Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility Systems in Texas

Funded by:

Texas On-Site Wastewater Treatment Research Council

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Prepared by:

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RS&Y

REED, STOWE & YANKE
A Limited Liability Company

September 12, 2001

Mr. Warren Samuelson, Executive Secretary
Texas On-Site Wastewater Treatment Research Council
C/O Installer Certification Section, MC-178
P.O. Box 13087
Austin, Texas 78711-3087

RE: Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility (OSSF) Systems in Texas

Dear Mr. Samuelson:

Reed, Stowe and Yanke, LLC (RS&Y) is pleased to provide the results of the "Study to Determine the Magnitude, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility (OSSF) Systems in Texas" to the Texas On-Site Wastewater Treatment Research Council (Council).

Based on the results of the statewide survey administered for this project, the number of reported chronically malfunctioning OSSFs in the State is approximately 148,573, which represents approximately 13% of the OSSF systems represented by the survey results. These results indicate that there is a potentially serious threat to human health and the environment due to the large number of chronically malfunctioning OSSFs in Texas. As a part of this study, RS&Y evaluated reasons for chronically malfunctioning OSSFs in Texas. Several of the key reasons for malfunction include the following:

- OSSF systems that are older and/or pre-regulatory tend to be problematic and have a higher malfunction rate than newer OSSF systems. The reasons for this high rate of malfunction include, but are not limited to; installation in improper soil types, installation in an undersized lot, system is undersized for current uses, and improper operation and maintenance.
- Since the development of regulations, other types of problems related to OSSFs have emerged. These problems are typically related to the need for on-going maintenance, which is a requirement of many of the newer systems.
- Factors that contribute to malfunctions frequently include a **lack** of (1) public education programs for OSSF owners, (2) effective enforcement programs, and (3) records about existing OSSF systems.

Developing solutions to the problems presented by malfunctioning OSSFs is a significant challenge facing the State of Texas. Meeting this challenge will require the replacement of many OSSFs in the State and the development and implementation of more effective education, management and enforcement programs by local authorized agents and the TNRCC. Should you have any questions regarding the content of this study, please contact Mr. Scott Pasternak at (512) 450-0991.

Sincerely,

Reed, Stowe & Yanke, LLC

Reed, Stowe and Yanke, LLC

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EXECUTIVE SUMMARY

The State of Texas contains approximately 1.5 million households that rely upon on-site sewage facility (OSSF) systems for wastewater disposal and the numbers are increasing each year. Approximately 55,052 OSSF systems were installed in Texas in 1999, and approximately 49,616 systems were installed in 2000. Unlike households connected to centralized systems, households with OSSF systems are required to have a general understanding of the operation and maintenance needs of the system in order to ensure that it functions properly.

When an OSSF system is not functioning properly, it cannot only become an inconvenience for the homeowner, but it can create threats to public health and the environment. This threat to public health can reach beyond the individual household and extend to the community at large. Recent research completed by the United States Environmental Protection Agency (U.S. EPA) identified a number of public health and environmental problems related to the malfunction of OSSFs.[1] Effluent from malfunctioning OSSF systems can provide a medium for the transmission of disease. For example, the U.S. EPA has estimated that approximately 169,000 viral and 34,000 bacterial illnesses occur each year as the result of drinking contaminated groundwater. Malfunctioning OSSFs have been identified as a potential source of this contamination. Within the context of the natural environment, malfunctioning OSSFs have also been considered a primary reason for reduced harvests in many shellfish growing areas.

Project Overview

In 2000, the Texas On-Site Wastewater Treatment Research Council (Council) determined that there was a need to study the magnitude of, and reasons for, chronically malfunctioning OSSFs in the State of Texas. Given the large size of Texas and the various soil types and climate conditions within the state, the Council decided to approach the research from a regional perspective. Reed, Stowe & Yanke, LLC (RS&Y) was retained by the Council in October of 2000 to research the issues and factors that contribute to OSSF malfunction, as well as determine the extent of the problem in the various regions of Texas.

After reviewing the existing literature and the available data on OSSF systems, RS&Y determined that the Council's project goals would best be attained through the administration of a survey to the Designated Representatives across Texas. It was decided that Designated Representatives were the appropriate survey population due to their comprehensive knowledge of issues related to OSSF malfunctions within their respective jurisdictions. The survey contained questions that were designed to ascertain the reasons for chronically malfunctioning OSSF systems and covered topics such as

[1] *EPA Guidelines for Management of Onsite/Decentralized Wastewater Systems (Draft).* United States Environmental Protection Agency. September 26, 2000. Pages 1-2.

system design, operation and maintenance, OSSF owner education, effective treatment technologies, soil type, and climate conditions. The survey was mailed to 278 Designated Representatives in January of 2001.

Figure ES.1 On-Site Wastewater Regions of Texas

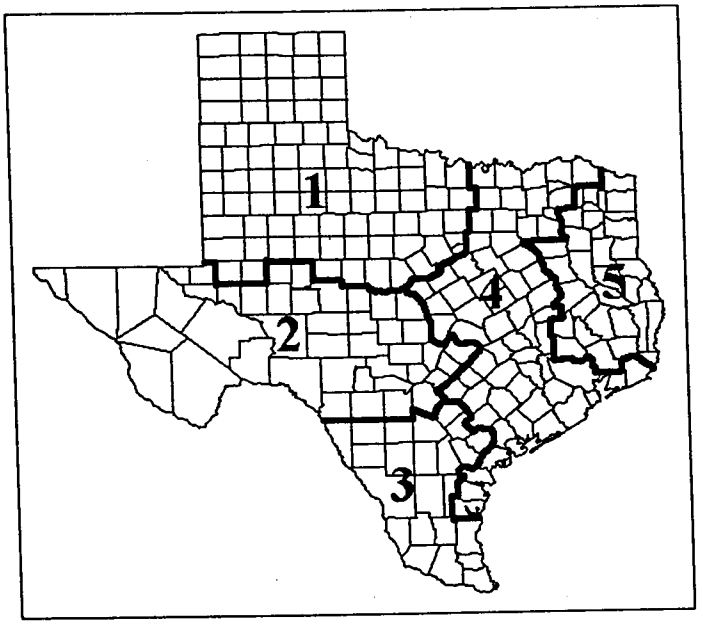
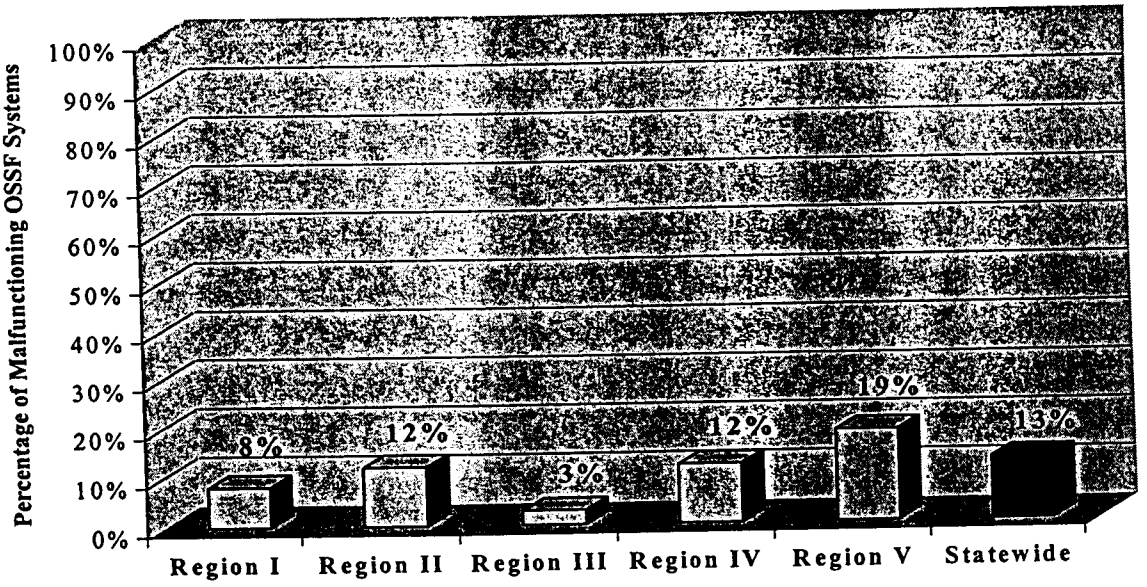


Chart ES.1 Percentage of Chronically Malfunctioning OSSF Systems

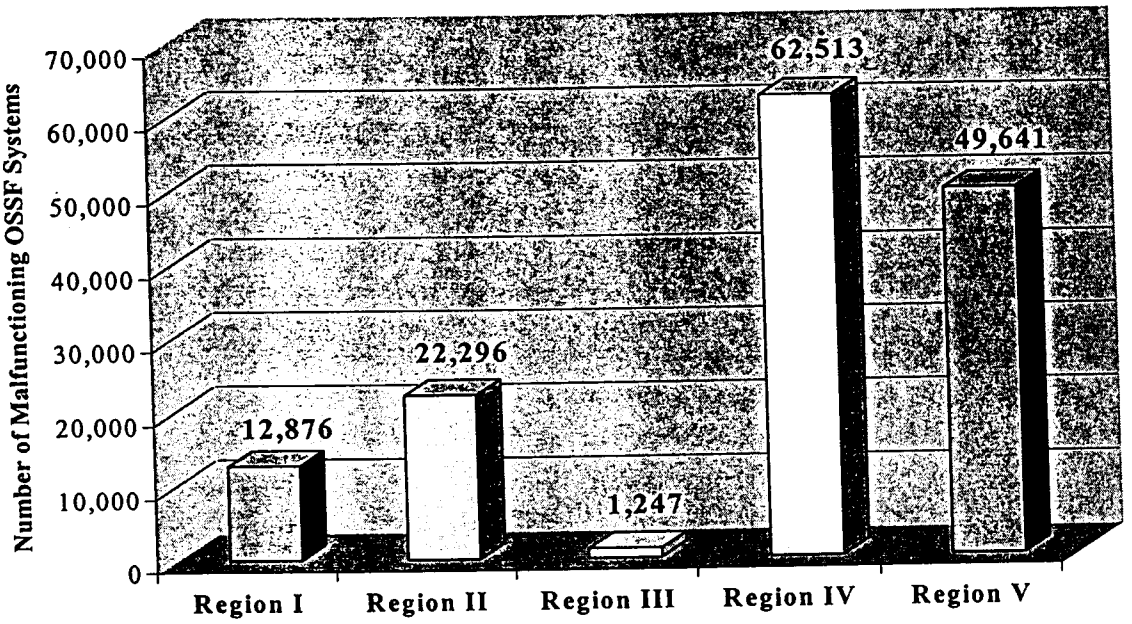


The statewide survey response rate, based on the number of completed surveys returned, was 64%. The survey results were compiled and analyzed on a regional basis and these

regions are presented in Figure ES.1. The analyzed survey results were successful in fulfilling the project goals, and will be an important resource for OSSF professionals and policymakers alike. Important trends in the factors that contribute to OSSF malfunction were revealed through the survey results, as well as data that offers insight into the number of chronically malfunctioning OSSF systems in the State of Texas.

Chart ES.1 shows the percentage of OSSF systems that were reported to malfunction chronically in each region of the State. Statewide, approximately 13% of the OSSF systems were reported to be chronically malfunctioning. Chart ES.2 shows the approximate number of chronically malfunctioning OSSF systems by region. The total number of chronically malfunctioning systems reported through the survey results in the State was approximately 148,573.

Chart ES.2 Total Number of Chronically Malfunctioning Systems per Region



The actual total number of malfunctioning OSSF systems in Texas is certain to be higher, as the survey's response rate was less than 100%. However, the rate of OSSF malfunction for the entire State is still unknown and cannot be projected based on survey responses. The project team determined that it would not be statistically valid to use the regional rates of chronic OSSF malfunction for the jurisdictions that responded to the survey, and extrapolate those figures to determine the rate of malfunction for all OSSF systems across the State. Although it might be a useful exercise for the purposes of antidotal discussion, it would not necessarily be representative of the opinions and situations in the remaining jurisdictions.

Document Format

This document is divided into five sections. Section 1 describes the methodology used to determine the type of research instrument used in the project, the process of creating the survey instrument, the survey distribution process, and the limitations of the survey. This section also illustrates the regional approach used to analyze the survey results, including a map that depicts the State of Texas divided into the five regions. A copy of the survey questionnaire is located in Appendix A.

Section 2 presents the regional analyses of the survey results. The survey results are presented from Region I through Region V, with the analyzed data discussed in the order in which it was listed on the actual survey questionnaire. The survey results are described in a text format as well as in various tables that illustrate the raw data results and percentage ratios. Key findings from each region are summarized in the next section, "Key Findings Summary" of the Executive Summary.

Section 3 of this report presents a regional comparison of the survey results from the five regions of the State. This section compares and contrasts the significant factors in OSSF malfunction reported in the survey results from each region. Section 4 discusses in detail the major policy issues and key findings that resulted from the survey analysis presented in Section 2. These policy issues are summarized on page xi of the Executive Summary.

The recommendations of the report are presented in Section 5. In this section, the project team has developed a set of recommendations based on the policy issues discussed in Section 4. The project team would like to emphasize that the recommendations presented in this discussion are not intended to provide a comprehensive resolution to all problems effecting OSSF systems. The purpose of these recommendations is to highlight actions that the Council could take based on the findings of this study. These recommendations have also been developed to help identify and prioritize future Council research projects based on the major reasons for malfunctioning OSSFs.

Key Findings Summary

Region I: Key Findings Summary

- Region I reported that approximately 8% of the OSSF systems in the reporting jurisdictions were chronically malfunctioning.
- The age of the OSSF system was ranked as the highest contributor to malfunction. Pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 51% of survey respondents and a moderate contributor by 29%.
- Operation and maintenance issues were ranked as the second highest contributor to malfunction. Problems with operation and maintenance practices were reported to

severely contribute to OSSF malfunction by 34% of the respondents and to moderately contribute by 34%.

- The lack of education for OSSF owners was reported to contribute severely to OSSF malfunction by 34% of the respondents and moderately contribute by 31%. Additionally, 60% of the respondents in Region I reported that OSSF owners do not receive sufficient information about how to properly operate their system.
- Region I did not report significant OSSF problems due to climate or a high water tables and septic tanks/leaching chambers were reported to function well in the region.

Region II: Key Findings Summary

- Region II reported that approximately 12% of the OSSF systems in the reporting jurisdictions were chronically malfunctioning.
- The age of the OSSF system was ranked as the highest contributor to malfunction. Pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 22% of the survey respondents and a moderate contributor by 37%.
- The factors that contribute to OSSF malfunction in Region II were varied and were generally reported as being less severe than in other regions of the State. Areas of concern for many respondents included: a lack of education for OSSF owners, improper operation and maintenance, and problems with soils, such as tightly-packed clay soils that do not allow for proper leaching and fractured limestone soils that allow sewage to flow directly into the ground.

Region III: Key Findings Summary

- Region III reported that approximately 3% of the OSSF systems in the reporting jurisdictions tend to chronically malfunction. This is the lowest reported rate of OSSF malfunction for any region in the State.
- Region III had an unusually low response rate of 44% and the returned surveys only represent approximately 32% of the total number of OSSF systems in the region. Due to this low regional response rate and the lower OSSF representation, the results from this regional analysis may not be representative of the OSSF issues in the entire region, nor can they be assumed to represent the opinions of the majority of Designated Representatives in the region.
- According to the Designated Representatives that responded to the survey, the age of the OSSF system was ranked as the highest contributor to malfunction. Pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 50% of the survey respondents and a moderate contributor by 25%.
- Improper system design ranked as the second highest contributor to malfunction and 38% of the respondents reported that it severely contributes to malfunction, while

19% stated it was a moderate contributor. Examples of system design issues reported in the region include OSSF systems that are too small for the sewage load from the facility and lot sizes and/or drainfields that are too small.

Region IV: Key Findings Summary

- Region IV reported that approximately 12% of the OSSF systems in the reporting jurisdictions were chronically malfunctioning.
- Soils were ranked as the highest contributor to OSSF malfunction in Region IV. Soils were found to severely contribute to malfunction by 42% of the respondents and to moderately contribute by 36%. Specifically, tightly-packed clay soils that do not allow for proper leaching were reported to be severe contributors to malfunction by 51% of the respondents and a moderate contributor by 22%.
- The age of the OSSF system was ranked as the second highest contributor to malfunction. Pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 46% of the survey respondents and a moderate contributor by 32%.
- Lack of education for OSSF owners was reported to contribute severely to malfunction by 28% of the respondents and moderately contribute by 46%. Additionally, 85% of the respondents in Region IV stated that OSSF owners do not receive sufficient information about how to properly operate their system.
- Operation and maintenance was generally reported to be a moderate contributor to malfunction in Region IV. A total of 15% of the respondents reported that operation and maintenance was a severe contributor to malfunction while 51% reported it was a moderate contributor. Specifically, failure to renew maintenance contracts and failure to add the proper disinfectant to the system were identified as the two main contributors to malfunction under the operation and maintenance category.

Region V: Key Findings Summary

- Region V reported that approximately 19% of the OSSF systems in the reporting jurisdictions were chronically malfunctioning. This is the highest reported rate of malfunction for any region.
- Soil was ranked as the highest contributor to malfunction, with 66% of the respondents reporting severe contribution to malfunction, and 14% reporting moderate contribution. Tightly-packed clay soils were reported to contribute severely to malfunction by 69% of the respondents and moderately by 24%.
- High water tables were ranked as the second highest contributor to malfunction and were reported to severely contribute to malfunction by 34% of the respondents and moderately contribute to malfunction by 31%.

