis of daily inventory records taken by the tank owner/operator are described in the test protocol "Standard Test Procedures for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods," EPA Document Number EPA/530/UST - 90/007, June 1990. KWA has conducted this evaluation in accordance with the EPA protocol and the results have been reported on the appropriate forms in Attachment A of this report.

In 1994, the U.S. EPA established the National Work Group on Leak Detection Evaluations (NWGLDE) [3] to review third-party evaluations. This workgroup developed a test protocol for SIR methods used to test manifolded tanks and for determining size limitations.[4] This report presents the results of an analysis of the EnviroSIR Statistical Inventory Reconciliation Method according to the NWGLDE protocol.

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[1] 40CFR Part 280, Subpart D

[2] "Standard Test Procedures for Evaluating Leak Detection Methods," EPA/530 UST-90/001-7, March to October 1990. Seven different procedures were developed for different leak detection methods and released between March and October 1990.

[3] The National Work Group for Leak Detection Evaluations consists of a group of State and Federal Regulators that review leak detection evaluations, new evaluation protocols, and other issues affecting the leak detection and underground storage tank industry.

[4] Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations, November 14, 1996.

2.0 Description of the EnviroSIR Method

The official EPA forms in Attachment A of this evaluation, “Description of Statistical Inventory Reconciliation Method,” contain a complete description of the EnviroSIR Method.

The EnviroSIR Method is a means of detecting product losses from underground storage tanks by conducting a detailed statistical analysis of daily inventory measurements. The purpose of the EnviroSIR Method is to provide either periodic monitoring of UST's to identify any existing or emergent losses of product. The EnviroSIR Method includes a fully automated software package which contains embedded algorithms for conducting leak detection testing. This software package analyzes inventory, sales, and delivery data for leaks.

The basic approach involves a systematic evaluation of the inventory observations obtained by the UST owner/operator who either gauges the tank manually or records data from an automatic tank gauging system. The observations consist of the amount of product dispensed daily, deliveries of product to the tank system, and gauge readings in either inches (centimeters) or gallons (liters), or both. In order to identify loss trends in an inventory record, the EnviroSIR Method evaluates the cumulative differences between calculated book inventory of product and actual volumes of product in the tank over time, as determined by daily gauging. The statistical analyses consists of identifying the influences of various sources of error which have been introduced in the inventory data and eliminating the effects that they cause in the inventory record.

According to The vendor, EnviroSIR is capable of automatically calibrating the tank chart utilizing the first 30 to 45 daily records of inventory data. Furthermore, utilizing a proprietary built-in algorithm, the EnviroSIR program is capable of eliminating reconciliation errors due to tank deformation and tilt not accounted for in the automatic tank chart calibration. The method’s ability to calibrate the tank chart, eliminate errors due to tank deformation and tilt were not evaluated for this report.

EnviroSIR calculates a daily leak rate based on the previous 30 to 45 day inventory data records. With this feature, a tank owner/operator does not have to wait until the end of a given month to identify leak problems. All leaks or potential leaks can be monitored on a daily basis, therefore, reducing response time when problem occurs.

For this evaluation, Ken Wilcox Associates was provided with a copy of this software and its user instructions. Ken Wilcox Associates independently operated the EnviroSIR software without the presence of The vendor to determine the results of this evaluation. Data from both single and manifolded tanks was used in the evaluation.

3.0 Limitations of the EnviroSIR Method Specified

EnviroSIR, LLC recommends strict conformance with EnviroSIR protocols based on methodical research and study of fuel characteristics, inventory data, and Automatic Tank Gauge (ATG) products over the past five years.[5] Deviations from EnviroSIR protocol require written permission from EnviroSIR. EnviroSIR strongly recommends the following protocol to overcome inherent limitations:

1. Performing a precision tightness test on all tanks and piping as well as calibrating dispenser meters within 6 months prior to the use of EnviroSIR system. This is required so the system does not mask out a potentially existing leak during the process of automatically calibrating the tank charts.

2. The use of an approved electronic tank gauge in conjunction with the EnviroSIR system when performing Monthly Monitoring (0.2 gal/h) on single tanks larger than 20,000 gallons capacity or tanks having a throughput that exceeds 75,000 gal/month. This recommendation is also true for each tank in a manifolded tank system.

3. The use of an approved electronic tank gauge that adequately measures the product level in conjunction with the EnviroSIR system when performing Annual Tank Tightness Testing (0.1 gal/h) regardless of tank capacity or throughput.

4. Although the EnviroSIR Method is designed to automatically (without the need of an SIR specialist) detect leaks down to 0.1 gal/h with a high level of confidence, the method will in certain exceptional cases generate a flag that requires an EnviroSIR **trained and certified** specialist to carefully analyze the data and make a final decision. These exceptional cases arise when one or more of the following sources of excessive errors occurs: a) excessive inaccuracy in the product level measurements; b) extreme weather (temperature) conditions; c) serious tank deformation not accounted for in the tank chart; d) non-synchronized sales and stick data. It should be noted, however, that these exceptional cases are rare and that the EnviroSIR program is designed with proprietary built-in algorithms to substantially minimize their effect by utilizing more than 30 days (up to 60) of inventory data. Furthermore, temperature compensated inventory data can be used to reduce daily variances in the case of extreme weather conditions.

[5] "Methods and Apparatus for Use in Ultrasonic Ranging", S. W. Berjaoui, co-inventor, U.S. Patent 5,568,449, 1996).

4.0 Presentation of Inventory Data

The EnviroSIR Method analyzes daily inventory measurements to conduct leak detection testing. A minimum of 28 daily records must be provided for SIR analysis. The essential data that must be provided to EnviroSIR Method includes:

- **!** Measurement of height of product and/or associated volume conversions for the days the tanks are in active operation.

- **!** Deliveries or amount of product transferred to the tank by date and amount.

- **!** A record of the amount of product dispensed from the tank system during each day of active use.

5.0 Additional Items Reported to the Operator Using the EnviroSIR Method

In addition to detecting a consistent loss of product over time, other sources of error may be identified, compensated for, or quantified by the SIR Method. Once identified, the effect of the influences of these sources of error are eliminated from the record to identify the underlying loss trend, if any, that may exist. However, the standard EPA test protocol does not stipulate that these features of the analytical procedures be evaluated. The vendor has identified several sources of error, which have been listed below, that the EnviroSIR Method compensates for and/or quantifies.

The following factors are compensated for by the EnviroSIR Method.

- **!** Dispensing Meter Errors
- **!** Calibration Errors
- **!** Conversion Chart Miscalibration
- **!** Thermal Effects whenever Temperature is Available
- **!** Delivery Errors
- **!** Gauging Errors

The following effects are quantified by the EnviroSIR Method.

- **!** Leak rate
- **!** Dipstick Errors

The following effects are identified only by the EnviroSIR Method.

- **!** Delivery Errors
- **!** Unexplained Losses or Gains
- **!** Water Inflow
- **!** Water Outflow

The official EPA forms in Attachment A of this evaluation, “Description of Statistical Inventory Reconciliation Method,” contain a complete description of the EnviroSIR Method.

6.0 Description of Standard EPA Evaluation Methods

Because the EnviroSIR Method uses a fully automated software package, Ken Wilcox Associates was able to conduct the evaluation without the presence of the vendor. Ken Wilcox Associates used the EnviroSIR software package to analyze the data with simulated leaks and obtain leak detection results.

The complete evaluation procedures for statistical inventory reconciliation methods are described in the EPA evaluation protocol.[6] This protocol specifies that Statistical Inventory Reconciliation methods can be classified as either quantitative or qualitative procedures, depending upon how the results are reported. Quantitative procedures report results in terms of leak rate. Qualitative procedures report results in terms of pass, fail or inconclusive. The protocol provides detailed test methods for evaluating each type of procedure.

Since the EnviroSIR Method reports results in terms of loss rate, those portions of the EPA protocol pertaining to quantitative statistical inventory reconciliation methods were used. Sections of this protocol which apply specifically to quantitative methods include Section 6.2.4.b, Experimental Design for Quantitative Data and Section 7.2, Estimation of the SIR Method's Performance Parameters for Quantitative Data.

Information describing each tank system that was used in the evaluation has been provided in Table 1 of this evaluation. Inventory Data from 43 UST systems demonstrated to be tight were collected. The data sets used in the evaluation came from both single and manifolded tank systems which ranged in total volumes from 10,000 to 30,000 gallons. The tank systems used in the evaluation came from a variety of geographical locations. The data included records from a range of hot, mild and cold weather months.