- The age of the OSSF system was ranked as the third highest contributor to malfunction. Pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 55% of the survey respondents and a moderate contributor by 31%.
- Lack of education for OSSF owners was found to severely contribute to malfunction by 34% of the respondents and moderately contribute to malfunction by 45%. Additionally, 79% of respondents in Region V stated that OSSF owners do not receive sufficient information about how to properly operate their system.
- Failure to renew maintenance contracts was reported to be a severe contributor to malfunction by 48% of the respondents and a moderate contributor by 45%. A failure to add the proper disinfectant to the system was reported to be a severe contributor by 38% of the respondents and a moderate contributor by 45%. These factors were the two main contributors to malfunction under the operation and maintenance category.
- One hundred percent of the respondents reported that aerobic system treatment technologies function well and 93% reported that surface irrigation systems function well.

Synopsis of Policy Issues

Issue 1: Malfunctioning OSSFs are a significant problem in Texas based on the results of the survey. In the State of Texas, there are approximately 148,573 chronically malfunctioning systems, which represents about 13% of all OSSFs.

Issue 2: OSSF systems installed in improper soil classes was the factor that had the highest impact on OSSF system malfunction in Region IV and Region V.

Issue 3: Malfunctions related to system age and "grandfathered" systems was the category that consistently ranked as having the highest impact on the malfunction of OSSF systems in Region I, Region II, and Region III. The age of the OSSF systems was ranked as the second highest factor in Region IV and the third highest factor in Region V. The age of OSSF systems is also affected by several other factors, as many older systems were installed prior to the development of regulations.

Issue 4: System operation and maintenance issues related to surface irrigation/aerobic systems, such as a lack of maintenance contracts and improper addition of disinfectant to the OSSF system, were the key reasons for malfunction in Region IV and Region V.

Issue 5: A need for more education for OSSF system owners is a key issue. Approximately 73% of responding Designated Representatives believe that OSSF owners are not receiving adequate education regarding their systems.

Issue 6: Lack of enforcement was reported to contribute to the chronic malfunction of OSSF systems in parts of all regions of the State.

Issue 7: Lack of records regarding existing OSSF systems was a problem for many of the Designated Representatives that responded to the survey. Due to a number of reasons, they often are unaware of existing OSSF systems in their jurisdiction. This lack of information can make it difficult to conduct inspections and track maintenance compliance.

Issue 8: There is a need for further research regarding malfunctioning OSSF systems in Region III of the State based on the relatively low response rate from this area in the survey.

Synopsis of Recommendations

Recommendation 1: Inform State and Local Officials about OSSF Problems

Prior to this study, information documenting the extent of malfunctioning OSSF systems in Texas did not exist on a comprehensive basis. Through the results of the survey administered for this study, there is now an understanding of the number of chronically malfunctioning OSSFs in Texas. Based on these results, there is a significant statewide problem of malfunctioning OSSFs and there is a need for the Council to inform state and local officials about the extent of this problem. By providing local and state officials with this information, there is a greater likelihood that they will have an interest in allocating sufficient resources to address problems related to malfunctioning OSSFs in Texas.

Recommendation 2: Use this Study to Help Prioritize Future Council Projects

Through the completion of this study, the Council now has information on both a regional and statewide level detailing the extent of chronically malfunctioning OSSFs and the major reasons for these malfunctions. The Council could use the information provided by this study to help guide decisions regarding the need for future research projects. For example, the Council could prioritize the need for future research projects based on key findings for malfunction that are discussed for each region of the State in Section 2 and for the State as a whole in Section 3.

Recommendation 3: Develop a Comprehensive Resource Guide

Based on the key findings included in the policy issue discussions of Section 4, there is a need to develop technical assistance resources or guidance manuals to help Designated Representatives fulfill their responsibilities. A comprehensive resource guide could be developed and provided to Designated Representatives throughout the State, and it could also be available on the Council's web site.

The resource guide should be developed in such a manner that the Designated Representatives can use individual sections independent of information from other sections. The resource guide should also include specific recommendations on steps that could be taken to implement each topic. Additionally, the recommendations should be based upon case studies of other Texas communities that have effectively developed and implemented programs to address various OSSF problems.

Recommendation 4: Conduct Further Regional Research

In order obtain an understanding of the magnitude of, and reasons for, malfunctioning OSSF systems in Region III, which includes the area of South Texas know as the Lower Rio Grande Valley, the project team recommends that the Council fund additional research in this area of the State. This research is needed because the survey response rate for this region was significantly lower than the response rates for the other four regions of the State. This research would ideally build from the research completed through this study.

This future research could be conducted through a combination of case studies, interviews and/or surveys. This additional research could be especially helpful in determining potential infrastructure or other resource needs in this area of the State. Information gathered through the additional research would be valuable and useful for Region III since there are several state and federal programs that can provide financial assistance for water and wastewater infrastructure problems in the border region.

INTRODUCTION

Project Background

Reliable, efficient and effective wastewater treatment and disposal are functions that most households have come to take for granted. Households that are connected to a centralized wastewater system are not usually concerned with the functions of wastewater disposal, except when it relates to the monthly water and wastewater bill. However, many households across the State of Texas are not connected to centralized wastewater systems, but instead rely on On-Site Sewage Facility (OSSF) systems, such as septic tanks.

Approximately 1.5 million households in the State of Texas rely upon OSSF systems for wastewater disposal, and the number is increasing each year. Approximately 55,052 OSSF systems were installed in Texas in 1999, and approximately 49,616 systems were installed in 2000. Unlike households connected to centralized systems, households with OSSF systems are required to have a general understanding of the operation and maintenance needs of their system in order to ensure that it functions properly.

When an OSSF system is not functioning properly, it cannot only be an inconvenience for the homeowner, but can result in threats to public health and the environment for individual households and to the community at large. Effluent from malfunctioning OSSF systems provides a medium for the transmission of disease. Malfunctions can result in a backup of untreated or partially treated sewage into the home and/or yard. Such OSSF malfunctions can provide a medium for the transmission of disease and may result in the contamination of groundwater and surface water.

The effects of groundwater contamination can be quite tangible. For example, the United States Environmental Protection Agency has estimated that approximately 169,000 viral and 34,000 bacterial illnesses occur each year as the result of drinking contaminated groundwater. Malfunctioning OSSFs have been identified as one of the likely sources of this contamination. Malfunctioning OSSFs have also been considered a primary reason for reduced harvests in many shellfish growing areas.[2] Because malfunctioning OSSF systems can have troublesome, if not dangerous, consequences for the community at large, the Texas On-Site Wastewater Treatment Research Council (Council) decided to fund this research project to examine the problem in more detail.

Prior to this study, the Council was unaware of any comprehensive studies at the local or regional level that thoroughly investigated and reported the magnitude of chronically malfunctioning OSSF systems in Texas, as well as the reasons for their failure. The Council believed that this information would be invaluable for identifying future research

[2] *EPA Guidelines for Management of Onsite/Decentralized Wastewater Systems (Draft).* United States Environemntal Protection Agency. September 26, 2000. Pages 1-2.

projects and/or prioritizing resource needs to address OSSF system malfunction. Therefore, the Council retained the services of Reed, Stowe & Yanke, LLC in October of 2000 to research the problem of malfunctioning OSSF systems in Texas, determine the magnitude of the problem in various regions of the State, and to ascertain the reasons for the malfunctions.

Texas On-Site Wastewater Treatment Research Council

The Texas On-Site Wastewater Treatment Research Council was created in 1987 for the purpose of having an entity that is specifically devoted to addressing problems related to malfunctioning OSSF systems across the State. The mission of the Council is to develop methods to enhance on-site disposal throughout the State of Texas by improving the quality of treatment and disposal, and lowering the cost of installation and/or maintenance of OSSF systems. The Council accomplishes this mission through the funding of innovative research projects that evaluate the performance of OSSF systems and provide technical and policy recommendations designed to improve OSSF functions. This research makes valuable information available to residents across the State of Texas regarding new technologies and OSSF management issues.

Project Purpose

The purpose of this project is to determine the magnitude of, and reasons for, chronically malfunctioning OSSF systems in Texas. There is a distinct lack of data regarding the rates of OSSF malfunction, as well as the reasons for OSSF malfunctions throughout the State. Many research projects have been performed that identify, evaluate, and recommend solutions for malfunctioning OSSF systems. However, these projects tend to be site or community specific and do not provide insight into the problems of OSSF systems across the entire State. When previous statewide research studies on OSSF systems were identified, they were determined to be too narrow in scope to adequately address the objectives of the Council.

Another purpose of the study is to determine if OSSF issues vary by region within the state. The Council determined that because the State of Texas is so large and has such a diversity of climatic and geographic characteristics, the reasons for OSSF malfunctions were likely to vary across the State. In order to test this hypothesis, the Council wanted the State divided into regions that have similar soil type and climatic characteristics. As a result of this regional approach, the project analysis is able to provide insight into trends related to the rates of, and reasons for, OSSF malfunction within each region. Additionally, comparisons may be drawn between the different regions of the State.

Document Format

This document is divided into five sections. Section 1 describes the methodology used to determine the type of research instrument used in the project, the process of creating the survey instrument, the survey distribution process, and the survey limitations. This

section also illustrates the regional approach used to analyze the survey results, including a map that depicts the State of Texas divided into the five regions. The reasons for dividing the State into regions and a description of the soil and climatic conditions in each region are also discussed in this section.

Section 2 presents the regional analysis of the survey results. The survey results are presented from Region I through Region V, with the analyzed data discussed in the order in which it was listed on the actual survey questionnaire. The survey results are described in a text format as well as in various tables that illustrate the raw data results and percentage ratios. At the end of each regional analysis is a section for the key findings, which summarizes the survey results and briefly highlights the most common issues reported in each region.

Section 3 presents a regional comparison of the survey results from the five regions of the State. This section compares and contrasts the significant issues in OSSF malfunction reported for each region. Section 4 discusses in detail the major policy issues and key findings that resulted from the survey analysis presented in Section 3. The final recommendations are presented in Section 5.

The appendices of the document contain the survey instrument and the literature review. Appendix A is a copy of the actual survey questionnaire that was mailed to the Designated Representatives across Texas. Also included in Appendix A is a copy of the instructions for completing the survey.

Appendix B contains a literature review that identifies and documents previous research and databases related to OSSF malfunctions in Texas. The information provided through this research was used to help the project team develop a detailed work plan for analyzing the reasons for, and magnitude of, chronically malfunctioning OSSF systems in Texas by region.

Acknowledgements

The success of this project is due in large part to the wealth of ideas, energy, support and commitment offered by numerous professionals involved in the creation and analysis of this survey. Knowledgeable professionals whose input is greatly appreciated provided important feedback to the project team in the development of the survey instrument. Dozens of Designated Representatives offered their valuable time, experience, and insights about OSSF issues through telephone interviews. The Texas On-Site Wastewater Treatment Research Council provided guidance and assistance in the analysis of the survey results, and recognized several important opportunities for continued research. Lastly, TNRCC staff from the On-Site Sewage Facility Program contributed their support, time, and resources through every phase of the project. The project team considers the success of this study to be the result of the hard work and thoughtful diligence of each individual who was involved in the process.

SECTION 1: METHODOLOGY

The Texas On-Site Wastewater Treatment Research Council's (Council) original goal in developing this project was to conduct a statistical study to determine the causes of OSSF system malfunction on a regional and statewide basis. Data regarding the actual number of OSSF systems across the State and their rates of malfunction would be necessary to conduct a statistical analysis on the issue of OSSF system malfunctions. However, after a thorough search for such information, it was discovered that the type of detailed data that would be necessary to conduct a statistical study was non-existent.

Therefore, it became necessary to consider alternative methods of exploring this issue. After much consideration and discussion regarding the best way to achieve the project goals, the project team decided to design and administer a survey for professionals who work regularly with OSSF systems. The background research involved in the preparation of the survey instrument, including articles, databases and various research projects related to OSSF malfunctions, can be found in Appendix B of this report.

The project methodology section begins with an overview of the existing data limitations and the survey design process. This is followed by a description of the development of the survey instrument, its questions, design issues, response rates, and limitations. Lastly, a description of the regional breakdown of the State into the five regions of analysis, as well as a map depicting the regional boundaries, is presented on pages 11 and 12.

Existing Data

The first step in an attempt to determine the cause of OSSF system malfunctions across the State would be to compile a list of factors or circumstances that might cause a system to malfunction. A researcher would likely choose to perform a regression analysis to determine whether those factors or circumstances could prove, with statistical confidence, that they affect the functioning of OSSF systems. In such an analysis, the malfunction or success of an OSSF system would be the equation's dependent variable. Those factors believed to cause malfunctions would be the independent variables. Independent variables in this example might be soil type, age of the system, and maintenance history.

One might expect the regression analysis to show that OSSF systems are more likely to malfunction when the systems are installed in poor soils, are older, and are not well maintained. However, to perform this type of analysis, it is necessary to have data not only for OSSF systems that have malfunctioned, but to also to have data for OSSF systems that have operated properly.

From the statewide perspective, the only data set that was identified as potentially appropriate for statistical analyses was the Texas Water Development Board's *Statewide Water and Wastewater Needs Survey*. This survey provides useful qualitative data on the magnitude of OSSF malfunction across the State. However, the survey responses are not

appropriate for statistical analysis. The survey only collected information for communities where OSSF systems are experiencing problems and did not collect any information on communities with properly functioning OSSF systems.

A review of the literature concerning OSSF systems research at the regional level also failed to identify any other data sources that would be useful for statistical analysis. There are at least two reasons why this is so. First, many of the studies cited in this report's literature review located in Appendix B appear to be based upon engineering studies and qualitative data sources, such as interviews, case studies, surveys, etc. Second, when there are data for OSSF systems within a county, the sample sizes are usually very small and may not be representative of the entire county, and are certainly too small to be representative of the regions identified by the Council.

Since there did not appear to be an acceptable data set for statistical analysis, the Council's options were to either gather a new data set that would be appropriate for statistical analysis or employ a qualitative research technique to study the problem. While the former option would best satisfy the Council's informational desires, this option would have been prohibitive from a time and financial perspective. The second option was judged to be the more practical of the two.

A qualitative research technique would provide a valid methodology for studying the problems of OSSF systems, despite its lack of statistical analysis. Within the realm of qualitative research there are a number of appropriate techniques that a researcher may employ to obtain valid results. The project team determined that a survey instrument targeted to individuals responsible for working with OSSF systems at the local level would be the most effective and efficient means of attaining the Council's research goals. With input from the Council and the TNRCC, the project team decided to administer the survey to the State's Designated Representatives.

Designated Representatives were chosen as the most appropriate survey population for two reasons. First, they represent all of the geographic areas of the State. Each Authorized Agent and its respective Designated Representative has a jurisdiction that is exclusive and does not overlap with other jurisdictions. Therefore, if the Designated Representative of each jurisdiction of the State received a survey, then results from the entire State would be included in the survey analysis.

Second, this population was determined to have the most comprehensive understanding of the issues regarding OSSF systems. The job description of the Designated Representatives requires that they conduct construction inspections, as well as ensure the maintenance of accurate records regarding permitting, fees, inspections, maintenance reports and complaints. Ideally, the Designated Representatives would have a comprehensive understanding of the issues related to OSSF systems in their jurisdiction.

Survey Instrument

The success of any survey is dependent upon the quality of its design and how well it is administered. To ensure the quality of this survey, the project team reviewed current survey design literature so that the appropriate techniques were applied. Additionally, a survey implementation plan was developed to ensure that the maximum effort was made to obtain the highest response rate possible. A copy of the survey instrument can be found in Appendix A of this report.

Survey Development Process

The first draft of the survey was designed by the project team and was based upon OSSF issues that were identified through discussions with TNRCC staff and Council members, as well as through findings from the literature review. TNRCC staff and Council members provided both written and verbal comments through meetings and correspondence, which furnished guidance on the survey's focus, content, and design. The project team incorporated advisory comments and submitted the draft survey to the Council for approval.

The next step was to provide the survey to four professionals with extensive experience working with OSSF systems. The survey was reviewed to determine the appropriateness of the questions in terms of difficulty, detail, and comprehensiveness. The reviewers responded with a number of useful and insightful comments that were incorporated into the final version. Specifically, the comments provided by these four reviewers made recommendations for rephrasing and clarifying survey questions, clarifying the instructions for individual questions, and changes for avoiding respondent bias. Additionally, the reviewers offered new questions to obtain more specific technical information about OSSF malfunctions across the State.

The survey included questions covering a wide range of factors that influence the operation and functioning of OSSF systems. Factors discussed in the survey include the issues of soil, climate, system age, design, installation, and maintenance, OSSF regulations, owner education, and Designated Representative training. This survey was not designed to be a comprehensive discussion of all the factors that could affect the functioning of OSSF systems, but was intended to provide an opportunity for Designated Representatives to detail the issues that most often affect the functioning of OSSF systems in their jurisdictions.