Simulated leaks were introduced into the inventory data by decrementing the appropriate volumes to each days level reading after the level values were converted to volumes using the strapping chart. The specific procedures for this are described in Section 6.2.4, Create Evaluation Data Base--Step 4, of the EPA Evaluation Protocol.

Leak rates of zero, 0.05 gal/h, 0.10 gal/h, and 0.20 gal/h were introduced into the data. Eight data sets were created for each of the induced leak rates. Nine of the data sets were then duplicated from the data sets with leak rates of 0.05 gal/hr, 0.1 gal/hr, and 0.20 gal/hr.

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[6] Standard Test Procedures for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods, EPA Document Number EPA/530/UST - 90/007, June 1990.

Table 1. Summary of EnviroSIR SIR Evaluation Data Sets and Results

Test No.	Location of Tank	Data Collection Method	Inventory Start Date (mmddyy)	Inventory End Date (mmddyy)	Type of Product Stored	Tank Volume (gallons)	Manifold Description (No. Tanks-Size)	EPA Season Class	Output (gal)	Days of Data	Date of Tightness Test	Nominal Leak Rate	Induced Leak Rate	Reported Rate	Reported - Induced
1	San Diego, CA	Stick	3/1/94	3/31/94	Unleaded	12,000	Not Manifolded	Mild	13218	31	Oct-94	0.2	0.214	0.22	0.006
2	San Diego, CA	Stick	4/1/94	4/30/94	Unleaded	12,000	Not Manifolded	Mild	12986	30	Oct-94	0.05	0.048	0.07	0.022
3	San Diego, CA	Stick	5/1/94	5/31/94	Unleaded	12,000	Not Manifolded	Mild	11961	31	Oct-94	0	0	-0.06	-0.06
4	San Diego, CA	Stick	6/1/94	6/30/94	Unleaded	12,000	Not Manifolded	Hot	13193	30	Oct-94	0.1	0.128	0.19	0.062
5	San Diego, CA	Stick	7/1/94	7/31/94	Unleaded	12,000	Not Manifolded	Hot	14916	31	Oct-94	0	0	0	0
6	San Diego, CA	Stick	8/1/94	8/31/94	Unleaded	12,000	Not Manifolded	Hot	13288	31	Oct-94	0.1	0.087	0.07	-0.017
7	San Diego, CA	Stick	9/1/94	9/30/94	Unleaded	12,000	Not Manifolded	Mild	12981	30	Oct-94	0	0	0.02	0.02
8	San Diego, CA	Stick	10/1/94	10/31/94	Unleaded	12,000	Not Manifolded	Mild	14033	31	Oct-94	0.2	0.233	0.24	0.007
9	San Diego, CA	Stick	11/1/94	11/30/94	Unleaded	12,000	Not Manifolded	Mild	14862	30	Oct-94	0.1	0.136	0.11	-0.026
10	Newark, NJ	Stick	3/1/94	3/31/94	Unleaded	20,000	2-10,000 gal	Mild	32204	31	Dec-94	0.2	0.193	0.18	-0.013
11	Houston, TX	Stick	3/1/94	3/31/94	Unleaded	24,000	2-12,000 gal	Mild	12841	31	Oct-94	0.2	0.205	0.2	-0.005
12	Houston, TX	Stick	4/1/94	4/30/94	Unleaded	24,000	2-12,000 gal	Mild	13153	30	Oct-94	0.05	0.064	0.07	0.006
13	Houston, TX	Stick	7/1/94	7/31/94	Unleaded	24,000	2-12,000 gal	Hot	11617	31	Oct-94	0.2	0.177	0.16	-0.017
14	Houston, TX	Stick	8/1/94	8/31/94	Unleaded	24,000	2-12,000 gal	Hot	12405	31	Oct-94	0.05	0.039	0.02	-0.019
15	Houston, TX	Stick	9/1/94	10/1/94	Unleaded	24,000	2-12,000 gal	Mild	11789	31	Oct-94	0.05	0.055	0.06	0.005
16	Houston, TX	Stick	12/1/94	12/31/94	Unleaded	24,000	2-12,000 gal	Cold	14487	31	Oct-94	0	0	0.02	0.02
17	Houston, TX	Stick	1/1/95	1/31/95	Unleaded	24,000	2-12,000 gal	Cold	18459	31	Oct-94	0	0	-0.03	-0.03
18	Houston, TX	Stick	2/1/95	2/28/95	Unleaded	24,000	2-12,000 gal	Cold	18897	28	Oct-94	0.2	0.22	0.22	0
19	Ft. Lauderdale, FL	Stick	8/1/93	8/31/93	Unleaded	30,000	3-10,000 gal	Hot	22637.2	31	Oct-94	0	0	0.04	0.04
20	Ft. Lauderdale, FL	Stick	3/1/94	3/31/94	Unleaded	30,000	3-10,000 gal	Mild	30056.8	31	Oct-94	0	0	0	0
21	Ft. Lauderdale, FL	Stick	4/1/94	4/30/94	Unleaded	30,000	3-10,000 gal	Mild	25709.3	30	Oct-94	0	0	0.01	0.01
22	Ft. Lauderdale, FL	Stick	8/1/94	8/31/94	Unleaded	30,000	3-10,000 gal	Hot	25173	31	Oct-94	0.05	0.058	0.04	-0.018
23	Ft. Lauderdale, FL	Stick	9/1/94	9/30/94	Unleaded	30,000	3-10,000 gal	Mild	25391.1	30	Oct-94	0	0	0.01	0.01
24	Ft. Lauderdale, FL	Stick	10/1/94	10/31/94	Unleaded	30,000	3-10,000 gal	Mild	25951.1	30	Oct-94	0.1	0.11	0.11	0
25	New Orleans, LA	ATGS	8/1/96	8/31/96	Unleaded	10,000	Not Manifolded	Hot	24145	31	Aug-96	0	0	0	0
26	New Orleans, LA	ATGS	6/1/96	6/28/96	Unleaded	10,000	Not Manifolded	Hot	22013	28	Aug-96	0.05	0.042	0.03	-0.012
27	New Orleans, LA	ATGS	8/1/96	8/31/96	Unleaded	10,000	Not Manifolded	Hot	35695	31	Aug-96	0	0	-0.01	-0.01
28	New Orleans, LA	ATGS	8/1/96	8/31/96	Unleaded	10,000	Not Manifolded	Hot	35115	31	Aug-96	0.05	0.05	0.04	-0.01

Table 1. Summary of EnviroSIR SIR Evaluation Data Sets and Results

Test No.	Location of Tank	Data Collection Method	Inventory Start Date (mmddyy)	Inventory End Date (mmddyy)	Type of Product Stored	Tank Volume (gallons)	Manifold Description (No. Tanks-Size)	EPA Season Class	Output (gal)	Days of Data	Date of Tightness Test	Nominal Leak Rate	Induced Leak Rate	Reported Rate	Reported - Induced
29	Lincoln, NE	ATGS	3/1/96	3/31/96	Unleaded	10,000	Not Manifolded	Mild	38151	31	May-96	0	0	0	0
30	Atlanta, GA	ATGS	2/1/96	2/29/96	Unleaded	12,000	Not Manifolded	Cold	58479	29	Jan-96	0	0	0.01	0.01
31	Atlanta, GA	ATGS	4/1/96	4/30/96	Unleaded	12,000	Not Manifolded	Mild	73735	31	Aug-96	0.2	0.18	0.15	-0.03
32	Atlanta, GA	ATGS	6/1/96	6/30/96	Unleaded	12,000	Not Manifolded	Hot	73623	30	Aug-96	0.1	0.089	0.13	0.041
33	San Diego, CA	Stick	7/1/94	7/31/94	Unleaded	12,000	Not Manifolded	Hot	14916	31	Oct-94	0.2	0.185	0.19	0.005
34	San Diego, CA	Stick	8/1/94	8/31/94	Unleaded	12,000	Not Manifolded	Hot	13288	31	Oct-94	0	0	-0.02	-0.02
35	Houston, TX	Stick	12/1/94	12/31/94	Unleaded	24,000	2-12,000 gal	Cold	14487	31	Oct-94	0.1	0.094	0.11	0.016
36	Houston, TX	Stick	1/1/95	1/31/95	Unleaded	24,000	2-12,000 gal	Cold	18459	31	Oct-94	0.1	0.077	0.05	-0.027
37	Houston, TX	Stick	2/1/95	2/28/95	Unleaded	24,000	2-12,000 gal	Cold	18897	28	Oct-94	0	0	0	0
38	Ft. Lauderdale, FL	Stick	8/1/94	8/31/94	Unleaded	30,000	3-10,000 gal	Hot	25173	31	Oct-94	0	0	-0.02	-0.02
39	Ft. Lauderdale, FL	Stick	9/1/94	9/30/94	Unleaded	30,000	3-10,000 gal	Mild	25391.1	30	Oct-94	0.05	0.044	0.05	0.006
40	Ft. Lauderdale, FL	Stick	10/1/94	10/31/94	Unleaded	30,000	3-10,000 gal	Mild	25951.1	30	Oct-94	0	0	0	0
41	Atlanta, GA	ATGS	2/1/96	2/29/96	Unleaded	12,000	Not Manifolded	Cold	58479	29	Aug-96	0.1	0.103	0.12	0.017
42	Newark, NJ	Stick	7/1/94	7/31/94	Unleaded	20,000	2-10,000 gal	Hot	35949	31	Dec-94	0	0	-0.05	-0.05
43	Ft. Lauderdale, FL	Stick	7/1/94	7/31/94	Unleaded	30,000	3-10,000 gal	Hot	29559	31	Oct-94	0	0	0.07	0.07