Survey Design Issues

Careful attention and thought was put into the design of the survey. One important consideration was the issue of confidentiality. The project team wanted to make it known that specific responses provided by the Designated Representatives would remain confidential and that none of the individual responses would be provided to the Council or to the TNRCC. It was hoped that this assurance of confidentiality would encourage the Designated Representatives to return the completed surveys without concern that their

responses might somehow be used to judge the quality of their professional work. To address this issue, statements were placed on the survey and its accompanying cover letter asserting that all individual responses would remain confidential and would not be reported to the Council or the TNRCC.

Another design goal was to structure the survey's questions and layout so that they would not be viewed as too confusing or difficult. This involved phrasing questions to be more understandable and making appropriate use of technical terminology. The survey attempted to minimize difficult data requests by restructuring or eliminating questions that were not absolutely necessary. The survey was ultimately improved at each step of the process by creating multiple drafts that required feedback and edits from industry professionals and experts from across the State, resulting in a survey instrument that was satisfactory to all involved in its design.

Survey Distribution and Response Rate

A comprehensive list of Designated Representatives from across the State of Texas was provided to the project team by TNRCC and the surveys were mailed to each Designated Representative on the list. Survey respondents were given the option of returning the completed survey via U.S. mail or by electronic facsimile. Each survey included a stamped, addressed envelope for the convenience of the respondent. The surveys were sent out on January 29, 2001 and respondents were asked to reply no later than February 28, 2001. Each survey included contact information for the project team in case a respondent had any questions. If a Designated Representative requested a new copy of the survey, this copy was typically sent by electronic facsimile.

After the initial deadline of February 28, 2001 had passed, a follow-up effort was undertaken during the month of March to solicit responses from Designated Representatives who had not yet returned their completed surveys. These Designated Representatives were contacted and asked if they were willing to complete the survey. If they were interested, an additional survey was faxed to the respondent for their convenience. All Designated Representatives who did not initially turn in a completed survey were given at least one follow-up phone call, while those from larger counties received two follow-up phone calls. Unfortunately, many of the follow-up phone calls made by the project team were left on voice-mail or through phone messages and were not returned by the Designated Representative.

The overall final survey response rate was 64%. This is a relatively high number for this type of survey and provided the project team with a representative sample of the target population. Another way to measure the survey's response rate is to consider the percentage of OSSF systems across the entire State that is represented by the completed surveys. Designated Representatives who responded to the survey represented approximately 1,180,621 of the 1,569,942 OSSF systems in the State, resulting in an OSSF representation response rate of 75%.

Limitations of the Survey

All surveys, regardless of the effort placed into the design process, contain some limitations that prevent them from fully measuring their intended phenomena. In the case of this survey, several limitations were identified during its design and after its completion.

Despite the pre-testing and review measures taken, there was some confusion by the Designated Representatives with regard to the survey instructions. This confusion was limited to questions #4, #6, and #10. Question #4 asks for the total number of malfunctioning systems in the Designated Representative's jurisdiction. Some answered the question using information for one year of malfunctioning OSSF data, while others answered it with a more general "snapshot" approach of malfunctioning systems. Because respondents answered the question in several ways, the project team decided to telephone each of the survey respondents to ask the question again. Rather than clarifying the original question, respondents were asked two new questions:

1. "In the typical/average year, how many malfunctioning OSSF systems are you made aware of through calls, complaints, etc.?"

2. "Approximately what percentage of the total OSSF systems in your jurisdiction tend to malfunction chronically, year in and year out?"

Through the process of calling each of the survey respondents to ask the new questions, opportunities were made to further discuss issues surrounding OSSF malfunctions. For Designated Representatives that had the time and were willing to discuss the issues further, this proved to be a valuable opportunity for the project team to gain further insight into the issues and challenges facing Designated Representatives across the State.

Question #6 also caused problems, where respondents were asked to rank the factors that impact the functionality of OSSFs. Almost half of the respondents ranked each factor separately with a value between 1 and 10, rather than rank ordering the factors collectively. In other words, the intent of the question was to rank all factors with a value of either 1, 2, 3... or 10, with no two factors having the same ranking. Responses that were not ranked in the manner stated above were not included in the study's analysis.

In the case of Question #10, Designated Representatives were asked to list the total number of OSSF systems in their jurisdiction, as well as total number of malfunctioning systems, by age. This question required access to historical information and was rarely answered in full. When the question was answered, the results occasionally conflicted with other responses provided in the survey. Due to a low response rate to this question, it was not included in the analysis.

Lastly, an important limitation of the survey involves the accuracy of the source information. The responses provided in the survey often reflected individual opinions

and were not verified for their accuracy. Many of the respondents provided estimations based upon their personal knowledge without referring to more definitive sources. In many cases, more definitive sources of information simply did not exist, and the respondents provided information based upon their experience and firsthand knowledge of their jurisdiction. Using personal knowledge as a source of information was encouraged during this study, but it likely produced incomplete, and possibly inaccurate, responses.

Consequently, the key findings produced by this survey simply report the combined responses of the Designated Representatives. An external volume of data cannot verify the accuracy of this study's findings because the information simply has not been gathered on a comprehensive statewide basis. Therefore, the findings included in this product may not be a completely accurate reflection of OSSF systems in the State.

Finally, it should be pointed out that the results from the survey are not appropriate for statistical analyses. As discussed above, the threats to the validity of the data collected prevent a legitimate use of the survey's findings for statistical analyses. Thus, one should not infer any **causal** relationships using statistical techniques from the findings produced in this report. A "causal" relationship refers to an assumption that one event causes another event, when in fact there may be other unknown or undetected factors that are causing the phenomenon.

What the findings of this survey do provide, however, is a general understanding of what factors affect OSSF malfunction across Texas according to the majority of the State's Designated Representatives. The survey results are analyzed on a regional basis and presented in Section 2 of this document.

Dividing the State into Regions

It was determined that in order to best analyze the results of this project, the State of Texas should be divided into regions. Texas includes an incredible variation in soil type, topography, and climate conditions across Texas. Conditions range from the arid desert-like lands in the west, to the centrally located hilly limestone subsoils, to the humid pine forests in the east, to the coastal beaches along the Gulf of Mexico. The Council believed that this variation would likely mean that different factors contribute to OSSF malfunction, depending on the region of the State in which the OSSF system was located.

To divide the State of Texas into regions based on soil and climate conditions, the project team used a map that was previously developed for the Council by the Texas Agricultural Extension Service. This map was originally included in the "Texas Onsite Wastewater Treatment Council Research Survey of Research and Technology Transfer Needs in Texas," which was completed August 31, 1995. The map, which was based on soil and climatic conditions across the State, was developed to help the Council establish priorities for future research and educational projects. This map, "On-Site Wastewater

Regions of Texas," is included as Figure 1. Brief descriptions of the five regions outlined in the map are listed below:[3]

Region I: This region is commonly referred to as the Texas Panhandle. The average annual precipitation in the region ranges from 14 to 32 inches. Most of the soils in the Panhandle and the areas just south and east of the City of Wichita Falls can be characterized as having mostly loamy surface layers and clayey subsoils. Some areas are sandy throughout or have sandy surface layers, while other areas have limestone or lime accumulations in the subsoil.

Region II: This region includes west Texas and stretches eastward into south central Texas. The average annual precipitation in this region ranges from 8 to 32 inches. The western part of the region is desert-like with undulating loamy or clayey soils and limestone and igneous rock outcroppings. Toward the eastern portion of this region, the soils are moderately deep cracking with shallow clayey and loamy soils, and some stony and gravelly areas.

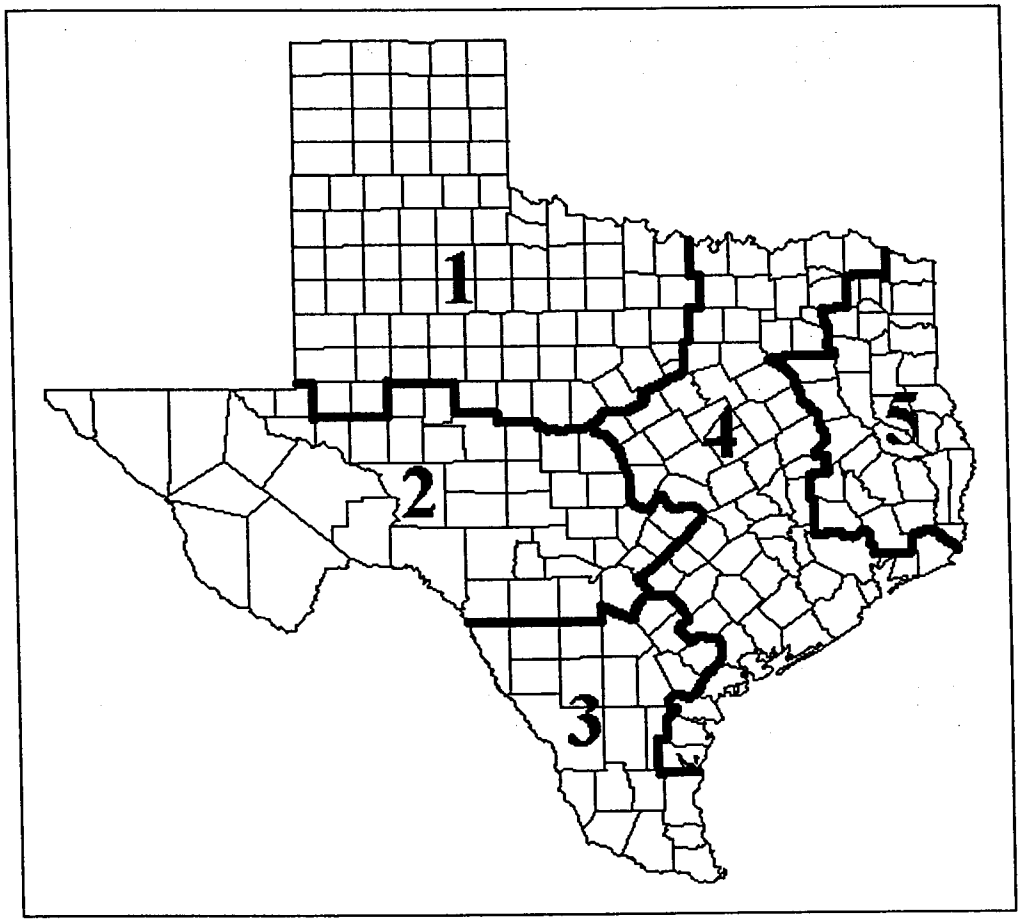
Region III: This region includes the very southern tip of Texas and is typically referred to as the Lower Rio Grande Valley. The average annual precipitation in the region ranges from 22 to 26 inches. The stretch of land bordering the Rio Grande River has mostly sandy surface layers and sand throughout, with loamy to clayey subsoils. South of San Antonio, soils are deep with loamy surface and clayey subsoils. The very southern tip and coastal stretches have poorly drained saline loamy soils and deep sandy soils.

Region IV: This region covers parts of north, central and coastal Texas. The average annual precipitation in the region ranges from 28 to 52 inches. The central strip of soil stretching from Dallas to San Antonio can be characterized as having limestone, calcium and/or lime crackling clayey soils, bordered to the east by soils with sandy surface layers and loamy subsoils. The coastal area has poorly and moderately well drained clayey soil with loamy surface layers. Some areas have the saline clayey soils of marshes and the sand soils of beaches.

Region V: This region includes east Texas. The average annual precipitation in the region ranges from 40 to 52 inches, the highest average in Texas. Most of this region has gently rolling hills with loamy or sandy surface layers with mostly clayey subsoils. Some areas have poorly drained loamy soils.

[3] For all five regions, precipitation data and soil descriptions were obtained from "General Soils Map of Texas, 1973;" Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas, 1973.

Figure 1. On-Site Wastewater Regions of Texas



SECTION 2: REGIONAL ANALYSIS

This section describes the results of the surveys that were completed and returned by Designated Representatives from across the State. The survey responses were coded, entered into a database, sorted by region, and analyzed. The analysis is discussed in detail below and the data are presented in the order in which they were listed on the survey questionnaire. The data from each region was analyzed separately. The results of the analysis for Regions I through Region V are presented below and followed by a discussion of the key findings. The key findings present a summary of the survey results and highlights the most common issues reported in the region.

Region I

Region I contains the northwestern regions of the State including the Texas Panhandle, which is an arid region with relatively little rainfall. The regional economy is largely based in agriculture, oil/gas production and ranching. Region I contains the cities of Amarillo, Lubbock, Wichita Falls, Abilene, and Midland-Odessa.

Description of Survey Results

Table I.A illustrates that of the 51 surveys mailed to Designated Representatives in Region I, 35 were completed and returned, resulting in the second highest regional response rate of 69%. Another measure of response rate used in this analysis was the percentage of OSSF systems that are represented by the completed surveys.[4] The estimated number of OSSF systems in Region I, using adjusted 1990 Census data, was 218,100. The 35 Designated Representatives that responded to the survey are responsible for an estimated 158,997 of the 218,100 OSSF systems. Therefore, an estimated 73% of the total OSSF systems in the region are represented by the survey results.

Table I.A: Survey Response Profile

Region I Data	Frequency	Percentage
Total number of counties in the region	86	
Total number of surveys mailed to Designated Representatives	51	
Response rate based on total number of surveys completed	35	69%
Total estimated OSSF systems in Region I from U.S. Census Bureau data	218,100	
Response rate based on OSSF systems represented by completed surveys	158,997	73%

[4] This response rate was determined by using the number of OSSF systems in each Texas county according to the 1990 Census, adjusted by the county's growth rate from 1990 to 2000. From this data, the total number of OSSF systems in each region was determined. The total number of OSSF systems in each jurisdiction that returned a completed survey was subtracted from the estimated number of OSSF systems in the entire region. The difference was used to calculate the response rate based on the number of OSSF systems that are represented by the completed surveys.

Table I.B provides background information regarding the Designated Representatives who completed the survey. Region I reported that a total of 69% of the respondents have been a Designated Representative for three years or more and only 9% have been on the job for less than one year. This is an important factor to consider when analyzing the survey results because time on the job should correlate to an understanding of the issues and problems regarding OSSF systems. Approximately 40% of the survey respondents stated that they referenced a computer database when filling out the survey, while 89% used personal knowledge and 91% used files and/or paperwork.

Table I.B: Designated Representative Background Information

Question/Answer	Frequency	Percentage
How long have you been a Designated Representative?		
Less than 1 Year	3	9%
1 to 3 Years	8	23%
More than 3 Years	24	69%
Total	**35**	**100%**
Select all sources of information you used to provide answers for this survey.		
Personal Knowledge	31	89%
Files/Paperwork	32	91%
Computer Database	14	40%

Table I.C describes the responses to a question about the overall malfunction rates of OSSF systems in Region I. Designated Representatives were asked to provide the percentage of OSSF systems in their entire jurisdiction that tend to chronically malfunction. OSSF systems were considered to be chronically malfunctioning if they were prone to failure from year to year. Of the estimated 158,997 OSSF systems located in Region I, approximately 12,876, or 8%, were reported to malfunction chronically as reported by the Designated Representatives. It is important to note that this figure is an estimation. Survey responses to this question were usually based on the Designated Representatives' educated guess and professional knowledge and experience within their jurisdiction.

Table I.C: Malfunctioning OSSF Systems

Estimated OSSF Malfunctions	Total	Percentage
Estimated number of chronically malfunctioning OSSF systems based on survey response data.	12,876	8%

Table I.D illustrates the number of OSSF systems that are installed in each of the Soil Classes I through IV. Designated Representatives were asked to estimate the percentage of the total number of OSSF systems in their jurisdiction that is most typically installed in each soil category. According to Designated Representatives, approximately 43% of OSSF systems in Region I were installed in Soil Class I-b and Class II. With respect to soil texture, these soil types tend to be well suited for standard subsurface disposal methods, such as conventional septic systems. Approximately 20% of systems were reported to be installed in Soil Class I-a or Soil Class IV, which are considered to be

unsuitable for conventional septic systems. Soil Class III contained approximately 37% of OSSF systems. This soil type is generally considered suitable for conventional systems, unless the soil structure is problematic.

Table I.D: OSSF Systems by Soil Classification

Soil Classification	Frequency	Percentage
Soil category where OSSF systems are most typically installed in Region I.		
I-a: (sandy-texture soils that contain more than 30% gravel)	15,863	10%
I-b: (sandy soils that contain 30% gravel or less)	18,456	12%
II: (coarse loamy soils that include sandy loam and loam textures)	49,424	31%
III: (fine loamy soils that include silt, loam, clay, and sand)	59,103	37%
IV: (fine-textured soils that contain more than 40% clay-sized particles)	16,132	10%
Total OSSF systems Installed in Region I[5]	158,978	100%

Table I.E: Ranking of Factors in Malfunctioning OSSF Systems

Category	Average	Mode
Ranking of the impact of the following categories on the malfunction of OSSF systems in your jurisdiction. (1= greatest impact; 10= lowest impact)		
Age of the Systems	**2.2**	**1**
Climate	8.0	9
Design	5.5	6
High Water Table	8.8	10
Installation/Construction	5.6	6
Lack of Education/Public Awareness	**4.2**	**3**
Operation & Maintenance	**3.2**	**1**
Regulations	6.9	10
Small Lot Size and Population Density	5.8	6
Soils	4.8	5

Table I.E provides a list of possible factors that contribute to OSSF malfunction ranked on a scale of 1 to 10, with 1 denoting factors that have the greatest impact. The most common response, or "mode," denotes the most frequently occurring number in the series and is listed in the second column in Table I.E. The category that was found to have the most significant impact on malfunction was the age of the OSSF system. The average ranking for system age was a 2.2 and the most common response was a ranking of 1, which denotes the greatest impact on malfunction. Operation and maintenance was only slightly behind system age, with an average ranking of 3.2 and a most common ranking of 1. Another category that fell into the third highest rank was lack of education/public awareness, which had an average ranking of 4.2, with a most common ranking of 3.

Factors that did not appear to be of great concern, according to the responses, include the issues of high water table, climate, and regulations. The lack of problems with the high

[5] The number of total OSSF systems installed in Region I presented in Table I.D does not exactly match the number presented in Table I.A because some responses to this question may not have totaled 100%.

water table and climate is fairly intuitive due to the arid nature of the region and relatively sparse rainfall. Lower humidity and precipitation combined with hot summers result in increased evaporation. High rates of evaporation can aid in the functioning of OSSF systems.

Table I.F presents an expanded analysis of the factors that contribute to malfunctioning OSSF systems. The respondents were asked to report the level of impact that each category has on the malfunction of OSSF systems in their jurisdiction, including the options of severe, moderate, minimal, or none. The results of this particular question are relatively clear and provide some specific guidance for understanding the factors that contribute to OSSF malfunctions in Region I. Two categories that present relatively few problems for the region as a whole were climate and high water table. Climate was found to have minimal or no effect on malfunctioning systems by 91% of survey respondents, while high water table had minimal or no effect on malfunction according to 89% of respondents.

The category that was reported as being the highest contributor to OSSF malfunction in Region I was pre-regulatory "grandfathered" systems. A full 51% of the Designated Representatives stated that grandfathered systems contribute severely to malfunction and another 29% stated that they contribute moderately to malfunction. This directly corresponds to the results presented in Table I.E that ranked the age of the system to be the most significant factor in OSSF malfunction.

Two categories that had over one-third of respondents report severe impacts on malfunction were lack of education for OSSF owners and improper operation and maintenance. The lack of education for OSSF owners was reported to contribute severely to malfunction by 37% and moderately by 31%. Improper operation and maintenance was reported to severely contribute to malfunction by 34% and moderately contribute by 34%.

Table I.F: Contributing Factors to the Malfunctioning OSSF Systems

Category	Severe		Moderate		Minimal		None	
	#	%	#	%	#	%	#	%
Climate	1	3%	2	6%	18	51%	14	40%
High Water Table	1	3%	3	9%	16	46%	15	43%
Improper Installation/Construction	3	9%	17	49%	12	34%	3	9%
Improper Operation & Maintenance	**12**	**34%**	**12**	**34%**	**9**	**26%**	**2**	**6%**
Improper System Design	2	6%	14	40%	14	40%	5	14%
Lack of Education for OSSF Owner	**13**	**37%**	**11**	**31%**	**6**	**17%**	**3**	**9%**
Lack of Training for Designated Representatives	1	3%	4	11%	13	37%	17	49%
Lack of Training for Designers	4	11%	3	9%	15	43%	13	37%
Lack of Training for Installers	1	3%	10	29%	14	40%	10	29%
Pre-Regulatory "Grandfathered" Systems	**18**	**51%**	**10**	**29%**	**3**	**9%**	**3**	**9%**
Small Lot Size	6	17%	15	43%	10	29%	4	11%
Soils	6	17%	12	34%	12	34%	5	14%

Table I.G provides a more detailed analysis of specific contributing factors to OSSF malfunction that include the following categories: soil, design, climate, and operation and maintenance. Overall, Region I did not report any of the factors as being significant contributors to malfunction when compared to other regions of the State. In general, the percentage of Designated Representatives that found any of the factors in Table I.G to be severe contributors to malfunction was much lower than reported in other regions.

Table I.G: Effects of Soil, Design, Climate and O&M on OSSF Systems

Category	Severe		Moderate		Min./None	
	#	%	#	%	#	%
SOIL						
Tightly-packed clay soils do not allow proper leaching	**4**	**11%**	**12**	**34%**	**19**	**54%**
Rocky soils allow sewage to drain too quickly through the system	1	3%	8	23%	26	74%
Fractured limestone soils allow sewage to flow directly into the ground	1	3%	8	23%	26	74%
Solid rock subsurface makes it difficult to construct adequate drainfield	**5**	**14%**	**9**	**26%**	**21**	**60%**
Soils are too naturally saturated to absorb effluent (high water table)	1	3%	7	20%	27	77%
DESIGN						
Improper classification of soil type	1	3%	12	34%	22	63%
OSSF system is not appropriate for the soil type and/or climate	0	0%	9	26%	26	74%
Drainfield is too close to traffic areas resulting in damage from vehicles	0	0%	10	29%	25	71%
Location of drainfield causes drainage problems due to topography	2	6%	4	11%	29	83%
OSSF system is too small for the sewage load from the facility	5	14%	4	11%	26	74%
OSSF system is too small for the sewage strength from the facility	3	9%	4	11%	28	80%
Water runoff from rooftops, patios and driveways is not properly diverted	1	3%	3	9%	31	89%
The lot size and/or drainfield is too small	**5**	**14%**	**9**	**26%**	**21**	**60%**
CLIMATE						
Flooding... Systems are located in a floodplain	0	0%	4	11%	31	89%
Frequent rainfall causes ground saturation	0	0%	3	9%	32	91%
Cold winters cause soils to freeze	0	0%	2	6%	33	94%
Increased rainfall and less evaporation during winter months	1	3%	5	14%	29	83%
OPERATION & MAINTENANCE						
OSSF system or parts are worn out or damaged and not replaced	2	6%	8	23%	25	71%
OSSF system is not pumped as often as necessary	**7**	**20%**	**11**	**31%**	**17**	**49%**
Improper disposal of solvents, grease and other substances into OSSF	2	6%	12	34%	21	60%
Residence fail to renew their maintenance contracts	4	11%	3	9%	28	80%
Required disinfectant is either incorrectly added or not added to OSSF	4	11%	5	14%	26	74%
Roots from trees or shrubs are interfering with drainfield lines	2	6%	12	34%	21	60%
Driving over drainfields with vehicles	1	3%	10	29%	24	69%
Paving over or constructing facilities on drainfield	0	0%	10	29%	25	71%

According to the majority of Designated Representatives, soils are not a significant problem for the region as a whole. However, some respondents did report severe and

moderate problems with certain types of soils. For example, the clay soils had a severe impact on malfunction for 11% of respondents and had a moderate impact on malfunction for 34%. The presence of a solid rock subsurface that makes it difficult to construct an adequate drainfield was a severe problem for 14% of respondents, and a moderate problem for 26%.

The same pattern can be drawn from the responses to the category of design. The majority of Designated Representatives found that design issues resulted in minimal or no impact on the malfunction of OSSF systems. The factor that was reported to contribute more severely to malfunction was lot sizes and/or drainfields that are too small. Approximately 14% of Designated Representatives reported severe impacts from this factor, and 26% reported moderate impacts.

The category of climate was overwhelmingly reported to present minimal or no contributing effects on the malfunction of OSSF systems in Region I. This is consistent with responses to other survey questions on the same topic.

The issue that was reported to have the most significant impact on malfunctioning OSSF systems was under the operation and maintenance category. OSSF systems that are not pumped often enough were a severe problem for 20% of Designated Representatives, and a moderate problem for 31%. Several other issues were reported to contribute moderately to malfunction, but the failure to regularly pump OSSF systems was the only category in Table I.G that had more than half of the respondents reporting severe or moderate impacts on malfunctioning OSSF systems.

Table I.H: Functionality of Different Types of OSSF Systems

Types of OSSF Systems	Function Well		Function Poorly	
	#	%	#	%
Absorptive Mounds	7	20%	0	0%
Drip Emitters	6	17%	0	0%
Evapotranspiration Beds	13	39%	2	6%
Gravelless Pipe	12	34%	5	14%
Leaching Chambers	**29**	**83%**	**1**	**3%**
Low Pressure Dosing	10	29%	0	0%
Standard Trenches/Beds	**26**	**74%**	**2**	**6%**
Surface Irrigation	11	31%	3	9%

Table I.I: Functionality of Different Treatment Technologies

Types of Treatment Technologies	Function Well	%
Aerobic Systems	**18**	**51%**
Sand Filters	3	9%
Trickling Filters	0	0%
Constructed Wetlands	0	0%
Septic Tanks	**33**	**94%**

Tables I.H and I.I illustrate the functionality of different types of OSSF systems and different types of treatment technologies. Leaching chambers and standard trenches/beds were found to function well by 83% and 74% of respondents respectively. Additionally, approximately 94% of Designated Representatives reported that conventional septic tanks function well in Region I. Aerobic systems were also reported to function well by 51% of respondents.

Table I.J shows the opinions of Designated Representatives on the benefits of the 1997 rule changes. Designated Representatives were asked whether they agreed with the statement: "the 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained." Only two respondents disagreed or strongly disagreed with this statement. The majority of respondents agreed or strongly agreed with this statement, giving it an approval rating of 66%. However a total of 29% of the respondents were neutral on the issue. This represents a relatively high approval rating for the rule changes from the Designated Representatives in Region I and is consistent with responses from other regions.

Table I.J: 1997 Rule Changes

Survey Opinions	Frequency	%
Strongly Agree	9	26%
Agree	14	40%
Neutral	10	29%
Disagree	1	3%
Strongly Disagree	1	3%

Table I.K provides the results of inquiries into the adequacy of OSSF owner education and Designated Representative training. When asked whether OSSF owners receive sufficient information on how to properly care for and operate their systems, 60% of survey respondents said no. When asked to state whether they receive adequate training from TNRCC regarding the duties and responsibilities of being a Designated Representative, only 20% said no.

Table I.K: Owner Education and Designated Representative Training

Question/Answer	Yes	%	No	%
In your opinion, do owners of OSSF systems receive sufficient information to have a fundamental understanding of how to properly care for and operate their OSSF system?	14	40%	21	60%
Do you believe that you are receiving adequate training from the TNRCC regarding the responsibilities and duties of a Designated Representative?	28	80%	7	20%

Key Findings

Region I reported that approximately 8% of its OSSF systems chronically malfunction. After reviewing the survey results reported by Region I, the most significant factor that contributes to the malfunction of OSSF systems is the system's age. Other issues that

contribute to OSSF malfunctions in the region include operation and maintenance practices and a lack of education for OSSF owners.

The age of the OSSF systems and the pre-regulatory "grandfathered" systems are consistently noted as significant factors that contribute to the malfunction of OSSF systems in Region I.

- The age of the OSSF system was ranked as the highest factor contributing to OSSF malfunction (Table I.E).

- Pre-regulatory "grandfathered" systems were reported to contribute severely to malfunction by 51% of the respondents, while an additional 29% found them to contribute moderately to OSSF malfunction (Table I.F).

The issue of OSSF system operation and maintenance was also shown to be an important factor in malfunction according to the survey responses.

- Operation and maintenance was ranked as the second highest contributing factor to OSSF system malfunction (Table I.E).

- Operation and maintenance was found to severely contribute to OSSF malfunction by 34% of respondents and moderately contribute by an additional 34% (Table I.F).

- Under the category of operation and maintenance, OSSF systems that are not pumped as often as necessary were reported to be a severe contributor to malfunction by 20% of the respondents and a moderate contributor to malfunction by 31% (Table I.G).

Another problematic issue for Region I was the lack of education and/or public awareness regarding OSSF systems. It could be argued that poor operation and maintenance practices by OSSF owners are the result of insufficient OSSF owner education regarding their systems. These two issues were both ranked similarly by the survey respondents in Region I.

- A lack of education or public awareness was ranked as having the third highest impact on OSSF malfunction, with an average ranking of 4.2 and the most common response of 3 (Table I.E).

- Approximately 37% of the survey respondents found the lack of education for OSSF owners to severely affect the functioning of OSSF systems, while an additional 31% reported it was a moderate contributor (Table I.F).

- Sixty percent of the survey respondents reported that OSSF owners do not receive sufficient information regarding how to properly operate and maintain their OSSF systems (Table I.K).

It is also important to note which factors can be reasonably ruled out as contributors to OSSF malfunction in Region I. Some categories that were found to present severe problems in other regions resulted in minimal concerns for this region. For instance, the climate and the high water table factors were consistently reported to have minimal or no relationship to malfunctioning OSSF systems in Region I. These responses are intuitive given the arid nature of the region in general, hot summers and low humidity, and the relatively low rainfall. Such climatic conditions contribute to high evaporation rates, which are ideal for proper OSSF functioning.

The soils in Region I were reported as being problematic for several of the survey respondents. Specifically, tightly-packed clay soils and solid rock subsurfaces were reported to contribute to OSSF malfunction. However, a large majority of the survey respondents stated that leaching chamber and standard trench OSSF systems perform well in Region I. Additionally, 94% of respondents reported that septic tanks perform well in the region. Therefore, while the issue of soils may be problematic for some jurisdictions within Region I, it may not be a significant concern for the majority of jurisdictions in Region I.

Region II

Region II stretches from the western tip of Texas through the Texas Hill Country. The region is bordered on the south by the Rio Grande River and contains the cities of El Paso, Austin, and San Antonio, as well as Big Bend National Park. Region II may contain the most variety in terms of climatic conditions of any of the other regions, with rainfall and humidity becoming more plentiful traveling from the western portions of the region near El Paso toward the eastern areas in the Hill Country.

Description of Survey Results

Table II.A illustrates that of the 46 surveys mailed to Designated Representatives in Region II, 27 were completed and returned, resulting in a regional survey response rate of 59%. Another measure of response rate used in this analysis was the percentage of OSSF systems that are represented by the completed surveys.[6] The estimated number of OSSF systems in Region II, using data projected from the 1990 U.S.Census, was 211,797. The 27 Designated Representatives that responded to the survey are responsible for an estimated 185,431 of the total 211,797 OSSF systems in the region. Therefore, an estimated 88% of the total OSSF systems in the region are represented by the survey results.

Table II.A: Survey Response Profile

Region II Data	Frequency	Percentage
Total number of counties in the region	44	
Total number of surveys mailed to Designated Representatives	46	
Response rate based on total number of surveys completed	27	59%
Total estimated OSSF systems in Region II from U.S. Census Bureau data	211,797	
Response rate based on OSSF systems represented by completed surveys	185,431	88%

Table II.B: Designated Representative Background Information

Question/Answer	Frequency	Percentage
How long have you been a Designated Representative?		
Less than 1 Year	5	19%
1 to 3 Years	6	22%
More than 3 Years	16	59%
Total	27	100%
Select all sources of information you used to provide answers for this survey.		
Personal Knowledge	25	93%
Files/Paperwork	21	78%
Computer Database	15	56%

[6] See footnote #4 on page 12 for the methodology used to determine this response rate.

Table II.B provides background information regarding the Designated Representatives who completed the survey. Region II reported that approximately 59% have been on the job for 3 years or more. At 59%, Region II and Region V both had the highest percentage of Designated Representatives who accessed a computer database when answering the survey questions.

Table II.C describes the responses to a question about the overall malfunction rates of OSSF systems in Region II. Designated Representatives were asked to provide the percentage of OSSF systems in their jurisdiction that tend to chronically malfunction. OSSF systems were considered to be chronically malfunctioning if they were prone to failure from year to year. Of the estimated 185,431 OSSF systems in the responding jurisdictions, approximately 22,296, or 12%, were reported to malfunction chronically as reported by the Designated Representatives. It is important to note that this figure is an estimation. Survey responses to this question were usually based on the Designated Representatives' educated guess and professional knowledge and experience with their jurisdiction.

Table II.C: Malfunctioning OSSF Systems

Estimated OSSF Malfunctions	Total	Percentage
Estimated number of chronically malfunctioning OSSF systems based on survey response data.	22,296	12%

Table II.D illustrates the number of OSSF systems that are installed in each of the Soil Classes I through IV. Designated Representatives were asked to estimate the percentage of the total number of OSSF systems in their jurisdiction that is most typically installed in each soil category. Responses for this question did not total 100% because the answers provided on the surveys for Region II did not always total 100%. Approximately 29% of OSSF systems in Region II were installed in Soil Class I-b and Soil Class II. With respect to soil texture, these soil types tend to be well suited for standard subsurface disposal methods, such as conventional septic systems. Approximately 27% of systems were reported to be installed in Soil Class I-a or Soil Class IV, which are considered to be unsuitable for conventional septic systems. Soil Class III contained approximately 43% of OSSF systems. This soil type is generally considered suitable for conventional systems, unless the soil structure is problematic.

Table II.D: OSSF Systems by Soil Classification

Soil Classification	Frequency	Percentage
Soil category where OSSF systems are most typically installed in Region I.		
I-a: (sandy-texture soils that contain more than 30% gravel)	10,479	6%
I-b: (sandy soils that contain 30% gravel or less)	21,503	12%
II: (coarse loamy soils that include sandy loam and loam textures)	30,538	17%
III: (fine loamy soils that include silt, loam, clay, and sand)	80,267	43%
IV: (fine-textured soils that contain more than 40% clay-sized particles)	38,618	21%
Total OSSF systems Installed in Region II	**181,405**	**98%**

Table II.E provides a list of possible factors that contribute to OSSF malfunction ranked on a scale of 1 to 10, with 1 denoting factors that have the greatest impact on malfunction. The most common response, or "mode," denotes the most frequently occurring number in the series and is listed in the second column in Table II.E. Respondents found the age of the OSSF system to have the greatest impact on malfunction in Region II, which also corresponds to the ranking of this factor in Region I.