7.0 Description of the NWGLDE Database Requirements

A list of the database requirements necessary for an SIR Method to be used on both single and manifolded tanks is provided below. This list has been taken directly from the NWGLDE protocol.

A. If a SIR method is to be used for manifolded tanks as well as single tanks, the evaluation must contain between 30% and 75% conclusive data from manifolded tank systems. This is a minimum of 12 conclusive data sets for quantitative methods and 36 conclusive for qualitative methods.

B. If manifold tank systems are included, then the SIR program is limited to the number of tanks in the 80th percentile plus one. The tank records are to be ordered by the number of tanks in the manifold from least to largest starting with the single tank records. The 80th percentile is the tank record such that 80% of the tank records have less than or equal to this number of tanks in the record. For example, a data set with 41 conclusive records has 28 single tank records, 4 two tank records, and 9 three tank records. Take 80% of 41 to get 32.8. Fractions are moved to the next integer, in this case 3. Counting from smallest to largest, the 33rd record has 3 tanks in the manifold. Therefore, limit the method to manifolded UST systems that have no more than four tanks.

C. Again, the distribution of the number of tanks in the manifold should represent the intended use of the method. However, use of the method should not be extended to more difficult cases without justification based upon adequate data in the evaluation.

D. To justify the use of the SIR method for single and manifold tanks, results for single and manifold tanks must be shown to be similar. To make this comparison, the database must conform to the following:

I. At least 24 of the 41 records must be usable and conclusive for quantitative methods; 80 of the 120 conclusive and usable for qualitative methods.

*II. For **quantitative** methods, a minimum of 3 of the 8 records from tight tank conditions, and 3 of the 8 records from each group with induced leak rates must be from manifolded systems. The total number of manifolded record results which are conclusive and usable must be at least 12.*

8.0 Summary of the Database used in the Evaluation

A complete summary of the data sets used in the evaluation is contained in Table 1. The database consisted of a total of 43 data sets of which 20 were from single tanks and 23 were from manifolded tanks. Results were reported for each of the 43 data sets, i.e., there were no inconclusive results reported. The table below lists the number of single and manifolded tank data sets with various induced leak rates.

Induced Leak Rate	Single Tanks	Manifolded Tanks	Both
Zero gal/hr	8	11	19
0.05 gal/hr	3	5	8
0.1 gal/hr	5	3	8
0.2 gal/hr	4	4	8

The NWGLDE requires that between 30% and 75% of the conclusive data be from manifolded tanks. This analysis meets this requirement with 53% of the conclusive data being from manifolded tanks.

9.0 Procedures for Conducting Standard EPA Calculations

9.1 Basic Statistics

The n pairs of estimated and induced leak rate data are used to calculate the mean squared error, variance, standard deviation, and bias of the method.

9.11 Mean Squared Error

The mean squared error, MSE, is given by:

$$MSE = \sum_{i=1}^{n} (L_i - S_i)^2/n$$

where L_i is the leak rate reported by the SIR Method and S_i is the actual induced leak rate, for i from 1 to n for the different data bases.

9.12 Bias

The bias, B, is estimated by:

$$B = \sum_{i=1}^{n} (L_i - S_i)/n$$

The bias, B, is the average difference between the measured and induced leak rates over the number of tests. The bias is a measure of the accuracy of the method and can be either positive or negative.

9.13 Variance and Standard Deviation

The variance is found from the formula:

$$\sigma^2 = \sum_{i=1}^{n} [(L_i - S_i) - B]^2/(n-1)$$

Denote the standard deviation by SD. The standard deviation is the square root of the variance.

9.2 Test for Zero Bias

To test whether the SIR Method has a bias that is statistically significantly different from zero, the following statistical test on the bias, B, calculated above is performed.

Compute the t-statistic:

$$t = \sqrt{n}\ B/SD$$

From a t-table, obtain the critical value corresponding to a t with (n-1) degrees of freedom and a two-sided 5% significance level. For example, with n = 41, there are 40 degrees of freedom and the two-sided 5% significance level leads to a critical value of 1.684. Denote this value by t_c. Compare the absolute value of t to t_c. If the absolute value of the calculated t is less than the critical value, the bias is not significantly different from zero and the system is assumed unbiased. If the absolute value of the calculated value of t exceeds the critical value then the method has a significant bias. If the bias, B, is positive, the system systematically over estimates the leak rate. If B is negative, the system under estimates the leak rate.

9.3 Probability of False Alarm, P_{FA}

The probability of a false alarm, P_{FA}, is the probability that the measured leak rate will exceed the threshold or criterion for indicating a leak when the tank is actually tight. Generally, if the estimated leak rate exceeds a specified leak rate or threshold, C, the tank is judged by the SIR Method to be leaking. If C denotes the criterion or threshold for indicating a leak, B denotes the estimated bias of the system, SD denotes the standard deviation, then the probability of a false alarm can be written as:

$$P_{FA} = P\{\ t > (C-B)/SD\ \}$$

where the probability is calculated from a t-distribution with the number of degrees of freedom associated with the standard deviation. This formula assumes that the errors are approximately normally distributed. If the bias, B, was not significantly different from zero, B is taken to be zero.

9.4 Probability of Detection, P_D

The probability of detection, P_D, is the probability that the system will correctly identify a leak of specified size. In general for a leak rate of size R, P_D is given by:

$$P_D = P\{ t > (C-R-B)/SD \}$$

where C, B, and SD are as before, and the probability is calculated from the t-distribution with degrees of freedom corresponding to the SD.

9.5 Supplemental Calculations

Certain supplemental calculations which may be of interest include the minimum threshold and minimum detectable leak rate. The equations for calculating the minimum threshold and the minimum detectable leak rate have been provided below.

9.51 Minimum Threshold Calculation

The minimum threshold, $C_{5\%}$ for which a leak can be declared for the required 5% probability of a false alarm is given by:

$$C_{5\%} = t_{5\%, (n-1)} (SD) + B$$

where $t_{5\%}$ denotes the 5^{th} percentile student's t value with (n-1) degrees of freedom, SD denotes the standard deviation, and B denotes the bias.

9.52 Minimum Detectable Leak Rate Calculation

The minimum leak rate, $R_{5\%}$ which can be detected with a 95% probability using the minimum threshold, $C_{5\%}$ is given by:

$$R_{5\%} = 2C_{5\%} - 2B$$

where SD denotes the standard deviation and B denotes the bias.

10.0 Procedures for Determining if the SIR Method can be used on Single and Manifolded Tanks

To determine if an SIR Method can be used on single and manifolded tanks, it is necessary to calculate the overall P(D) and P(FA) for the entire database used in the evaluation using the equations in the original EPA SIR protocol to determine whether the combined data meets the 95% and 5% performance standard. If the combined data meets the 95% and 5% performance standard, then it is necessary to calculate the mean and standard deviation separately for the single and manifold groups and make a comparison between the two. This must also be done for the bias for each group.