The average ranking for system age was 2.7 and the most common response was a ranking of 1. The factor determined to have the second highest impact on malfunction was small lot size and population density. This factor had an average ranking of 3.8 and the most common response was a ranking of 1. The issues that appeared to produce the least concern in Region II were regulations, with an average ranking of 8.3, and high water table, with an average ranking of 7.3.

Table II.E: Ranking of Factors in Malfunctioning OSSF Systems

Category	Average	Mode
Ranking of the impact of the following categories on the malfunction of OSSF systems in your jurisdiction. (1= greatest impact; 10= lowest impact)		
Age of the Systems	**2.7**	**1**
Climate	7.1	6
Design	5.3	4
High Water Table	7.3	10
Installation/Construction	5.5	5
Lack of Education/Public Awareness	5.6	6
Operation & Maintenance	4.3	4
Regulations	8.3	10
Small Lot Size and Population Density	**3.8**	**1**
Soils	5.1	3

Table II.F presents an expanded analysis of the factors that contribute to malfunctioning OSSF systems. The respondents were asked to state the level of impact that each category has on the malfunction of OSSF systems, including the options of severe, moderate, minimal, or none. The three issues that were reported as having the most significant contribution to OSSF malfunction were pre-regulatory "grandfathered" systems, improper operation and maintenance, and lack of education for OSSF owners.

Problems with pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 22% of respondents, and a moderate contributor to malfunction by 37%. This is consistent with the responses in Table II.E that ranked system age as the factor that has the highest impact on malfunction.

Improper operation and maintenance was found to be a severe contributor to malfunction by 19% of respondents, and a moderate contributor to malfunction by 48% of respondents. Lack of education for OSSF owners was also found to be an important issue that contributes to malfunction. Approximately 19% of respondents stated that it

severely contributes to malfunction while an additional 33% stated it moderately contributes to malfunction.

Factors that were not reported to have significant effects on OSSF malfunction were a lack of training for Designated Representatives, a lack of training for installers, and a lack of training for designers of OSSF systems. No respondents found these factors to be severe problems and very few rated them as moderate concerns.

Table II.F: Contributing Factors to the Malfunctioning OSSF Systems

Category	Severe		Moderate		Minimal		None	
	#	%	#	%	#	%	#	%
Climate	0	0%	5	19%	10	37%	9	33%
High Water Table	2	7%	4	15%	8	30%	10	37%
Improper Installation/Construction	1	4%	10	37%	12	44%	1	4%
Improper Operation & Maintenance	**5**	**19%**	**13**	**48%**	**3**	**11%**	**3**	**11%**
Improper System Design	0	0%	11	41%	8	30%	3	11%
Lack of Education for OSSF Owner	**5**	**19%**	**9**	**33%**	**8**	**30%**	**2**	**7%**
Lack of Training for Designated Representatives	0	0%	2	7%	10	37%	12	44%
Lack of Training for Designers	0	0%	4	15%	15	56%	5	19%
Lack of Training for Installers	0	0%	3	11%	16	59%	5	19%
Pre-Regulatory "Grandfathered" Systems	**6**	**22%**	**10**	**37%**	**6**	**22%**	**1**	**4%**
Small Lot Size	5	19%	5	19%	11	41%	3	11%
Soils	4	15%	9	33%	8	30%	3	11%

Table II.G provides a more detailed analysis of specific contributing factors to malfunction that include the following categories: soil, design, climate, and operation and maintenance. However, the survey did not produce a clear consensus about which issues presented the greatest problems. Several issues were reported as moderate contributors to malfunction, but there are no factors that were found to severely contribute to OSSF malfunction by even one-third of Designated Representatives.

Each category, with the exception of climate, had at least two factors that were reported to contribute significantly to OSSF malfunctions. However, only the category of operation and maintenance included factors that were reported as severe or moderate concerns by more half of the respondents.

Under the category of soil, several of the scenarios were found to present problems for OSSF systems. Specifically, tightly-packed clay soils that do not allow for proper leaching were found to be a severe contributor to malfunction by 22% of the respondents and a moderate contributor to malfunction by an additional 22%. Fractured limestone soils that allow sewage to flow directly into the ground were identified as a severe contributor to malfunction for 22% of the respondents, and a moderate contributor for 19%.

The category of system design had several factors that were found to moderately contribute to malfunction. Lot sizes and drainfields that are too small were reported as severe contributors to malfunction by 11% of the respondents, and a moderate contributor by 37%. OSSF systems that are too small for the sewage load from the facility were a severe problem for only 7%, but a moderate problem for 44%. Other categories under system design were reported to be a moderate or severe issue of concern for over one-third of respondents.

Table II.G: Effects of Soil, Design, Climate and O&M on OSSF Systems

Category	Severe		Moderate		Min./None	
	#	%	#	%	#	%
SOIL						
Tightly-packed clay soils do not allow proper leaching	**6**	**22%**	**6**	**22%**	**15**	**56%**
Rocky soils allow sewage to drain too quickly through the system	2	7%	10	37%	15	56%
Fractured limestone soils allow sewage to flow directly into the ground	**6**	**22%**	**5**	**19%**	**16**	**59%**
Solid rock subsurface makes it difficult to construct adequate drainfield	4	15%	5	19%	18	67%
Soils are too naturally saturated to absorb effluent (high water table)	2	7%	5	19%	20	74%
DESIGN						
Improper classification of soil type	1	4%	10	37%	16	59%
OSSF system is not appropriate for the soil type and/or climate	1	4%	9	33%	17	63%
Drainfield is too close to traffic areas resulting in damage from vehicles	1	4%	6	22%	20	74%
Location of drainfield causes drainage problems due to topography	2	7%	6	22%	19	70%
OSSF system is too small for the sewage load from the facility	**2**	**7%**	**12**	**44%**	**13**	**48%**
OSSF system is too small for the sewage strength from the facility	1	4%	5	19%	21	78%
Water runoff from rooftops, patios and driveways is not properly diverted	1	4%	6	22%	20	74%
The lot size and/or drainfield is too small	**3**	**11%**	**10**	**37%**	**14**	**52%**
CLIMATE						
Flooding... Systems are located in a floodplain	0	0%	3	11%	24	89%
Frequent rainfall causes ground saturation	0	0%	8	30%	19	70%
Cold winters cause soils to freeze	0	0%	2	7%	25	93%
Increased rainfall and less evaporation during winter months	2	7%	6	22%	19	70%
OPERATION & MAINTENANCE						
OSSF system or parts are worn out or damaged and not replaced	2	7%	8	30%	17	63%
OSSF system is not pumped as often as necessary	**6**	**22%**	**10**	**37%**	**11**	**41%**
Improper disposal of solvents, grease and other substances into OSSF	3	11%	9	33%	15	56%
Residence fail to renew their maintenance contracts	2	7%	8	30%	17	63%
Required disinfectant is either incorrectly added or not added to OSSF	4	15%	6	22%	17	63%
Roots from trees or shrubs are interfering with drainfield lines	**4**	**15%**	**12**	**44%**	**11**	**41%**
Driving over drainfields with vehicles	4	15%	8	30%	15	56%
Paving over or constructing facilities on drainfield	2	7%	6	22%	19	70%

The category of operation and maintenance included several scenarios that were problematic for OSSF systems. OSSF systems that are not pumped as often as necessary were found to contribute severely to OSSF malfunction by 22% of the respondents, while an additional 37% reported a moderate contribution to malfunction. Roots from trees or shrubs that interfere with drainfield lines were reported as a severe contributor to malfunction by 15% of the respondents and a moderate contributor to malfunction by 44%. Although several issues listed in this table are of concern, it may not be possible to interpret any one factor as having a significantly greater impact on malfunction, with the exception of climate, which clearly was not reported to significantly contribute to OSSF malfunction in Region II.

Table II.H: Functionality of Different Types of OSSF Systems

Types of OSSF Systems	Function Well		Function Poorly	
	#	%	#	%
Absorptive Mounds	8	30%	1	4%
Drip Emitters	7	26%	0	0%
Evapotranspiration Beds	9	33%	2	7%
Gravelless Pipe	9	33%	2	7%
Leaching Chambers	**17**	**63%**	**0**	**0%**
Low Pressure Dosing	**14**	**52%**	**1**	**4%**
Standard Trenches/Beds	**19**	**70%**	**0**	**0%**
Surface Irrigation	12	44%	4	15%

Table II.I: Functionality of Different Treatment Technologies

Types of Treatment Technologies	Function Well	%
Aerobic Systems	12	44%
Sand Filters	4	15%
Trickling Filters	2	7%
Constructed Wetlands	0	0%
Septic Tanks	**24**	**89%**

Tables II.H and II.I illustrate the functionality of different types of OSSF systems and the different types of treatment technologies. The types of OSSF systems that had the highest approval ratings in Region II were standard trenches and beds with 70%, leaching chambers with 63%, and low pressure dosing with 52%. However, it appears that many of the OSSF systems perform well in one jurisdiction or another. The results shown in Table II.I illustrate that conventional septic tank technology performs well in the majority of the reporting jurisdictions, with an 89% approval rating.

Table II.J shows the opinions of Designated Representatives on the benefits of the 1997 rule changes. Designated Representatives were asked whether they agree with the statement: "the 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained." Only three respondents disagreed or strongly disagreed with this statement. The majority of respondents agreed or strongly agreed, with an approval rating of 78%. This high approval rating for the rule

changes from the Designated Representatives in Region II is consistent with the responses from other regions.

Table II.J: 1997 Rule Changes

Survey Opinions	Frequency	%
Strongly Agree	7	26%
Agree	14	52%
Neutral	3	11%
Disagree	2	7%
Strongly Disagree	1	4%

Table II.K provides the results of inquiries into the adequacy of OSSF owner education and Designated Representative training. When asked whether OSSF owners receive sufficient information on how to properly care for and operate their systems, 67% of survey respondents said no. When asked to state whether they receive adequate training from the TNRCC regarding the duties and responsibilities of being a Designated Representative, only 7% said no. All other regions, with the exception of Region III, had at least 20% state that there is a need for more training for Designated Representatives.

Table II.K: Owner Education and Designated Representative Training

Question/Answer	Yes	%	No	%
In your opinion, do owners of OSSF systems receive sufficient information to have a fundamental understanding of how to properly care for and operate their OSSF system?	9	33%	18	67%
Do you believe that you are receiving adequate training from the TNRCC regarding the responsibilities and duties of a Designated Representative?	25	93%	2	7%

Key Findings

Region II reported that approximately 12% of OSSF systems chronically malfunction. There are several factors that contribute to OSSF malfunction in Region II and no one particular issue can be said to have the greatest impact on malfunction. Additionally, the percentage of Designated Representatives that reported "severe" problems in Region II was generally less than in other regions.

One of the more significant factors that affects the functioning of OSSF systems in Region II appears to be the age of the systems and the pre-regulatory "grandfathered" systems. This issue was also reported to be a major concern for Region I.

- System age was ranked as having the highest impact on OSSF malfunction, with an average ranking of 2.7, and the most common ranking of 1 (Table II.E)

- A total of 22% of the survey respondents stated that pre-regulatory "grandfathered" systems contribute severely to OSSF malfunction, while 37% reported moderate contribution to OSSF malfunction (Table II.F).

Small lot sizes and population density, and other system design related issues, were found to be significant contributors to OSSF malfunction in Region II.

- Small lot size and population density was ranked as having the second highest impact on OSSF malfunction, with an average ranking of 3.8 and the most common survey response of 1 (Table II.E).

- A total of 38% of the survey respondents found small lot size to be a severe or moderate contributor to OSSF malfunction (Table II.F).

- Two system design issues were reported to present problems for OSSF systems in Region II. OSSF systems that are too small for the sewage load from the facility were reported as a severe or moderate problem for 51% of the survey respondents. Lot sizes or drainfields that are too small were reported to severely or moderately contribute to malfunction by 48% of the respondents (Table II.G).

- Improper system installation and construction, and improper system design, were found to severely or moderately contribute to OSSF malfunction by 41% of respondents (Table II.F).

Another issue that impacted the functioning of OSSF systems in Region II was operation and maintenance.

- Operation and maintenance was ranked as having the third highest impact on OSSF malfunction with an average ranking of 4.3 and the most common response of 4 (Table II.E).

- Improper operation and maintenance was reported to severely contribute to malfunction by 19% of the respondents and moderately contribute to OSSF malfunction by 48% of survey respondents (Table II.F).

- OSSF systems that are not pumped as often as necessary were a severe contributor to malfunction for 22% of the respondents, and a moderate contributor to malfunction for 37%. Roots from trees or shrubs that interfere with drainfield lines were found to severely impact OSSF malfunction by 15% of respondents, and moderately contribute to malfunction by 44% (Table II.G).

Another contributing factor to the malfunction of OSSF systems in Region II was the soil class. Approximately 27% of the OSSF systems in Region II were reportedly installed in Soil Class I-a and Soil Class IV. Both of these soil types are unsuitable for the proper functioning of conventional septic systems.

- Approximately 17% of the respondents reported that soils severely contribute to the malfunctioning of OSSF systems, while an additional 34% reported a moderate contribution to malfunction (Table II.F).

- Tightly-packed clay soils that do not permit proper leaching presented a severe or moderate problem for 44% of the respondents, while fractured limestone soils were reported to be severe or moderate problems for 41% of the respondents (Table II.G).

Region III

Region III contains jurisdictions in the southernmost part of the State, commonly referred to as the Middle and Lower Rio Grande Valley. It is bordered on the west and south by the Rio Grande River and contains three counties that border the Gulf of Mexico. It contains the cities of Laredo, McAllen, Harlingen, and Brownsville.

Description of Survey Results

Table III.A illustrates that of the 36 surveys mailed to Designated Representatives in Region III, 16 were completed and returned, resulting in a regional response rate of 44%. This constituted the lowest response rate of any region. Another measure of the response rate used in this analysis was the percentage of OSSF systems that are represented by the completed surveys.[7] The estimated number of OSSF systems in Region III using data projected from the 1990 Census, was 138,291. The 16 Designated Representatives that responded to the survey are responsible for an estimated 44,465 of the 138,291 OSSF systems. Therefore, an estimated 32% of the total OSSF systems in the region are represented by the survey results.

Due to the low regional response rate and the lower OSSF representation, the results from this regional analysis may not be representative of the OSSF issues in the entire region, nor can they be assumed to represent the opinions of the majority of Designated Representatives in the region. The survey results discussed for Region III are only representative of the views and opinions expressed by those Designated Representatives who returned a completed survey.

Table III.A: Survey Response Profile

Region III Data	Frequency	Percentage
Total number of counties in the region.	23	
Total number of surveys mailed to Designated Representatives.	36	
Response rate based on total number of surveys completed.	16	44%
Total estimated OSSF systems in Region III from U.S. Census Bureau data.	138,291	
Response rate based on OSSF systems represented by completed surveys.	44,645	32%

Table III.B provides background information regarding the Designated Representatives who completed the survey. Region III reported that 31% of Designated Representatives have been on the job for over three years, which was the lowest reported number of any region in Texas. The majority of Designated Representatives, approximately 63%, have been employed in their position between 1 and 3 years.

Region III reported that 19% of the Designated Representatives referenced a computer database when filling out the survey, which was the lowest reported rate of any region.

[7] See footnote #4 on page 12 for the methodology used to determine this response rate.

Based on survey responses, the use of files/paperwork and personal knowledge was the main source of information for the majority of the survey responses.

Table III.B: Designated Representative Background Information

Question/Answer	Frequency	Percentage
How long have you been a Designated Representative?		
Less than 1 Year	1	6%
1 to 3 Years	10	63%
More than 3 Years	5	31%
Total	16	**100%**
Select all sources of information you used to provide answers for this survey.		
Personal Knowledge	14	88%
Files/Paperwork	11	69%
Computer Database	3	19%

Table III.C describes the response to a question about the overall malfunction rates of OSSF systems in Region III. Designated Representatives were asked to provide the percentage of OSSF systems in their entire jurisdiction that tend to chronically malfunction. OSSF systems were considered to be chronically malfunctioning if they were prone to failure from year to year. Of the estimated 138,291 OSSF systems in the region, approximately 1,247, or 3%, were believed to chronically malfunction, as reported by the Designated Representatives, representing the lowest regional rate of chronic malfunction in the State.

It is important to note that this figure for chronically malfunctioning OSSF systems is an estimation. Survey responses to this question were usually based on the Designated Representatives' educated guess and professional knowledge and experience with their jurisdiction. Additionally, it is important to consider the low regional response rate and even lower OSSF representation for Region III when interpreting these survey results.

Table III.C: Malfunctioning OSSF Systems

Estimated OSSF Malfunctions	Total	Percentage
Estimated number of chronically malfunctioning OSSF systems based on survey response data.	1,247	3%

Table III.D illustrates the number of OSSF systems that were installed in each of the Soil Classes I through IV. Designated Representatives were asked to estimate the percentage of the total number of OSSF systems in their jurisdiction that is most typically installed in each soil category. Responses for this question did not total 100% because the answers provided on the surveys for Region II did not always total 100%.