A list of the required calculations is provided below:

A. Mean Squared Error for Single and Manifolded Tanks Separately

B. Variance and Standard Deviation for Single and Manifolded Tanks Separately

C. Test for Zero Bias for Single and Manifolded Tanks Separately

D. Comparison of Standard Deviations of Single vs. Manifolded Tanks

E. Comparison of Biases of Single vs. Manifolded Tanks

F. Probability of a False Alarm, P(FA), for Single and Manifolded Tanks, Separately

G. Probability of Detecting a Leak Rate of R Gallon Per Hour, P(D), for Single vs. Manifolded Tanks, Separately

If the standard deviations and biases of single vs. manifolded tanks are not significantly different, then the SIR method is not affected by manifolding. Therefore, it is not necessary to calculate the P(D) and P(FA) separately for each. It is only necessary to report the overall P(D) and P(FA) for the combined data. There will be only one volume limitation which will be applicable to both single and manifolded UST's.

If both the single and manifolded groups meet the 95% and 5% performance standard, then the method may be used on both single and manifolded tank systems.

11.0 Procedures for Determining the SIR Method's Volume Limitation

Determination of whether tank size affects the performance of the SIR method can be conducted on the entire database as a whole if the method is found to perform equivalently on single and manifolded tanks. In this case, there will be only one maximum volume limitation that is applicable to both single tanks and manifolded systems.

In particular, the 80th percentile determines a limitation on tank size. The 80th percentile is the tank size corresponding to the integer greater than or equal to 0.8n, where n is the number of records counting from the smallest tank size to the largest.

To justify extrapolation to larger tank sizes, the results for small and large tanks must be shown to be similar. To make this comparison, divide the data records into two groups based on volume. The two groups should be of nearly equal size, but if there are many records at one tank size (e.g., 10,000 gallons), it may not be possible to make the two groups exactly equal. The following calculations are then necessary to determine if the SIR Method is affected by larger tank sizes.

A. Variance and Standard Deviation for Large and Small Tanks Separately

B. Comparison of Standard Deviation of Large vs. Small Tanks

C. Comparison of Biases of Large vs. Small Tanks

If the standard deviations and biases of large vs. small volume groups are not significantly different, then the SIR method is not affected by increasing volume. In this case, the maximum size limitation is 1.5 times the 80th percentile.

Additionally, the smallest, 25th, 50th (median), 75th, 80th percentile, and the largest tank size are reported.

12.0 Procedures for Determining the Number of Manifolded Tanks that the SIR Method can be Applied to

If manifold tank systems are included, then the SIR program is limited to the number of tanks in the 80th percentile plus one. The tank records are to be ordered by the number of tanks in the manifold from least to largest starting with the single tank records. The 80th percentile is the tank record such that 80% of the tank records have less than or equal to this number of tanks in the record.

13.0 Results of the Standard EPA Calculations

The results of the statistical analysis based on the reported results have been summarized in Table 2 of this report. The EnviroSIR Method exceeds the EPA requirements for Statistical Inventory Reconciliation Leak Detection Methods.

13.1 Probability of False Alarm, P_{FA}

The differences between the induced rate and the measured rates for each set of inventory data were used to calculate the standard deviation of the EnviroSIR Method. The standard deviation is then used to calculate the P_{FA} using the appropriate threshold according to the equation in Section 9.0 of this report.

13.11 P_{FA} for Monthly Monitoring

When the EnviroSIR Method is used for Monthly Monitoring for 0.2 gal/hr leaks, a threshold of 0.1 or 0.15 gal/hr is used. The software allows the user to select the threshold used to detect 0.2 gal/h leaks. The corresponding P_{FA} was calculated to be 0.1% for a 0.1 gal/h threshold and 0.1% for a 0.15 gal/h threshold.

13.12 P_{FA} for Annual Tank Tightness Testing

When the EnviroSIR Method is used for Annual Tank Tightness Testing for 0.1 gal/hr leaks, a threshold of 0.05 gal/hr is used. The corresponding P_{FA} was calculated to be 2.6%.

13.2 Probability of Detection, P_D

The differences between the induced rate and the measured rates for each set of inventory data were used to calculate the standard deviation of the EnviroSIR Method. The standard deviation is then used to calculate the P_D using the appropriate threshold according to the equation in Section 9.0 of this report.

13.21 P_D for Monthly Monitoring

When the EnviroSIR Method is used for Monthly Monitoring for 0.2 gal/hr leaks, a threshold of 0.1 or 0.15 gal/hr is used. The software allows the user to select the threshold used to detect 0.2 gal/h leaks. The corresponding P_D was calculated to be 99.9% for a 0.2 gal/h leak when a threshold of 0.1 gal/h is used and 97.4% for a 0.2 gal/h when a 0.15 gal/h is used.

Table 2. Summary of the Standard EPA Calculations for the EnviroSIR Method

Parameter	Value
Basic Statistics	
Mean Squared Error	0.00061 gal^2/h^2
Bias	Negligible
Standard Deviation	0.0025 gal/h
Variance	0.00063 gal^2/h^2
Monthly Monitoring	
Threshold	0.1 / 0.15 gal/hr
Probability of False Alarm (P_{FA})	0.1 / 0.1%
Probability of Detection (P_D)	99.9 / 97.4%
Annual Tightness Testing	
Threshold	0.05 gal/hr
Probability of False Alarm (P_{FA})	2.6%
Probability of Detection (P_D)	97.4%
Limitations	
Maximum Tank Size (Single Tanks)	45,000 gallons
Maximum Tank Size (Manifolded Tank Systems)	45,000 gallons
Maximum Number of Tanks in a Manifolded System	4 tanks
Minimum Number of Usable Daily Records Necessary	28
Optional Calculations	
Minimum Threshold for 5% P_{FA}	0.042 gal/h
Minimum Leak Rate Detectable with 95% P_D	0.084 gal/h

13.22 P_D for Annual Tank Tightness Testing

When the EnviroSIR Method is used for Annual Tank Tightness Testing for 0.1 gal/hr leaks, a threshold of 0.05 gal/hr is used. The corresponding P_D was calculated to be 97.4% for a 0.1 gal/hr leak.

13.3 Supplemental Calculations

Certain supplemental calculations which may be of interest include the minimum threshold and minimum detectable leak rate. These values are calculated using the equations provided in Section 9.0 of this report.

13.31 Minimum Threshold

The minimum threshold for which a leak can be declared for the required 5% P_{FA} is 0.042 gal/hr. If a threshold of less than 0.042 gal/hr is used, the method will have a P_{FA} greater than 5%,

13.32 Minimum Detectable Leak Rate

The minimum leak which can be detected with a 95% probability using a threshold of 0.042 gal/hr is 0.084 gal/hr.

14.0 Results of the Comparison of the Single and Manifolded Tanks

The calculations described in Section 10.0 of this report are tabulated below.

Parameter	Single Tanks	Manifolded Tanks	Both
Number of Results Reported	20	23	43
Mean Squared Error	0.00066	0.00057	0.00061
Variance	0.00069	0.00060	0.00063
Standard Deviation	0.0263	0.0244	0.0250
Bias	0.00025	-0.00070	-0.00026
Probability of False Alarm (0.1 / 0.15 gal/h Threshold)	0.1 / 0.1%	0.1 / 0.1%	0.1 / 0.1%
Probability of Detection (0.2 gal/h Leak using a 0.1 / 0.15 gal/h Threshold)	99.9 / 96.4%	99.9 / 97.4%	99.9 / 97.4%
Probability of False Alarm (0.05 gal/h Threshold)	3.6%	2.6%	2.6%
Probability of Detection (0.1 gal/h Leak using a 0.05 gal/h Threshold)	96.4%	97.4%	97.4%

A statistical comparison was made between the standard deviations for the single and manifolded tanks. This comparison requires that an two-sample F-test be done on the standard deviations of the single and the manifolded tanks. The resulting F-test value must be less than the 95th percentile of an F-distribution value with 19 degrees of freedom in the numerator and 22 degrees of freedom in the denominator. The calculated F-test value is 1.12 and the 95th percentile F-distribution value is 2.13. Since the calculated value is less than the 95th percentile value, there is justification that the method can be used on single and manifolded tanks.

A statistical comparison was also made between the biases for the single and manifolded tanks. This comparison requires that a two-sample t-test be done to determine if there is any significant difference in the biases. The calculated t-test value is compared to a two-sided 5% critical value from a t-distribution with 42 degrees of freedom. If the absolute value of the t-test value does not exceed the critical value, then there is no evidence that the bias is different for single tanks compared to

manifolded tanks. The absolute value of the t-test for this analysis is 0.12 and the critical value is 2.02. Since the t-test value is less than the critical value, there is justification that the method can be used on single and manifolded tanks.

The P(FA) is less than 5% for the single tank, manifolded tank, and combined data set results. The P(D) is greater than 95% for the single tank, manifolded tank, and combined data set results. Since both groups meet the P(FA) and P(D) performance standards, the method may be used on both single and manifolded tank systems.

15.0 Results of the Volume Limitations

The entire database of 43 data sets was divided into small and large tanks. Since the single tanks were from smaller tank systems and the manifolded tanks were from larger tank systems, the division between small and large tanks is equivalent to the division between single and manifolded tanks. The volumes of the single tank data sets ranged from 10,000 gallons to 12,000 gallons. The volumes of the manifolded tank systems ranged from 20,000 to 30,000 gallons.

The calculations described in Section 11.0 of this report are tabulated below.

Parameter	Small Tanks	Large Tanks	Both
Number of Results Reported	20	23	43
Tank Volume Range	10,000 to 12,000 gallons	20,000 to 30,000 gallons	10,000 to 30,000 gallons
80^{th} Percentile Volume	12,000 gallons	30,000 gallons	30,000 gallons
Mean Squared Error	0.00066	0.00057	0.00061
Variance	0.00069	0.00060	0.00063
Standard Deviation	0.0263	0.0244	0.0250
Bias	0.00025	-0.00070	-0.00026

A statistical comparison was made between the standard deviations for the small and large tanks. This comparison requires that an two-sample F-test be done on the standard deviations of the small and large tanks. The resulting F-test value must be less than the 95^{th} percentile of an F-distribution value with 40 degrees of freedom in the numerator and 40 degrees of freedom in the denominator. The calculated F-test value is 1.12 and the 95^{th} percentile F-distribution value is 2.13. Since the calculated value is less than the 95^{th} percentile value, there is justification that the method is not affected by increasing volume.

A statistical comparison was also made between the biases for the small and large tanks. This comparison requires that a two-sample t-test be done to determine if there is any significant difference in the biases. The calculated t-test value is compared to a two-sided 5% critical value from a t-distribution with 80 degrees of freedom. If the

absolute value of the t-test value does not exceed the critical value, then there is no evidence that the bias is different between small and large tanks. The absolute value of the t-test for this analysis is 0.12 and the critical value is 2.02. Since the t-test value is less than the critical value, there is justification that the method is not affected by increasing volume.

The 80th percentile of the combined data sets is used to determine the volume limitation. This value is 30,000 gallons. The limitation specified by the NWGLDE protocol is 1.5 times the value of the 80th percentile volume. Therefore the EnviroSIR Method may be used on tank systems up to 45,000 gallons.

The smallest, 25th, 50th (median), 75th, 80th percentile, and the largest tank size are reported below.

Smallest Tank Size in the database:	10,000 gallons
Size of tank in the 25th percentile of database:	12,000 gallons
Size of tank in the 50th percentile of database:	20,000 gallons
Size of tank in the 75th percentile of database:	24,000 gallons
Size of tank in the 80th percentile of database:	30,000 gallons
Largest Tank Size in the database:	30,000 gallons
Maximum tank size the SIR Method may be applied to:	**45,000 gallons**

16.0 Results of the Number of Manifolded Tanks that the EnviroSIR Method can be Applied to

The EnviroSIR program is limited to the number of tanks in the 80th percentile plus one. The 80th percentile data set in the entire database was from a 3-tank manifolded system. Therefore, the EnviroSIR Method can be applied to manifolded tank systems with up to 4 tanks.

17.0 Conclusions

The following conclusions are based on the results of the testing described in this report.

1. The EnviroSIR Method exceeds the EPA criteria for Monthly Monitoring for 0.2 gal/hr leaks. (The EPA requirements specify that the method must have a P_D of at least 95% and a P_{FA} of no more than 5%).

2. The EnviroSIR Method exceeds the EPA criteria for Annual Tank Tightness Testing for 0.1 gal/hr leaks. (The EPA requirements specify that the method must have a P_D of at least 95% and a P_{FA} of no more than 5%).

3. Using the NWGLDE guidelines, the method may be applied to single and manifolded tanks with volumes up to 45,000 gallons.

4. Using the NWGLDE guidelines, the method may be applied to manifolded tank systems consisting of up to 4 tanks.

5. A minimum of 28 daily records must be used for the analysis.

Attachment A

EPA Forms for the EnviroSIR Statistical Inventory Reconciliation Method

Results of the U.S. EPA Standard Evaluation
Statistical Inventory Reconciliation

This form tells whether the statistical inventory reconciliation (SIR) method described below complies with requirements of the federal underground storage tank regulation. The evaluation was conducted by the vendor of the SIR method or a consultant to the vendor according to the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods." The full evaluation report also includes a form describing the method and a form summarizing the test data.

Tank owners using this leak detection method should keep this form on file to prove compliance with the federal regulations. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

Method Description

Name EnviroSIR

Version Version 1.0 for Single and Manifolded Tanks

Monthly Monitoring (0.2 gal/h leaks)

Vendor EnviroSIR, LLC

P.O. Box 52565
(address)

Lafayette,	LA	70505	U.S.A.	(318) 233-2383
(city)	(state)	(zip)	(country)	(phone)

Evaluation Results

If applicable, vendor's threshold = 0.10 / 0.15 gallon per hour ***(user selectable)*** or vendor's criterion: _____

This statistical inventory reconciliation method reports results on the following basis (check one):

(X) quantitative results (leak rate reported) ***See Attached Reporting Form***

( ) qualitative results (pass, fail, inconclusive)

The test results are:

		Reported Results				
		Tight	Leak	Inconclusive	Total Analyzed	Not Analyzed
Actual	Tight					
	Induced Leak					
	Total					

Evaluation Results

The proportions of inventory records reported inconclusive are:

0 % among tight tanks

0 % among leaking tanks

0 % among all tanks

The probability of false alarms, P(FA), based on the vendor's threshold, is 0.1 / 0.1 %.

For qualitative methods, a 95% confidence interval for P(FA) is from

_____ to _____ %.

The probability of detection, P(D), is 99.9 / 97.4 %. This is valid for a leak rate of (check one):

( ) 0.10 gallon per hour

(**X**) 0.20 gallon per hour

For qualitative methods, a 95% confidence interval for P(D) is from

_____ to _____ %.

Based on these results, the method (**X**) does ( ) does not meet the **federal** performance standards established by the U.S. Environmental Protection Agency of 0.20 gallon per hour at P(D) of 95% and P(FA) of 5%.

Test Conditions during Evaluation

The data evaluation set included data from tanks of the following sizes

Tank Size (gallons)	< 5,000	5,000-10,000	10,000-15,000	>15,000	Total # of Records
Number of Records	0	5	15	23	43

The tanks had various monthly throughputs.

Percentile of Records	25	50 median	75	100
Monthly throughput (gallons)	13,218	18,897	30,057	73,735

The data included 17 records during hot weather months.
18 records during mild weather months.
8 records during cold weather months.

Limitations on the Results

The performance estimates above are only valid when:

- **!** The method has not been substantially changed.
- **!** The vendor's instructions for using the method are followed.
- **!** The single or manifolded tank system is no larger than 45,000 gallons.
- **!** The manifolded tank system consists of no more than 4 tanks.
- **!** The data records cover 28 days or more.
- **!** For quantitative methods, the SIR method may be used for manifolded tank systems. There was not a significant difference in the performance between single and manifolded tanks. There is only one volume limitation which applies to both single and manifolded tanks.
- **!** Other limitations specified by the vendor or determined during testing:

> **Safety disclaimer: This test procedure only addresses the issue of the method's ability to detect leaks. It does not test data recording equipment for safety hazards.**

Certification of Results

I certify that the statistical inventory reconciliation method was applied according to the vendor's instructions. I also certify that the evaluation was performed according to the standard EPA test procedure for statistical inventory reconciliation and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, President
(printed name)

H. Kendall Wilcox
(signature)

October 20, 1998
(date)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

Grain Valley, MO 64029
(city, state, zip)

(816) 443-2494
(phone number)

Results of the U.S. EPA Standard Evaluation
Statistical Inventory Reconciliation

This form tells whether the statistical inventory reconciliation (SIR) method described below complies with requirements of the federal underground storage tank regulation. The evaluation was conducted by the vendor of the SIR method or a consultant to the vendor according to the U.S. EPA's "Standard Test Procedure for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods." The full evaluation report also includes a form describing the method and a form summarizing the test data.