Approximately 52% of OSSF systems in Region III were installed in Soil Class I-b and Soil Class II soils. With respect to soil texture, these soil types tend to be well suited for standard subsurface disposal methods, such as conventional septic systems. Approximately 9% of systems were reported to be installed in Soil Class I-a or Soil Class

IV soils, which are considered to be unsuitable for conventional septic systems. Soil Class III contains approximately 38% of OSSF systems. This soil type is generally considered suitable for conventional systems, unless the soil structure is problematic.

Table III.D: OSSF Systems by Soil Classification

Soil Classification	Frequency	Percentage
Soil category where OSSF systems are most typically installed in Region I.		
I-a: (sandy-texture soils that contain more than 30% gravel)	89	0%
I-b: (sandy soils that contain 30% gravel or less)	5,455	12%
II: (coarse loamy soils that include sandy loam and loam textures)	17,874	40%
III: (fine loamy soils that include silt, loam, clay, and sand)	16,847	38%
IV: (fine-textured soils that contain more than 40% clay-sized particles)	3,880	9%
Total OSSF systems Installed in Region III	**44,645**	**99%**

Table III.E provides a list of possible factors that contribute to OSSF malfunction ranked on a scale of 1 to 10, with 1 denoting factors that have the greatest impact. The most common response, or "mode," denotes the most frequently occurring number in a series and is listed in the second column in Table III.E. The category that was found to have the most significant impact on malfunction was the age of the OSSF system.

The ranking of system age as the highest contributor to malfunction was consistent with the responses from Region I and Region II. The average ranking for system age was a 3.3 and the most common response was a ranking of 1, which denotes the greatest impact on malfunction. System design was ranked only slightly behind system age, with an average ranking of 3.6 and a most common ranking of 3. A factor that did not appear to be of great concern for the region was climate, with an average ranking of 8.4. The lack of problems with climate is fairly intuitive due to the arid nature of the region and relatively sparse rainfall.

Table III.E: Ranking of Factors in Malfunctioning OSSF Systems

Category	Average	Mode
Ranking of the impact of the following categories on the malfunction of OSSF systems in your jurisdiction. (1= greatest impact; 10= lowest impact)		
Age of the Systems	**3.3**	**1**
Climate	8.4	10
Design	**3.6**	**3**
High Water Table	7.7	9
Installation/Construction	4.8	4
Lack of Education/Public Awareness	6.0	6
Operation & Maintenance	4.9	5
Regulations	7.7	10
Small Lot Size and Population Density	4.4	4
Soils	4.2	7

Table III.F presents an expanded analysis of the factors that contribute to malfunctioning OSSF systems. The respondents were asked to state the level of impact that each category has on the malfunction of OSSF systems, including the options of severe, moderate, minimal, or none. The three issues that were reported to have the most significant contribution to OSSF malfunction were pre-regulatory "grandfathered" systems, improper installation and construction, and improper system design.

Pre-regulatory "grandfathered" systems were reported to be a severe contributor to malfunction by 50% of the respondents, while another 25% reported them to be a moderate contributor to malfunction. The problem of system age was ranked as the most significant contributor to malfunction in Regions I, II and Region III. Improper system installation and construction, as well as improper system design were two issues that were reported to have a similar impact on malfunction. Approximately 38% of the respondents reported that both of these issues contribute severely to malfunction, while an additional 19% reported a moderate contribution to malfunction. Issues that did not appear to be of concern to the majority of Designated Representatives in the region include climate, high water table, and a lack of training for Designated Representatives.

Table III.F: Contributing Factors to the Malfunctioning OSSF Systems

Category	Severe		Moderate		Minimal		None	
	#	%	#	%	#	%	#	%
Climate	0	0%	0	0%	7	44%	8	50%
High Water Table	0	0%	3	19%	7	44%	5	31%
Improper Installation/Construction	**6**	**38%**	**3**	**19%**	**4**	**25%**	**2**	**13%**
Improper Operation & Maintenance	3	19%	5	31%	6	38%	1	6%
Improper System Design	**6**	**38%**	**3**	**19%**	**4**	**25%**	**2**	**13%**
Lack of Education for OSSF Owner	2	13%	6	38%	5	31%	1	6%
Lack of Training for Designated Representatives	0	0%	2	13%	7	44%	6	38%
Lack of Training for Designers	2	13%	3	19%	6	38%	4	25%
Lack of Training for Installers	3	19%	4	25%	4	25%	4	25%
Pre-Regulatory "Grandfathered" Systems	**8**	**50%**	**4**	**25%**	**2**	**13%**	**1**	**6%**
Small Lot Size	3	19%	8	50%	2	13%	2	13%
Soils	2	13%	6	38%	5	31%	2	13%

Table III.G provides a more detailed analysis of specific contributing factors to OSSF malfunction that include the following categories: soil, design, climate, and operation and maintenance. The results of this survey question show that among these four categories, the issue of system design was the most likely to contribute to OSSF system malfunction. OSSF systems that are too small for the sewage load from the facility were reported as a severe problem for 31% of the respondents, while 25% reported it as a moderate problem. Lot sizes and/or drainfields that are too small were reported as a severe contributor to malfunction by 38% and a moderate contributor by 13%. Finally, OSSF systems that are not appropriate for the soil type and/or climate were found to be a severe contributor to malfunction by 31% of the respondents, and a moderate contributor by 13%.

The only factor other than design that severely contributed to OSSF malfunction was related to soils. Tightly-packed clay soils that do not allow for proper leaching were found to be a severe contributor to malfunction by 31% of the respondents and a moderate contributor by 6%. As in Region I and Region II, it is possible to exclude climate as a factor of consequence when considering OSSF malfunction. Operation and maintenance issues were reported to contribute severely to malfunction by only a very few Designated Representatives. However, OSSF systems that are not pumped as often as necessary and roots from trees or shrubs that interfere with drainfield lines were both issues that respondents indicated were moderate contributors to malfunction.

Table III.G: Effects of Soil, Design, Climate and O&M on OSSF Systems

Category	Severe		Moderate		Min./None	
	#	%	#	%	#	%
SOIL						
Tightly-packed clay soils do not allow proper leaching	**5**	**31%**	**1**	**6%**	**10**	**63%**
Rocky soils allow sewage to drain too quickly through the system	1	6%	2	13%	13	81%
Fractured limestone soils allow sewage to flow directly into the ground	0	0%	2	13%	14	88%
Solid rock subsurface makes it difficult to construct adequate drainfield	1	6%	1	6%	14	88%
Soils are too naturally saturated to absorb effluent (high water table)	0	0%	3	19%	13	81%
DESIGN						
Improper classification of soil type	4	25%	2	13%	10	63%
OSSF system is not appropriate for the soil type and/or climate	**5**	**31%**	**2**	**13%**	**9**	**56%**
Drainfield is too close to traffic areas resulting in damage from vehicles	2	13%	1	6%	13	81%
Location of drainfield causes drainage problems due to topography	2	13%	2	13%	12	75%
OSSF system is too small for the sewage load from the facility	**5**	**31%**	**4**	**25%**	**7**	**44%**
OSSF system is too small for the sewage strength from the facility	3	19%	1	6%	12	75%
Water runoff from rooftops, patios and driveways is not properly diverted	0	0%	3	19%	13	81%
The lot size and/or drainfield is too small	**6**	**38%**	**2**	**13%**	**8**	**50%**
CLIMATE						
Flooding... Systems are located in a floodplain	1	6%	0	0%	15	94%
Frequent rainfall causes ground saturation	0	0%	2	13%	14	88%
Cold winters cause soils to freeze	0	0%	1	6%	15	94%
Increased rainfall and less evaporation during winter months	1	6%	1	6%	14	88%
OPERATION & MAINTENANCE						
OSSF system or parts are worn out or damaged and not replaced	2	13%	4	25%	10	63%
OSSF system is not pumped as often as necessary	2	13%	7	44%	7	44%
Improper disposal of solvents, grease and other substances into OSSF	1	6%	6	38%	9	56%
Residence fail to renew their maintenance contracts	0	0%	2	13%	14	88%
Required disinfectant is either incorrectly added or not added to OSSF	2	13%	0	0%	14	88%
Roots from trees or shrubs are interfering with drainfield lines	0	0%	8	50%	8	50%
Driving over drainfields with vehicles	2	13%	1	6%	13	81%
Paving over or constructing facilities on drainfield	1	6%	2	13%	13	81%

Tables III.H and III.I illustrate the functionality of different types of OSSF systems and different types of treatment technologies. The types of OSSF systems that had the highest approval ratings in Region III were standard trenches and beds with 75%, leaching chambers with 50%, and gravelless pipe with 50%. The results listed in Table III.I illustrate that conventional septic tank technology performs well in the majority of the reporting jurisdictions, with a 69% approval rating.

Table III.H: Functionality of Different Types of OSSF Systems

Types of OSSF Systems	Function Well		Function Poorly	
	#	%	#	%
Absorptive Mounds	0	0%	0	0%
Drip Emitters	0	0%	0	0%
Evapotranspiration Beds	4	25%	1	6%
Gravelless Pipe	**8**	**50%**	**2**	**13%**
Leaching Chambers	**8**	**50%**	**0**	**0%**
Low Pressure Dosing	4	25%	0	0%
Standard Trenches/Beds	**12**	**75%**	**0**	**0%**
Surface Irrigation	6	38%	0	0%

Table III.I: Functionality of Different Treatment Technologies

Types of Treatment Technologies	Function Well	%
Aerobic Systems	6	38%
Sand Filters	0	0%
Trickling Filters	0	0%
Constructed Wetlands	1	6%
Septic Tanks	**11**	**69%**

Table III.J shows the opinions of Designated Representatives on the benefits of the 1997 rule changes. Designated Representatives were asked whether they agree with the statement: "the 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained." Only one respondent disagreed or strongly disagreed with this statement. The majority of respondents agreed or strongly agreed, with an approval rating of 69%. This represents a high approval rating for the rule changes from the Designated Representatives in Region III and is consistent with responses from the other regions.

Table III.J: 1997 Rule Changes

Survey Opinions	Frequency	%
Strongly Agree	1	6%
Agree	10	63%
Neutral	4	25%
Disagree	1	6%
Strongly Disagree	0	0%

Table III.K provides the results of inquiries into the adequacy of OSSF owner education and Designated Representative training. When asked whether OSSF owners receive

sufficient information on how to properly care for and operate their systems, 44% of survey respondents said no. Region III is the only region in which the majority of respondents reported that OSSF owners are receiving adequate information regarding their systems.

When asked to state whether they receive adequate training from TNRCC regarding the duties and responsibilities of being a Designated Representative, only 6% said no. Therefore, an overwhelming majority of respondents did not believe additional training is needed. Region II reported results similar to Region III, while the remaining regions had at least 20% of the Designate Representatives report that there is a need for more training.

Table III.K: Owner Education and Designated Representative Training

Question/Answer	Yes	%	No	%
In your opinion, do owners of OSSF systems receive sufficient information to have a fundamental understanding of how to properly care for and operate their OSSF system?	9	56%	7	44%
Do you believe that you are receiving adequate training from the TNRCC regarding the responsibilities and duties of a Designated Representative?	15	94%	1	6%

Key Findings

Because of the low regional response rate and the even lower OSSF representation, Region III is unique. The reasons for the low response rate could not be determined from the survey itself. However, this area has traditionally had problems with environmental infrastructure, and some Designated Representatives may have been reluctant to further expose any problems. All regions of the State received the same survey package, instructions, deadlines, and follow up procedures. It is therefore important to factor in the effects of a low regional response rate on the overall validity of the results from this region. The results from the analysis of Region III may not be representative of the OSSF issues in the entire region, nor can they be assumed to represent the opinions of the majority of Designated Representatives in the region.

Region III reported that approximately 3% of OSSF systems malfunction chronically. This is the lowest reported rate of chronic malfunction in the State, and may not be an accurate reflection of the entire region due to the low response rate discussed above. The issue that was reported to have the greatest impact on the malfunction of OSSF systems in Region III is the age of the system and pre-regulatory "grandfathered" systems. Region I, Region II, and Region III all ranked this issue as the most significant factor in OSSF malfunction, while Region IV and Region V ranked it as either the second or third highest.

- The age of the OSSF systems was ranked to have the highest impact on system malfunction, with an average ranking of 3.3 and a most common ranking of 1 (Table III.E).

- The category that was reported to contribute most severely to OSSF malfunction was pre-regulatory "grandfathered" systems. Approximately 50% of the survey respondents reported that grandfathered systems severely contribute to malfunction, and another 25% reported a moderate contribution to malfunction (Table III.F).

Other issues that were found to be problematic for the region were system design issues.

- System design was ranked as having the second highest impact on OSSF malfunction in Region III (Table III.E).

- Improper system design was found to severely contribute to malfunction by 38% of the respondents, and moderately contribute to malfunction by 19% of respondents (Table III.F).

- Small lot sizes were reported to be a severe contributor to malfunction for approximately 19% of the respondents and a moderate contributor for 50% (Table III.F).

- OSSF systems that are too small for the sewage load from the facility were reported to contribute severely to malfunction by 31% of the respondents, and moderately contribute to malfunction by 25%. Lot sizes and/or drainfields that are too small were reported to severely contribute to malfunction by 38% of the respondents, and moderately contribute to malfunction by 13% (Table III.G).

Other issues were of notable concern, although they were not consistently reflected throughout the survey. For instance, under the category of operation and maintenance, approximately 57% of the respondents found that the lack of OSSF system pumping either moderately or severely contributed to malfunction in Region III according to the results in Table III.G. Additionally, 57% of the survey respondents believe that improper installation and/or construction severely or moderately contributed to OSSF malfunction according to Table III.F.

Region IV

Region IV is the largest of the five regions in terms of the total number of Designated Representatives, the total number of OSSF systems, and the total population. This region has a total of 67 counties in the central section of the State and extends from the Red River to the Gulf of Mexico in the south. Most of the Texas coastline is within this region. Region IV also contains the cities of Dallas-Fort Worth, Houston, Waco, Bryan-College Station, Victoria, Corpus Christi, Galveston and Beaumont.

Description of Survey Results

Table IV.A illustrates that of the 101 surveys mailed to Designated Representatives in Region IV, 72 were completed and returned, resulting in the highest regional response rate of 71%. Another measure of the response rate used in this analysis was the percentage of OSSF systems that are represented by the completed surveys.[8] The estimated number of OSSF systems in Region IV, using adjusted 1990 Census data, was 629,028. The 72 Designated Representatives that responded to the survey are responsible for an estimated 524,151 of the 629,028 OSSF systems. Therefore, an estimated 83% of the total systems in the region are represented by the survey results.

Table IV.A: Survey Response Profile

Region IV Data	Frequency	Percentage
Total number of counties in the region.	67	
Total number of surveys mailed to Designated Representatives.	101	
Response rate based on total number of surveys completed.	72	71%
Total estimated OSSF systems in Region IV from U.S. Census Bureau data.	629,028	
Response rate based on OSSF systems represented by completed surveys.	524,151	83%

Table IV.B: Designated Representative Background Information

Question/Answer	Frequency	Percentage
How long have you been a Designated Representative?		
Less than 1 Year	7	10%
1 to 3 Years	14	19%
More than 3 Years	51	71%
Total	72	100%
Select all sources of information you used to provide answers for this survey.		
Personal Knowledge	68	94%
Files/Paperwork	68	94%
Computer Database	36	50%

[8] See footnote #4 on page 12 for the methodology used to determine this response rate.

Table IV.B provides background information regarding the Designated Representatives who completed the survey. Region IV had the highest number of Designated Representatives reporting to be on the job for three years or more with 71%, and only 9% have been on the job for less than one year. Approximately 50% of the survey respondents stated that they referenced a computer database when completing the survey, while 94% used personal knowledge and 94% used files and/or paperwork.

Table IV.C describes the responses to a question about the overall malfunction rates of OSSF systems in Region IV. Designated Representatives were asked to provide the percentage of OSSF systems in their entire jurisdiction that tend to chronically malfunction. OSSF systems were considered to be chronically malfunctioning if they were prone to failure from year to year. Of the estimated 524,151 OSSF systems in the responding jurisdictions, approximately 62,513, or 12%, were believed to malfunction chronically as reported by the Designated Representatives. It is important to note that this figure is an estimation. Survey responses to this question were usually based on the Designated Representatives' educated guess and professional knowledge and experience with their jurisdiction.

Table IV.C: Malfunctioning OSSF Systems

Estimated OSSF Malfunctions	Total	Percentage
Estimated number of chronically malfunctioning OSSF systems based on survey response data.	62,513	12%

Table IV.D illustrates the number of OSSF systems that are installed in each of the soil classes I through IV. Designated Representatives were asked to estimate the percentage of the total number of OSSF systems in their jurisdiction that is most typically installed in each soil category. Responses for this question did not total 100% because one respondent reported that the majority of his systems were installed in a soil type other than the ones listed. Additionally, several respondents did not answer the question. Therefore, only 90.2% of the total OSSFs are accounted for in this region.