Tank owners using this leak detection method should keep this form on file to prove compliance with the federal regulations. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

Method Description

Name EnviroSIR

Version Version 1.0 for Single and Manifolded Tanks

Annual Tightness Testing (0.1 gal/h leaks)

Vendor EnviroSIR, LLC

P.O. Box 52565

(address)

Lafayette,	LA	70505	U.S.A.	(318) 233-2383
(city)	(state)	(zip)	(country)	(phone)

Evaluation Results

If applicable, vendor's threshold = 0.05 gallon per hour
or vendor's criterion: _____

This statistical inventory reconciliation method reports results on the following basis (check one):

(X) quantitative results (leak rate reported) ***See Attached Reporting Form***
( ) qualitative results (pass, fail, inconclusive)

The test results are:

		Reported Results: Tight	Leak	Inconclusive	Total Analyzed	Not Analyzed
Actual	Tight					
	Induced Leak					
	Total					

Evaluation Results

The proportions of inventory records reported inconclusive are:

0 % among tight tanks

0 % among leaking tanks

0 % among all tanks

The probability of false alarms, P(FA), based on the vendor's threshold, is 2.6 %.

For qualitative methods, a 95% confidence interval for P(FA) is from

_____ to _____ %.

The probability of detection, P(D), is 97.4 %. This is valid for a leak rate of (check one):

(**X**) 0.10 gallon per hour

( ) 0.20 gallon per hour

For qualitative methods, a 95% confidence interval for P(D) is from

_____ to _____ %.

Based on these results, the method (**X**) does ( ) does not meet the **federal** performance standards established by the U.S. Environmental Protection Agency of 0.10 gallon per hour [or 0.2 gallon per hour] at P(D) of 95% and P(FA) of 5%.

Test Conditions during Evaluation

The data evaluation set included data from tanks of the following sizes

Tank Size (gallons)	< 5,000	5,000-10,000	10,000-15,000	>15,000	Total # of Records
Number of Records	0	5	15	23	43

The tanks had various monthly throughputs.

Percentile of Records	25	50 median	75	100
Monthly throughput (gallons)	13,218	18,897	30,057	73,735

The data included 17 records during hot weather months.
18 records during mild weather months.
8 records during cold weather months.

Limitations on the Results

The performance estimates above are only valid when:

- **!** The method has not been substantially changed.
- **!** The vendor's instructions for using the method are followed.
- **!** The single or manifolded tank system is no larger than 45,000 gallons.
- **!** The manifolded tank system consists of no more than 4 tanks.
- **!** The data records cover 28 days or more.
- **!** For quantitative methods, the SIR method may be used for manifolded tank systems. There was not a significant difference in the performance between single and manifolded tanks. There is only one volume limitation which applies to both single and manifolded tanks.
- **!** Other limitations specified by the vendor or determined during testing:

> **Safety disclaimer: This test procedure only addresses the issue of the method's ability to detect leaks. It does not test data recording equipment for safety hazards.**

Certification of Results

I certify that the statistical inventory reconciliation method was applied according to the vendor's instructions. I also certify that the evaluation was performed according to the standard EPA test procedure for statistical inventory reconciliation and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, President
(printed name)

H. Kendall Wilcox
(signature)

October 20, 1998
(date)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

Grain Valley, MO 64029
(city, state, zip)

(816) 443-2494
(phone number)

Description
Statistical Inventory Reconciliation Method

This section describes briefly the important aspects of the statistical inventory reconciliation (SIR) method. It is not intended to provide a thorough description of the principles behind the SIR method and associated computer software.

General Information

Method name: EnviroSIR
If applicable:

Version and revision number Version 1.0 - Monthly Monitoring (0.2 gal/h leaks) and Annual Tightness Testing (0.1 gal/h)

Date October 20, 1998

Vendor EnviroSIR, LLC

Vendor address and phone number, including area code:

P.O. Box 52565

Lafayette, LA 70505 U.S.A. (318) 233-2383

Contact Mr. Sam Berjaoui, e-mail: sberjaoui@worldnet.att.net

Data Requirements

Does the method require use of a specified data form provided by the vendor?

( ) yes

(X) no

How are the inventory data recorded:

( ) manually, on provided forms

(X) manually, no forms provided

(X) hand entered into a computer

(X) direct entry from ATGS

(X) other Any method that provides all required data.

What is the required number of usable daily inventory records necessary to detect the indicated leak rate (gallon per hour) with 95% confidence?

If the leak rate is 0.10, the number of daily readings is 28.

If the leak rate is 0.20, the number of daily readings is 28.

Data Requirements (continued)

What is the vendor's recommended number of daily records?

(X) 60 daily records

( ) 90 daily records

( ) other, specify _____

Does the method allow for closure of the station on one or more consecutive days per week?

(X) yes

( ) no

Does the method require meter calibration?

(X) yes; specify how frequently Once a year recommended

( ) no (calibration recommended)

Identification of Causes for Discrepancies

Which of the following factors does the method consider? Check the appropriate categories.

	Identify only	Compensate	Not Considered
dispensing meter errors		X	
calibration errors		X	
conversion chart miscalibration		X	
vapor loss			X
thermal effects		X (when temp. info. available)	
others (list) delivery errors		X	
gauging errors		X	

Which of the following effects does the method identify and quantify?

	Identify only	Quantify	Not Considered
leak rate		X	
delivery errors	X		
unexplained losses or gains	X		
water inflow	X		
water outflow	X		
dipstick errors		X	
others (list)			

Reporting of Leak Status

Is the leak status reported in terms of a leak rate (e.g., gal/h or gal/day)?

(X) yes

( ) no

( ) if the answer to the above question is "No," how are the results reported?

Explain _____

What criterion does the method use to declare that a tank is leaking?

(X) average daily discrepancy exceeds threshold of See Below gal/h

( ) daily discrepancy relative to variability exceeds threshold of _____ gal/h

( ) water level change exceeds threshold of _____ inch

( ) statistically significant continuous loss at the _____ level of significance

(X) other (specify) threshold exceeds 0.1 / 0.15 gal/h (user selectable) for Monthly Monitoring (0.2 gal/h leaks) or 0.05 gal/h for Annual Tightness Testing (0.1 gal/h leaks)

Exceptions

Are there any conditions under which the statistical inventory method is inadequate?

(X) insufficient number of usable records

( ) irregular time intervals between dipstick readings

(X) unacceptable daily variability of inventory records (if excessive)

( ) others (describe briefly) _____

What elements in the record keeping are left to the discretion of the personnel on site?

(X) length of record keeping if beyond minimum requested

(X) others (describe briefly) Temperature compensated inventory, Monthly water levels

( ) none

If applicable, attach a copy of the inventory data collection form(s) as provided to the user by the vendor.

Reporting Form For Test Results
Statistical Inventory Reconciliation Method

Method Name and Version: EnviroSIR (Version 1.0)
Date: October 20, 1998

	Submitted	Results Reported by Vendor			
		If Quantitative		If Qualitative	
Record Code No.	Induced Leak Rate (gal/h)	Estimated Leak Rate (gal/h)	Est.-Ind. Leak Rate (gal/h)	Tank Tight? (Yes, No, or Inconclusive)	Vendor's Comments
1	0.214	0.220	0.006		
2	0.048	0.070	0.022		
3	0.000	-0.060	-0.060		
4	0.128	0.190	0.062		
5	0.000	0.000	0.000		
6	0.087	0.070	-0.017		
7	0.000	0.020	0.020		
8	0.233	0.240	0.007		
9	0.136	0.110	-0.026		
10	0.193	0.180	-0.013		
11	0.205	0.200	-0.005		
12	0.064	0.070	0.006		
13	0.177	0.160	-0.017		
14	0.039	0.020	-0.019		
15	0.055	0.060	0.005		
16	0.000	0.020	0.020		
17	0.000	-0.030	-0.030		
18	0.220	0.220	0.000		
19	0.000	0.040	0.040		
20	0.000	0.000	0.000		
21	0.000	0.010	0.010		
22	0.058	0.040	-0.018		
23	0.000	0.010	0.010		
24	0.110	0.110	0.000		
25	0.000	0.000	0.000		
26	0.042	0.030	-0.012		
27	0.000	-0.010	-0.010		
28	0.050	0.040	-0.010		
29	0.000	0.000	0.000		
30	0.000	0.010	0.010		
31	0.180	0.150	-0.030		
32	0.089	0.130	0.041		
33	0.185	0.190	0.005		
34	0.000	-0.020	-0.020		
35	0.094	0.110	0.016		
36	0.077	0.050	-0.027		
37	0.000	0.000	0.000		
38	0.000	-0.020	-0.020		
39	0.044	0.050	0.006		
40	0.000	0.000	0.000		
41	0.103	0.120	0.017		
42	0.000	-0.050	-0.050		
43	0.000	0.070	0.070		

Attachment B

NWGLDE Forms for the EnviroSIR Statistical Inventory Reconciliation Method

Results of NWGLDE Evaluation

Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations *for Quantitative SIR Methods*

The evaluation was conducted by the vendor of the SIR Method or a consultant to the vendor according to the U.S. EPA's "Standard Test Procedure for Evaluation Leak Detection Methods: Statistical Inventory Reconciliation Methods." The full evaluation report also includes a form describing the method and a form summarizing the test data. Tank owners using this leak detection system should keep this form on file to prove compliance with the National Work Group on Leak Detection Evaluations (NWGLDE) requirements. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

This form contains information on SIR methods that were evaluated using a database that conforms to the NWGLDE requirements for quantitative SIR Methods. The results of the evaluation and the corresponding NWGLDE requirements have been listed below. **Methods meeting all of the NWGLDE requirements listed on this form are capable of conducting leak detection testing according to the following:**

1. The SIR Method may be used on single and manifolded tanks.
2. The SIR Method is limited to testing tank sizes to the maximum applicable volume listed on this form.
3. The SIR Method may be used on manifolded tank systems containing the number of tanks listed on this form.

1.0 Method Description

Name: EnviroSIR

Version: Version 1.0 - Monthly Monitoring (0.2 gal/h leaks)

Vendor: EnviroSIR, LLC

P.O. Box 52565
(street address)

Lafayette,	LA	70505	U.S.A.	(318) 233-2383
(city)	(state)	(zip code)	(country)	(phone)

Date of Evaluation: October 20, 1998

Evaluator: Ken Wilcox Associates, Inc.

1125 Valley Ridge Drive
(street address)

Grain Valley,	Missouri	64029	(816) 443-2494
(city)	(state)	(zip code)	(phone)

2.0 Introductory Requirements

The SIR Method must conform to each of the requirements listed below to quality for testing single and manifolded tanks.

1. Percentage of conclusive data from manifolded systems: 53%

   (NWGLDE requirements are 30% to 75%)

2. Number of tanks in a manifolded tank system that the method is limited to:

   4

   (NWGLDE requirements are: number of tanks in the data set falling in the 80th percentile plus one)

3. Number of usable and conclusive data records from manifolded tanks in the evaluation:

From tight tank conditions:	11	of 19
From 0.05 gal/hr leaking tank conditions:	5	of 8
From 0.10 gal/hr leaking tank conditions:	3	of 8
From 0.20 gal/hr leaking tank conditions:	4	of 8
Total	23	of 43

   (NWGLDE requirements are at least 3 of 8 records from tight tank conditions, 3 of 8 records from each group with induced leak rates, and total of at least 12)

3.0 Calculations

Probability of Detection P(D) and Probability of False Alarm P(FA)
The NWGLDE requires that the SIR Method has a P(D) of 95% or higher and a P(FA) of 5% or less for each of the groups below:

If applicable, vendor's threshold = 0.1 / 0.15 gallon per hour ***(User selectable)***
or vendor's criterion: _____

Probability of Detection, P(D):	Total Database	99.9 / 97.4%
	Single Tanks	99.9 / 96.4%
	Manifolded Tanks	99.9 / 97.4%
Probability of False Alarm, P(FA):	Total Database	0.1 / 0.1%
	Single Tanks	0.1 / 0.1%
	Manifolded Tanks	0.1 / 0.1%

Basic Statistics
The following statistics are calculated for the entire database and for the single and manifolded tanks separately.

Mean Square Error:	Overall Database	0.00061 gal^2/hr^2
	Single Tanks	0.00066 gal^2/hr^2
	Manifolded Tanks	0.00057 gal^2/hr^2
Variance:	Overall Database	0.00063 gal^2/hr^2
	Single Tanks	0.00069 gal^2/hr^2
	Manifolded Tanks	0.00060 gal^2/hr^2
Standard Deviation:	Overall Database	0.0250 gal/hr
	Single Tanks	0.0263 gal/hr
	Manifolded Tanks	0.0244 gal/hr
Bias	Overall Database	negligible
	Single Tanks	negligible
	Manifolded Tanks	negligible

4.0 Comparison of Single vs. Manifolded Tanks

SIR Methods that do not meet the NWGLDE requirements for standard deviation and bias comparisons between single and manifolded tanks may require additional calculations to determine the applicability of the SIR Methods to single and manifolded tanks.

If the standard deviations and biases of single vs. manifolded tanks are not significantly different, then the SIR Method is not affected by manifolding. Therefore, it is not necessary to calculate the P(D) and P(FA) separately for each group. It is only necessary to report the overall P(D) and P(FA). There will also be only one volume limitation which will be applicable to both single and manifolded UST's.

Standard Deviation Comparison

If the calculated value of F listed below is less than the 95th percentile of an F-distribution with (n_1 - 1) degrees of freedom in the numerator (corresponding to SD_1) and (n_2 - 1) degrees of freedom in the denominator (corresponding to SD_2), where the sample sizes are n_1 and n_2 respectively, there is no significant evidence that the two population variances are different and there is justification for using the method on both single and manifolded tanks.

Calculated F (SD_1/SD_2)	1.12
95th percentile of an F-distribution (n_1 - 1)/(n_2 - 2)	2.13

Based on the Standard Deviation comparison above, there (**X**) is ( ) is not justification for using the method on both single and manifolded tanks.

Bias Comparison

If the absolute value of t_{bp} does not exceed a two-sided 5% critical value from a t-distribution with (n_1 + n_2 - 2) degrees of freedom (a = 0.05), then there is no evidence that the bias is different for single tanks compared to manifolded tanks and use of the method on both types of tanks is justified.

Calculated t-statistic (t_{bp})	0.12
Two-sided, 5% critical value from a t-distribution	2.02

Based on the Bias comparison, there (**X**) is ( ) is not justification for using the method on both single and manifolded tanks.

5.0 Volume Limitation

If the method meets the standard deviation and bias comparison requirements, there will be only one volume limitation which will be applicable to both single and manifolded UST's. If the SIR Methods does not meet the NWGLDE requirements for standard deviation and bias comparisons between single and manifolded tanks, the volume limitations will be different for single and manifolded tanks based on the tank sizes used in the database.

The results of the evaluation can be extended to tanks 50% larger than the 80th percentile of the tank sizes used in the evaluation database.

Complete Database (Single and Manifolded Tank Data Sets)

Smallest Tank Size in the database:	10,000 gallons
Size of tank in the 25th percentile of database:	12,000 gallons
Size of tank in the 50th percentile of database:	20,000 gallons
Size of tank in the 75th percentile of database:	24,000 gallons
Size of tank in the 80th percentile of database:	30,000 gallons
Largest Tank Size in the database:	30,000 gallons

Single Tank Data Sets

Smallest Tank Size in the database:	10,000 gallons
Size of tank in the 25th percentile of database:	10,000 gallons
Size of tank in the 50th percentile of database:	12,000 gallons
Size of tank in the 75th percentile of database:	12,000 gallons
Size of tank in the 80th percentile of database:	12,000 gallons
Largest Tank Size in the database:	12,000 gallons
Maximum applicable single tank size:	45,000 gallons

Manifolded Tank Data Sets)

Smallest Tank Size in the database:	20,000 gallons
Size of tank in the 25th percentile of database:	24,000 gallons
Size of tank in the 50th percentile of database:	24,000 gallons
Size of tank in the 75th percentile of database:	30,000 gallons
Size of tank in the 80th percentile of database:	30,000 gallons
Largest Tank Size in the database:	30,000 gallons
Maximum applicable manifolded tank size:	45,000 gallons

6.0 Maximum Number of Tanks in a Manifolded Tank System

If the method can be used on manifolded tank systems, then the SIR Method is limited to the number of tanks in the manifolded tank system in the 80th percentile of the database plus one.

Number of tanks in the manifolded tank system in the 80th percentile of the database:	3
Maximum number of tanks in a manifolded tank system that the method may be applied to:	4

7.0 Summary of Results

For quantitative methods, the SIR Method (**X**) may ( ) may not be used for manifolded tank systems. Was there a significant difference in the performance between single and manifolded tanks? ( ) yes (**X**) no

If no, report the performance and maximum volume for the overall database in the table below. There will only be one volume limitation which applies to both single and manifolded tanks.