Table IV.D: OSSF Systems by Soil Classification

Soil Classification	Frequency	Percentage
Soil category where OSSF systems are most typically installed in Region I.		
I-a: (sandy-texture soils that contain more than 30% gravel)	23,506	5%
I-b: (sandy soils that contain 30% gravel or less)	33,024	6%
II: (coarse loamy soils that include sandy loam and loam textures)	54,896	11%
III: (fine loamy soils that include silt, loam, clay, and sand)	110,058	21%
IV: (fine-textured soils that contain more than 40% clay-sized particles)	251,180	48%
Total OSSF systems Installed in Region IV	**472,664**	**90%**

According to Designated Representatives, approximately 17% of OSSF systems in Region IV were installed in Soil Class I-b and Soil Class II. With respect to soil texture, these soil types tend to be well suited for standard subsurface disposal methods, such as conventional septic systems. Approximately 53% of the systems were reported to be

installed in Soil Class I-a or Soil Class IV, which are considered to be unsuitable for conventional septic systems. Soil Class III contained approximately 21% of OSSF systems. This soil type is generally considered suitable for conventional systems, unless the soil structure is problematic.

Table IV.E provides a list of possible factors that contribute to OSSF malfunction ranked on a scale of 1 to 10, with 1 denoting factors that have the greatest impact. The most common response, or "mode," denotes the most frequently occurring number in a series and is listed in the second column in Table IV.E. Respondents found the two highest factors to be soils with an average ranking of 3.1, and the age of the system with an average of 3.5. The most common response for both of these categories was a ranking of 1. The category that is shown to have the least impact on the malfunction of OSSF systems is regulations, with an average rating of 8.5 and the most common response ranking of 10.

Table IV.E: Ranking of Factors in Malfunctioning OSSF Systems

Category	Average	Mode
Ranking of the impact of the following categories on the malfunction of OSSF systems in your jurisdiction. (1= greatest impact; 10= lowest impact)		
Age of the Systems	**3.5**	**1**
Climate	5.5	2
Design	5.4	4
High Water Table	6.4	9
Installation/Construction	5.8	5
Lack of Education/Public Awareness	5.5	6
Operation & Maintenance	4.9	5
Regulations	8.5	10
Small Lot Size and Population Density	6.3	9
Soils	**3.1**	**1**

Table IV.F presents an expanded analysis of the factors that contribute to malfunctioning OSSF systems. The respondents were asked to state the level of impact that each category has on the malfunction of OSSF systems, including the options of severe, moderate, minimal, or none. The four issues that were reported as having the most significant contribution to OSSF malfunction were pre-regulatory "grandfathered" systems, poor soil conditions, lack of education for OSSF owners, and small lot sizes.

Pre-regulatory "grandfathered" systems were reported to severely contribute to malfunction by 46% of the respondents and moderately contribute to malfunction by 32%. Poor soil conditions were reported to contribute severely to malfunction by 42% of the respondents and moderately by 36%. These two factors correspond in the level of importance to the high rankings presented in Table IV.E.

Lack of education for OSSF owners was found to be a severe contributor to malfunction by 28% of the respondents and a moderate contributor by 46%. This mirrors the opinion

presented in Table IV.K, which states that 85% of Designated Representatives believe that OSSF owners do not receive sufficient information regarding their OSSF systems. Another issue of concern for Region IV is the small lot sizes and population density that were reported to severely contribute to malfunction by 29% of the respondents and moderately contribute to malfunction by 26%. Operation and maintenance also was reported as an important concern for the region. Approximately 15% of respondents stated that operation and maintenance is a severe contributor to malfunction, while 51% reported it to be a moderate contributor to malfunction.

Table IV.F: Contributing Factors to the Malfunctioning OSSF Systems

Category	Severe		Moderate		Minimal		None	
	#	%	#	%	#	%	#	%
Climate	7	10%	28	39%	28	39%	5	7%
High Water Table	5	7%	22	31%	30	42%	12	17%
Improper Installation/Construction	4	6%	25	35%	36	50%	3	4%
Improper Operation & Maintenance	11	15%	37	51%	17	24%	3	4%
Improper System Design	8	11%	21	29%	29	40%	10	14%
Lack of Education for OSSF Owner	**20**	**28%**	**33**	**46%**	**15**	**21%**	**0**	**0%**
Lack of Training for Designated Representatives	1	1%	5	7%	34	47%	29	40%
Lack of Training for Designers	2	3%	19	26%	30	42%	18	25%
Lack of Training for Installers	2	3%	18	25%	37	51%	12	17%
Pre-Regulatory "Grandfathered" Systems	**33**	**46%**	**23**	**32%**	**10**	**14%**	**3**	**4%**
Small Lot Size	**21**	**29%**	**19**	**26%**	**20**	**28%**	**9**	**13%**
Soils	**30**	**42%**	**26**	**36%**	**10**	**14%**	**3**	**4%**

Table IV.G provides a more detailed analysis of specific problems for the following categories: soil, design, climate, and operation and maintenance. Under the category of soil, there were two specific problems that were reported to pose the most difficulties for OSSF systems. Tightly-packed clay soils that do not allow for proper leaching were a severe problem for 51% of respondents and a moderate problem for 22%. It is notable that over half of the respondents find this issue to be a severe contributor to malfunction. This challenge of poor soil conditions is also an issue of great concern for Region V. Additionally, soils that are too naturally saturated to absorb effluent due to marshy land or a high water table posed severe problems for 15% and moderate problems for 36%.

Problems under the category of design were more dispersed. Lots and drainfields that are too small were reported as severe contributors to malfunction by 28% and moderate contributors by 32%. OSSF systems that are too small for the sewage load from the facility were reported to contribute severely to malfunction by 19% of respondents, and moderately by 42%. OSSF systems that are inappropriate for the type of soil or climate were reported as severe contributors to malfunction by 22% and moderate contributors by 36%.

Table IV.G: Effects of Soil, Design, Climate and O&M on OSSF Systems

Category	Severe		Moderate		Min./None	
	#	%	#	%	#	%
SOIL						
Tightly-packed clay soils do not allow proper leaching	**37**	**51%**	**16**	**22%**	**19**	**26%**
Rocky soils allow sewage to drain too quickly through the system	2	3%	20	28%	50	69%
Fractured limestone soils allow sewage to flow directly into the ground	1	1%	19	26%	52	72%
Solid rock subsurface makes it difficult to construct adequate drainfield	6	8%	16	22%	50	69%
Soils are too naturally saturated to absorb effluent (high water table)	**11**	**15%**	**26**	**36%**	**35**	**49%**
DESIGN						
Improper classification of soil type	6	8%	29	40%	37	51%
OSSF system is not appropriate for the soil type and/or climate	**16**	**22%**	**26**	**36%**	**30**	**42%**
Drainfield is too close to traffic areas resulting in damage from vehicles	1	1%	22	31%	49	68%
Location of drainfield causes drainage problems due to topography	6	8%	31	43%	35	49%
OSSF system is too small for the sewage load from the facility	**14**	**19%**	**30**	**42%**	**28**	**39%**
OSSF system is too small for the sewage strength from the facility	5	7%	25	35%	42	58%
Water runoff from rooftops, patios and driveways is not properly diverted	9	13%	22	31%	41	57%
The lot size and/or drainfield is too small	**20**	**28%**	**23**	**32%**	**29**	**40%**
CLIMATE						
Flooding... Systems are located in a floodplain	3	4%	21	29%	48	67%
Frequent rainfall causes ground saturation	**16**	**22%**	**27**	**38%**	**29**	**40%**
Cold winters cause soils to freeze	0	0%	10	14%	62	86%
Increased rainfall and less evaporation during winter months	**20**	**28%**	**24**	**33%**	**28**	**39%**
OPERATION & MAINTENANCE						
OSSF system or parts are worn out or damaged and not replaced	9	13%	33	46%	30	42%
OSSF system is not pumped as often as necessary	**17**	**24%**	**34**	**47%**	**21**	**29%**
Improper disposal of solvents, grease and other substances into OSSF	7	10%	33	46%	32	44%
Residence fail to renew their maintenance contracts	**20**	**28%**	**23**	**32%**	**29**	**40%**
Required disinfectant is either incorrectly added or not added to OSSF	**19**	**26%**	**28**	**39%**	**25**	**35%**
Roots from trees or shrubs are interfering with drainfield lines	4	6%	35	49%	33	46%
Driving over drainfields with vehicles	3	4%	30	42%	39	54%
Paving over or constructing facilities on drainfield	4	6%	28	39%	40	56%

Problems with climate in Region IV center around two issues: increased rainfall and less evaporation during winter months and frequent rainfall that results in ground saturation. Increasing rainfall and less evaporation during winter months presented a severe problem for 28% of the respondents and a moderate problem for 33%. Frequent rainfalls resulting in ground saturation resulted in severe problems for 22% of the respondents and moderate problems for 38%.

Operation and maintenance problems were found to vary, but three main issues appear to have a significant impact the malfunction of OSSF systems in Region IV. First, required disinfectant that is either incorrectly added or not added to OSSF systems resulted in a severe problem for 26% of the respondents and a moderate problem for 39%. Second, residents that fail to renew their maintenance contracts were a severe problem for 28% of the respondents and a moderate problem for 32%. Finally, OSSF systems that are not pumped as often as necessary posed a severe problem for 24% of the respondents and a moderate problem for 47%.

Tables IV.H and IV.I illustrate the functionality of different types of OSSF systems and different types of treatment technologies. OSSF systems that tend to function well in Region IV include surface irrigation, with approval from 76% of the respondents, and low pressure dosing with 54%. Although 46% of the respondents stated that standard trenches/beds function well, another 22% stated that they function poorly. Additionally, 26% of the respondents stated that evapotranspiration beds perform well, but another 26% stated they function poorly. The same was true for gravelless pipe, in which 14% of the respondents claim that they function well and 14% claim that they function poorly. This lack of consensus and apparent contradiction may be an indication of the various soil conditions within the region or it might relate to other issues that need to be explored.

Table IV.I shows that the treatment technologies that were reported to function well in Region IV include aerobic systems with an overwhelming 92% approval rating, and septic tanks with a 67% approval rating.

Table IV.H: Functionality of Different Types of OSSF Systems

Types of OSSF Systems	Function Well		Function Poorly	
	#	%	#	%
Absorptive Mounds	10	14%	3	4%
Drip Emitters	24	33%	4	6%
Evapotranspiration Beds	19	26%	19	26%
Gravelless Pipe	14	19%	14	19%
Leaching Chambers	26	36%	12	17%
Low Pressure Dosing	**39**	**54%**	**8**	**11%**
Standard Trenches/Beds	33	46%	16	22%
Surface Irrigation	**55**	**76%**	**4**	**6%**

Table IV.I: Functionality of Different Treatment Technologies

Types of Treatment Technologies	Function Well	%
Aerobic Systems	**66**	**92%**
Sand Filters	9	13%
Trickling Filters	2	3%
Constructed Wetlands	8	11%
Septic Tanks	**48**	**67%**

Table IV.J shows the results of respondent opinions on the benefits of the 1997 rule changes. Designated Representatives were asked whether they agree with the statement:

"the 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained." In Region IV, 25% strongly agreed and 51% agreed. Only 7% either disagreed or strongly disagreed with the statement. This represents a high approval rating for the rule changes from the Designated Representatives in Region IV and is consistent with responses from other regions.

Table IV.J: 1997 Rule Changes

Survey Opinions	Frequency	%
Strongly Agree	18	25%
Agree	37	51%
Neutral	12	17%
Disagree	2	3%
Strongly Disagree	3	4%

Table IV.K provides the results of inquiries into the adequacy of OSSF owner education and Designated Representative training. When asked whether OSSF owners receive sufficient information on how to properly care for and operate their systems, 85% of survey respondents said no. When asked to state whether they receive adequate training from TNRCC regarding the duties and responsibilities of being a Designated Representative, only 25% said no.

Table IV.K: Owner Education and Designated Representative Training

Question/Answer	Yes	%	No	%
In your opinion, do owners of OSSF systems receive sufficient information to have a fundamental understanding of how to properly care for and operate their OSSF system?	11	15%	61	85%
Do you believe that you are receiving adequate training from the TNRCC regarding the responsibilities and duties of a Designated Representative?	54	75%	18	25%

Key Findings

Upon review of the survey results for Region IV, several factors appear to be reasons why 12% of the OSSF systems in this region chronically malfunction. These factors include soil, system age and pre-regulatory "grandfathered" systems, operation and maintenance, and a lack of education for OSSF owners.

For the survey questions that addressed soil issues, survey respondents consistently reported that soils had a significant impact on the malfunction of OSSF systems.

- Soils were ranked as having the highest impact on the malfunction of OSSF systems (Table IV.E).
- Tightly-packed clay soils that do not allow for proper leaching were reported to be a severe contributor to OSSF malfunction for 51% of the respondents, while 22% reported moderate contribution to malfunction

- A total of 42% of the survey respondents reported that soils were a severe contributor to malfunction while 36% reported a moderate contribution to malfunction (Table IV.F).

Soil conditions may also explain why survey respondents indicated problems with climate. Key climatic reasons for malfunction, as reported in Table IV.G, include frequent rainfall that causes ground saturation and increased rainfall and less evaporation during winter months.

These problems with the soils may account for the high approval rating of 92% for aerobic systems and 76% for surface irrigation. Surface irrigation/aerobic systems are especially effective for areas that have poor drainage. However, with the use of aerobic systems comes the increased homeowner responsibility for maintenance of the system in order to ensure proper functioning.

Another issue that has presented a problem for Designated Representatives in this region is the problem of older or "grandfathered" OSSF systems. Based on the survey results, it appears that there is a link between the age of OSSF systems and malfunction:

- Pre-regulatory "grandfathered" systems were reported to be a severe contributor to malfunction by 46% of the respondents, and a moderate contributor by 32% (Table IV.F).

- OSSF system age was ranked to be the second highest factor in the malfunction of the systems in Region IV (Table IV.E).

The following survey results support why improper operation and maintenance contributes to the malfunction of OSSF systems in Region IV:

- Improper operation and maintenance of OSSF systems was found to severely contribute to the malfunction of OSSF systems by 15% of the respondents, while 51% reported a moderate contribution to malfunction (Table IV.F).

- OSSF systems that are not pumped as often as necessary were reported to be a severe contributor to malfunction by 24% of the respondents, and a moderate contributor by 47% (Table IV.G).

- Required disinfectant either incorrectly added or not added to OSSF systems was reported as a severe contributor to malfunction by 26% of the respondents, and as a moderate contributor by 39% (Table IV.G).

A lack of education for OSSF system owners, which may contribute to operational and maintenance problems, was reported to be a significant factor related to OSSF malfunction in Region IV.

- Region IV reported to have more problems with the lack of OSSF system owner education than any other region in the survey, with 85% of Designated Representatives reporting that OSSF system owners do not receive adequate education regarding their systems (Table IV.K).

- A total of 28% of the survey respondents reported that a lack of OSSF owner education contributes severely to OSSF system malfunction and 46% reported a moderate contribution to malfunction (Table IV.F).

Region V

Region V consists of counties in the very eastern portion of the State and is bordered on the east by the Sabine River. This region receives higher annual rainfall totals than the rest of the State. Region V contains the cities of Tyler, Longview, Texarkana, Nacogdoches, and Huntsville. This region also contains several large national forests, parks and nature preserves due to the plentiful pine and hardwood forests in the area.

Description of Survey Results

Table V.A illustrates that of the 44 surveys mailed to Designated Representatives in Region IV, 29 were completed and returned, resulting in a regional response rate of 66%. Another measure of the response rate used in this analysis was the percentage of OSSF systems that are represented by the completed surveys.[9] The estimated number of OSSF systems in Region V, using data projected from the 1990 Census, was 372,726. The 29 Designated Representatives that responded to the survey are responsible for an estimated 267,397 of the 372,726 OSSF systems. Therefore, an estimated 72% of the total OSSF systems in the region are represented by the survey results.

Table V.A: Survey Response Profile

Region V Data	Frequency	Percentage
Total number of counties in the region.	34	
Total number of surveys mailed to Designated Representatives.	44	
Response rate based on total number of surveys completed.	29	66%
Total estimated OSSF systems in Region V from U.S. Census Bureau data.	372,726	
Response rate based on OSSF systems represented by completed surveys.	267,397	72%

Table V.B: Designated Representative Background Information

Question/Answer	Frequency	Percentage
How long have you been a Designated Representative?		
Less than 1 Year	3	10%
1 to 3 Years	7	24%
More than 3 Years	19	66%
Total	29	100%
Select all sources of information you used to provide answers for this survey.		
Personal Knowledge	28	97%
Files/Paperwork	28	97%
Computer Database	17	59%

Table V.B provides background information regarding the Designated Representatives who completed the survey. Region V reported that a total of 66% of the respondents

[9] See footnote #4 on page 12 for the methodology used to determine this response rate.

have been a Designated Representative for three years or more and only 10% have been on the job for less than one year. Approximately 59% of the survey respondents, the highest rate of any region, stated that they referenced a computer database when filling out the survey while 97% used personal knowledge and 97% used files and/or paperwork.

Table V.C describes the responses to a question about the overall malfunction rates of OSSF systems in Region V. Designated Representatives were asked to provide the percentage of OSSF systems in their entire jurisdiction that tend to chronically malfunction. OSSF systems were considered to be chronically malfunctioning if they were prone to failure from year to year. Of the estimated 267,397 OSSF systems in the responding jurisdictions, approximately 49,641, or 19%, were believed to chronically malfunction as reported by the Designated Representatives. Region V has the highest reported rate of malfunction of any of the regions in the State. It is important to note that this figure is an estimation. Survey responses to this question were usually based on the Designated Representatives' educated guess and professional knowledge and experience with their jurisdiction.