If yes, overall performance need not be reported, but performance and maximum volume must be reported separately for single and manifolded tanks, and the maximum volume for each group may be different.

The threshold used for the calculations below is 0.1 / 0.15 gal/hr (User selectable) .

Quantitative Evaluations	**P(FA)**	**P(D)**	**Maximum Volume**
Overall database	0.1 / 0.1%	99.9 / 97.4%	45,000 gallons
Single tanks only	0.1 / 0.1%	99.9 / 96.4%	45,000 gallons
Manifolded tanks only with up to 4 tanks.	0.1 / 0.1%	99.9 / 97.4%	45,000 gallons

>Safety disclaimer: This test procedure only addresses the issue of the method's ability to detect leaks. It does not test data recording equipment for safety hazards.

Certification of Results

I certify that the calculations and results contained on these forms were done according to the NWGLDE "Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations" for Quantitative SIR Methods. I also certify that the evaluation was performed according to the standard EPA test procedure for statistical inventory reconciliation and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, Ph.D., President
(printed name)

H. Kendall Wilcox
(signature)

October 20, 1998
(date)

Ken Wilcox Associates, Inc.
(organization performing evaluation)

Grain Valley, Missouri 64029, USA
(city, state, postal code, country)

(816) 443-2494
(phone number)

Results of NWGLDE Evaluation

Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations *for Quantitative SIR Methods*

The evaluation was conducted by the vendor of the SIR Method or a consultant to the vendor according to the U.S. EPA's "Standard Test Procedure for Evaluation Leak Detection Methods: Statistical Inventory Reconciliation Methods." The full evaluation report also includes a form describing the method and a form summarizing the test data. Tank owners using this leak detection system should keep this form on file to prove compliance with the National Work Group on Leak Detection Evaluations (NWGLDE) requirements. Tank owners should check with State and local agencies to make sure this form satisfies their requirements.

This form contains information on SIR methods that were evaluated using a database that conforms to the NWGLDE requirements for quantitative SIR Methods. The results of the evaluation and the corresponding NWGLDE requirements have been listed below. **Methods meeting all of the NWGLDE requirements listed on this form are capable of conducting leak detection testing according to the following:**

1. The SIR Method may be used on single and manifolded tanks.
2. The SIR Method is limited to testing tank sizes to the maximum applicable volume listed on this form.
3. The SIR Method may be used on manifolded tank systems containing the number of tanks listed on this form.

1.0 Method Description

Name: EnviroSIR

Version: Version 1.0 - Annual Tightness Testing (0.1 gal/h leaks)

Vendor: EnviroSIR, LLC

P.O. Box 52565
(street address)

Lafayette,	LA	70505	U.S.A.	(318) 233-2383
(city)	(state)	(zip code)	(country)	(phone)

Date of Evaluation: October 20, 1998

Evaluator: Ken Wilcox Associates, Inc.

1125 Valley Ridge Drive
(street address)

Grain Valley,	Missouri	64029	(816) 443-2494
(city)	(state)	(zip code)	(phone)

2.0 Introductory Requirements

The SIR Method must conform to each of the requirements listed below to quality for testing single and manifolded tanks.

1. Percentage of conclusive data from manifolded systems: 53%

   (NWGLDE requirements are 30% to 75%)

2. Number of tanks in a manifolded tank system that the method is limited to:

   4

   (NWGLDE requirements are: number of tanks in the data set falling in the 80th percentile plus one)

3. Number of usable and conclusive data records from manifolded tanks in the evaluation:

From tight tank conditions:	11	of 19
From 0.05 gal/hr leaking tank conditions:	5	of 8
From 0.10 gal/hr leaking tank conditions:	3	of 8
From 0.20 gal/hr leaking tank conditions:	4	of 8
Total	23	of 43

   (NWGLDE requirements are at least 3 of 8 records from tight tank conditions, 3 of 8 records from each group with induced leak rates, and total of at least 12)

3.0 Calculations

Probability of Detection P(D) and Probability of False Alarm P(FA)
The NWGLDE requires that the SIR Method has a P(D) of 95% or higher and a P(FA) of 5% or less for each of the groups below:

If applicable, vendor's threshold = 0.05 gallon per hour
or vendor's criterion: _____

Probability of Detection, P(D):	Total Database	97.4%
	Single Tanks	96.4%
	Manifolded Tanks	97.4%
Probability of False Alarm, P(FA):	Total Database	2.6%
	Single Tanks	3.6%
	Manifolded Tanks	2.6%

Basic Statistics
The following statistics are calculated for the entire database and for the single and manifolded tanks separately .

Mean Square Error:	Overall Database	0.00061 gal^2/hr^2
	Single Tanks	0.00066 gal^2/hr^2
	Manifolded Tanks	0.00057 gal^2/hr^2
Variance:	Overall Database	0.00063 gal^2/hr^2
	Single Tanks	0.00069 gal^2/hr^2
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Standard Deviation:	Overall Database	0.0250 gal/hr
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Bias	Overall Database	negligible
	Single Tanks	negligible
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SIR Methods that do not meet the NWGLDE requirements for standard deviation and bias comparisons between single and manifolded tanks may require additional calculations to determine the applicability of the SIR Methods to single and manifolded tanks.

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Standard Deviation Comparison

If the calculated value of F listed below is less than the 95th percentile of an F-distribution with (n_1 - 1) degrees of freedom in the numerator (corresponding to SD_1) and (n_2 - 1) degrees of freedom in the denominator (corresponding to SD_2), where the sample sizes are n_1 and n_2 respectively, there is no significant evidence that the two population variances are different and there is justification for using the method on both single and manifolded tanks.

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Calculated t-statistic (t_{bp})	0.12
Two-sided, 5% critical value from a t-distribution	2.02

Based on the Bias comparison, there (**X**) is ( ) is not justification for using the method on both single and manifolded tanks.

5.0 Volume Limitation

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Size of tank in the 80th percentile of database:	30,000 gallons
Largest Tank Size in the database:	30,000 gallons

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Smallest Tank Size in the database:	10,000 gallons
Size of tank in the 25th percentile of database:	10,000 gallons
Size of tank in the 50th percentile of database:	12,000 gallons
Size of tank in the 75th percentile of database:	12,000 gallons
Size of tank in the 80th percentile of database:	12,000 gallons
Largest Tank Size in the database:	12,000 gallons
Maximum applicable single tank size:	45,000 gallons

Manifolded Tank Data Sets)

Smallest Tank Size in the database:	20,000 gallons
Size of tank in the 25th percentile of database:	24,000 gallons
Size of tank in the 50th percentile of database:	24,000 gallons
Size of tank in the 75th percentile of database:	30,000 gallons
Size of tank in the 80th percentile of database:	30,000 gallons
Largest Tank Size in the database:	30,000 gallons
Maximum applicable manifolded tank size:	45,000 gallons

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Number of tanks in the manifolded tank system in the 80th percentile of the database:	3
Maximum number of tanks in a manifolded tank system that the method may be applied to:	4

7.0 Summary of Results

For quantitative methods, the SIR Method (**X**) may ( ) may not be used for manifolded tank systems. Was there a significant difference in the performance between single and manifolded tanks? ( ) yes (**X**) no

If no, report the performance and maximum volume for the overall database in the table below. There will only be one volume limitation which applies to both single and manifolded tanks.

If yes, overall performance need not be reported, but performance and maximum volume must be reported separately for single and manifolded tanks, and the maximum volume for each group may be different.

The threshold used for the calculations below is 0.05 gal/hr .

Quantitative Evaluations	**P(FA)**	**P(D)**	**Maximum Volume**
Overall database	2.6%	97.4%	45,000 gallons
Single tanks only	3.6%	96.4%	45,000 gallons
Manifolded tanks only with up to 4 tanks.	2.6%	97.4%	45,000 gallons

>Safety disclaimer: This test procedure only addresses the issue of the method's ability to detect leaks. It does not test data recording equipment for safety hazards.

Certification of Results

I certify that the calculations and results contained on these forms were done according to the NWGLDE "Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations" for Quantitative SIR Methods. I also certify that the evaluation was performed according to the standard EPA test procedure for statistical inventory reconciliation and that the results presented above are those obtained during the evaluation.

H. Kendall Wilcox, Ph.D., President
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