Table V.C: Malfunctioning OSSF Systems

Estimated OSSF Malfunctions	Total	Percentage
Estimated number of chronically malfunctioning OSSF systems based on survey response data.	49,641	19%

Table V.D illustrates the number of OSSF systems that are installed in each of the Soil Classes I through IV. Designated Representatives were asked to estimate the percentage of the total number of OSSF systems in their jurisdiction that is most typically installed in each soil category. Approximately 18% of OSSF systems in Region V were installed in Soil Class I-b and Soil Class II. With respect to soil texture, these soil types tend to be well suited for standard subsurface disposal methods, such as conventional septic systems. Approximately 55% of systems were reported to be installed in Soil Class I-a or Soil Class IV soils, which are considered to be unsuitable for conventional septic systems. Soil Class III contains approximately 27% of OSSF systems. This soil type is generally considered suitable for conventional systems, unless the soil structure is problematic.

Table V.D: OSSF Systems by Soil Classification

Soil Classification	Frequency	Percentage
Soil category where OSSF systems are most typically installed in Region I.		
I-a: (sandy-texture soils that contain more than 30% gravel)	3,544	1%
I-b: (sandy soils that contain 30% gravel or less)	11,463	4%
II: (coarse loamy soils that include sandy loam and loam textures)	37,534	14%
III: (fine loamy soils that include silt, loam, clay, and sand)	71,690	27%
IV: (fine-textured soils that contain more than 40% clay-sized particles)	143,275	54%
Total OSSF systems Installed in Region V	**267,397**	**100%**

Table V.E provides a list of possible factors that contribute to OSSF malfunction ranked on a scale of 1 to 10, with 1 denoting factors that have the greatest impact on malfunction. The most common response, or "mode," denotes the most frequently occurring number in a series and is listed in the second column in Table V.E. Respondents in Region V reported that soils had the greatest impact on OSSF malfunction. The average ranking was 2.6 and the most common response was a ranking of 1. This is consistent with the results from Region IV and the results reported in Table V.D, which found a high percentage of the OSSF installations in soils that are unsuitable for conventional septic systems.

The factor that was ranked as having the second highest impact on malfunction was the high water table, followed closely by the age of the OSSF system in third place. These factors had an average ranking of 4.2 and 4.3, respectively. The high water table and the problem of poor soil conditions are closely related that have similar effects on the function of OSSF systems.

Table V.E: Ranking of Factors in Malfunctioning OSSF Systems

Category	Average	Mode
Ranking of the impact of the following categories on the malfunction of OSSF systems in your jurisdiction. (1= greatest impact; 10= lowest impact)		
Age of the Systems	**4.3**	**4**
Climate	4.8	8
Design	6.4	9
High Water Table	**4.2**	**3**
Installation/Construction	7.2	8
Lack of Education/Public Awareness	5.9	7
Operation & Maintenance	5.9	6
Regulations	8.6	10
Small Lot Size and Population Density	5.1	2
Soils	**2.6**	**1**

Table V.F presents an expanded analysis of the factors that contribute to malfunctioning OSSF systems. The respondents were asked to state the level of impact that each category has on the malfunction of OSSF systems, including the options of severe, moderate, minimal, or none. The three issues that were reported as having the most significant contribution to OSSF malfunction in Region V were poor soil conditions, pre-regulatory "grandfathered" systems, and lack of education for OSSF owners.

The soils of the region were reported to severely contribute to malfunction by 66% of the respondents, and moderately contribute to malfunction by 14%. The issue of soils in Region V had more survey respondents report a "severe" contribution to malfunction (66%) of any other factor in any other region.

Pre-regulatory "grandfathered" systems were found to be a severe contributor to malfunction by 55% of the respondents, and a moderate contributor to malfunction by

31%. The issue of pre-regulatory "grandfathered" systems in Region V had the second highest number of survey respondents report a "severe" contribution to malfunction (55%) of any other factor in any other region. The third highest percentage of respondents reporting a "severe" contribution to malfunction was 51% for pre-regulatory grandfathered systems in Region I.

Another issue of importance in Region V is the lack of education for OSSF owners, which was found to severely contribute to malfunction by 34% of the respondents, and moderately contribute to malfunction by an additional 45%. Other issues that were also identified as significant contributors to malfunction include the high water tables and small lot sizes.

Table V.F: Contributing Factors to the Malfunctioning OSSF Systems

Category	Severe		Moderate		Minimal		None	
	#	%	#	%	#	%	#	%
Climate	6	21%	14	48%	7	24%	2	7%
High Water Table	10	34%	9	31%	8	28%	1	3%
Improper Installation/Construction	2	7%	9	31%	1	55%	1	3%
Improper Operation & Maintenance	1	3%	17	59%	8	28%	3	10%
Improper System Design	5	17%	8	28%	13	45%	3	10%
Lack of Education for OSSF Owner	**10**	**34%**	**13**	**45%**	**5**	**17%**	**1**	**3%**
Lack of Training for Designated Representatives	1	3%	2	7%	15	52%	11	38%
Lack of Training for Designers	1	3%	4	14%	17	59%	7	24%
Lack of Training for Installers	1	3%	5	17%	17	59%	6	21%
Pre-Regulatory "Grandfathered" Systems	**16**	**55%**	**9**	**31%**	**3**	**10%**	**1**	**3%**
Small Lot Size	10	34%	9	31%	8	28%	2	7%
Soils	**19**	**66%**	**4**	**14%**	**5**	**17%**	**1**	**3%**

Table V.G provides a more detailed analysis of specific factors contributing to malfunction that include the following categories: soil, design, climate, and operation and maintenance. Under the category of soils, tightly-packed clay soils that do not allow for proper leaching were reported as a severe problem by 69% of the respondents, and a moderate problem by 24%. Another factor in malfunction was soils that are too naturally saturated to absorb effluent, which was reported as a severe contributor to malfunction by 34% of the respondents and a moderate contributor by 34%. These results are consistent with the responses to other survey questions regarding the impact of soil conditions on OSSF systems.

Most of the factors listed under the system design category were of moderate concern to the respondents in Region V. The issue of OSSF systems that are not appropriate for the soil type, and/or climate, was reported as the most significant design issue, with 31% reporting a severe contribution to malfunction and 41% reporting a moderate contribution.

Climate concerns centered around two issues. Frequent rainfall that causes ground saturation was reported as a significant contributor for 45% of the respondents and a moderate contributor to malfunction by 38%. Increased rainfall and less evaporation in winter months was a severe contributor to malfunction for 34% of the respondents and a moderate contributor for 41%.

Table V.G: Effects of Soil, Design, Climate and O&M on OSSF Systems

Category	Severe		Moderate		Min./None	
	#	%	#	%	#	%
SOIL						
Tightly-packed clay soils do not allow proper leaching	**20**	**69%**	**7**	**24%**	**2**	**7%**
Rocky soils allow sewage to drain too quickly through the system	1	3%	4	14%	24	83%
Fractured limestone soils allow sewage to flow directly into the ground	1	3%	2	7%	26	90%
Solid rock subsurface makes it difficult to construct adequate drainfield	0	0%	4	14%	25	86%
Soils are too naturally saturated to absorb effluent (high water table)	**10**	**34%**	**10**	**34%**	**9**	**31%**
DESIGN						
Improper classification of soil type	3	10%	12	41%	14	48%
OSSF system is not appropriate for the soil type and/or climate	**9**	**31%**	**12**	**41%**	**8**	**28%**
Drainfield is too close to traffic areas resulting in damage from vehicles	0	0%	8	28%	21	72%
Location of drainfield causes drainage problems due to topography	1	3%	12	41%	16	55%
OSSF system is too small for the sewage load from the facility	6	21%	12	41%	11	38%
OSSF system is too small for the sewage strength from the facility	1	3%	12	41%	16	55%
Water runoff from rooftops, patios and driveways is not properly diverted	3	10%	7	24%	19	66%
The lot size and/or drainfield is too small	6	21%	13	45%	10	34%
CLIMATE						
Flooding... Systems are located in a floodplain	1	3%	9	31%	19	66%
Frequent rainfall causes ground saturation	**13**	**45%**	**11**	**38%**	**5**	**17%**
Cold winters cause soils to freeze	0	0%	5	17%	24	83%
Increased rainfall and less evaporation during winter months	**10**	**34%**	**12**	**41%**	**7**	**24%**
OPERATION & MAINTENANCE						
OSSF system or parts are worn out or damaged and not replaced	1	3%	18	62%	10	34%
OSSF system is not pumped as often as necessary	4	14%	17	59%	8	28%
Improper disposal of solvents, grease and other substances into OSSF	1	3%	13	45%	15	52%
Residence fail to renew their maintenance contracts	**14**	**48%**	**13**	**45%**	**2**	**7%**
Required disinfectant is either incorrectly added or not added to OSSF	**11**	**38%**	**13**	**45%**	**5**	**17%**
Roots from trees or shrubs are interfering with drainfield lines	6	21%	14	48%	9	31%
Driving over drainfields with vehicles	0	0%	8	28%	21	72%
Paving over or constructing facilities on drainfield	0	0%	9	31%	20	69%

Two operation and maintenance issues shown in Table V.G were reported as being important factors in OSSF system malfunction in Region V. Residents that fail to renew their maintenance contracts were a severe contributor to malfunction for 48% of

respondents, and a moderate contributor for 45%. Therefore, an overwhelming 93% of respondents reported severe or moderate contribution to malfunction for this issue.

The other factor of concern for the region was required disinfectants that are either incorrectly added, or not added, to the OSSF system. This was reported as a severe contributory to malfunction by 38% of the respondents and a moderate contributor by 45%. Again, these two factors pertain mostly to surface irrigation/aerobic systems. Due to the reported problems with soils and high water table in Region V, it is apparent that the region has attempted to address the issue by using aerobic systems in place of conventional septic tanks.

Tables V.H and V.I illustrate the functionality of different types of OSSF systems and different types of treatment technologies. The type of OSSF system that had the highest approval rating in Region V was surface irrigation, with a 93% approval rating. However, it appears that many of the OSSF systems listed perform well in one jurisdiction or another. Leaching chambers were reported to function well by 48% of the respondents and standard trenches/beds were reported to function well by 45%. Gravelless pipe systems were noted as functioning poorly in Region V, with a disapproval rating of 59%.

Table V.H: Functionality of Different Types of OSSF Systems

Types of OSSF Systems	Function Well		Function Poorly	
	#	%	#	%
Absorptive Mounds	1	3%	2	7%
Drip Emitters	10	34%	1	3%
Evapotranspiration Beds	2	7%	6	21%
Gravelless Pipe	7	24%	17	59%
Leaching Chambers	14	48%	4	14%
Low Pressure Dosing	10	34%	2	7%
Standard Trenches/Beds	13	45%	10	34%
Surface Irrigation	**27**	**93%**	**1**	**3%**

The results listed in Table V.I illustrate that aerobic systems perform well in Region V, with an overwhelming approval rating of 100%. Conventional septic tank technology was reported to function well in the majority of the reporting jurisdictions, with a 66% approval rating.

Table V.I: Functionality of Different Treatment Technologies

Types of Treatment Technologies	Function Well	%
Aerobic Systems	**29**	**100%**
Sand Filters	2	7%
Trickling Filters	2	7%
Constructed Wetlands	6	21%
Septic Tanks	**19**	**66%**

Table V.J shows the opinions of Designated Representatives on the benefits of the 1997 rule changes. Designated Representatives were asked whether they agree with the statement: "the 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained." Only two respondents strongly disagreed with this statement. The majority of respondents agreed or strongly agreed, with an approval rating of 79%. This represents a high approval rating for the rule changes from the Designated Representatives in Region V and is consistent with responses from other regions.

Table V.J: 1997 Rule Changes

Survey Opinions	Frequency	%
Strongly Agree	9	31%
Agree	14	48%
Neutral	4	14%
Disagree	0	0%
Strongly Disagree	2	7%

Table V.K provides the results of inquiries into the adequacy of OSSF owner education and Designated Representative training. When asked whether OSSF owners receive sufficient information on how to properly care for and operate their systems, 79% of survey respondents said no. This high rate of dissatisfaction with the education of OSSF owners was also reflected in Table V.F

When asked to state whether they receive adequate training from TNRCC regarding the duties and responsibilities of being a Designated Representative, 41% said no. Region V had the highest rate of dissatisfaction with the adequacy of the training made available to Designated Representatives.

Table V.K: Owner Education and Designated Representative Training

Question/Answer	Yes	%	No	%
In your opinion, do owners of OSSF systems receive sufficient information to have a fundamental understanding of how to properly care for and operate their OSSF system?	6	21%	23	79%
Do you believe that you are receiving adequate training from the TNRCC regarding the responsibilities and duties of a Designated Representative?	17	59%	12	41%

Key Findings

Region V survey respondents reported that approximately 19% of all OSSF systems chronically malfunction, which is the highest rate reported by any region. The survey results clearly attribute this relatively higher rate of malfunction to several factors. These factors include poor soil conditions, a high water table, older and/or "grandfathered" systems, lack of OSSF owner education, and inadequate system operation and maintenance practices.

Severe problems with poor soil conditions were consistently reported in all survey responses that related to soil issues. According to the survey results, poor soil conditions can be interpreted as being the most influential factor on the malfunction of OSSF systems in Region V.

- Soil Classes I-a and IV, considered inappropriate for conventional septic systems, were reported to contain 55% of all installed OSSF systems in the region (Table V.D).

- Soil was rated as having the greatest impact on the malfunction of OSSF systems, with an average rating of 2.6 and a most common response rating on 1 (Table V.E).

- Soil conditions were reported to severely contribute to the malfunction of OSSF systems by 66% of the survey respondents and moderately contribute to malfunction by 14% (Table V.F).

- Tighly-packed clay soils that do not allow proper leaching were considered to severely affect system malfunction by 69% of the respondents and moderately affect malfunction by 24% (Table V.G).

An additional issue related to soil conditions was the problem of high water tables in Region V. Either one of these two factors on its own can lead to OSSF malfunction, but the combination of the two factors is especially challenging for proper OSSF functioning.

- High water tables were ranked as having the second highest impact on the malfunction of OSSF systems (Table V.E).

- High water tables were found to contribute severely to the malfunction of OSSF systems by 34% of the respondents, and moderately contribute to malfunction by an additional 31% (Table V.F).

- Soils that are too naturally saturated to absorb effluent, (due to marshy land or a high water tables), were found to severely contribute to malfunction by 34% of the respondents and moderately contributed to malfunction by 34% (Table V.G).

The issue of old systems and pre-regulatory "grandfathered" systems was reported as another problem for Region V. This issue has been presented as a major concern for each region of the State.

- System age was ranked as having the third highest impact on system malfunction, with an average ranking of 4.3 and a most common ranking of 4 (Table V.E).

- Pre-regulatory or "grandfathered" systems were determined to be severe problems for 55% of the survey respondents, and moderate problems for 31% (Table V.F).

Lack of adequate OSSF owner education was determined to be another significant factor in the malfunction of OSSF systems in Region V.

- Lack of education for OSSF owners was reported as a severe contributor to system malfunction by 34% of the respondents, and a moderate contributor to malfunction for 45% (Table V.F).

- Approximately 79% of Designated Representatives stated that OSSF owners do not receive adequate information to properly care for and operate their OSSF systems (Table V.K).

A final issue that is directly related to the lack of education for OSSF owners is the problem of inadequate operation and maintenance practices. The operation and maintenance problems reported by Region V in the survey were specifically related to the care of surface irrigation/aerobic systems.

When the survey asked about operation and maintenance problems in general, the category was not reported to be of significant concern to the respondents. For instance, in Table V.E, operation and maintenance had an average ranking of 5.9 on a scale of 1 to 10 for factors that impact OSSF malfunction. Additionally, Table V.F illustrates moderate concerns with the issue. Only 3% of the respondents believed it to be a severe contributor to malfunction, while it was found to be a moderate contributor to malfunction by 59% of respondents.

However, when the operation and maintenance questions pertained to the functioning of the surface irrigation/aerobic OSSF systems, as in Table V.G, there was a higher reported concern over the issue. The two operation and maintenance issues discussed below mirror the results from Region IV, but are indicated as being more severe factors for malfunction in Region V.

- Residents that fail to renew their maintenance contracts were reported to be a severe contributor to malfunction by 48% of the respondents, and a moderate contributor by 45% (Table V.G).

- Required disinfectant that is either incorrectly added or not added to OSSF systems was reported to be a severe contributor to malfunction by 38% of respondents and a moderate contributor by 45% (Table V.G).

Representative for more than three years ranged from 59% to 71%. Region III reported the lowest rate of time at the position with 31%.

All regions, with the exception of Region III, reported a rate of computer database usage that ranged between 40% and 59%. Region III reported the lowest rate of computer usage with 19%. Because the survey question asks the respondent to indicate if they used a computer when filling out the survey data, the survey results cannot and should not be extrapolated into the number of Designated Representatives that have access to a computer. However, the number of respondents that referenced a computer database may be an indication of the technology available to, and utilized by, the Designated Representatives.

The rate of computer usage may also be an indication of the comprehensiveness of the record keeping regarding OSSF malfunctions. It is important to note that the rate of utilization of files and paperwork when filling out the survey was very high for all regions. However, if files and paperwork are not converted into a computer database, the likelihood of difficulties in tracking and maintaining accurate records may increase.

Malfunctioning OSSF Systems (Tables C)

Chart A.1 Percentage of Chronically Malfunctioning OSSF Systems by Region and Statewide

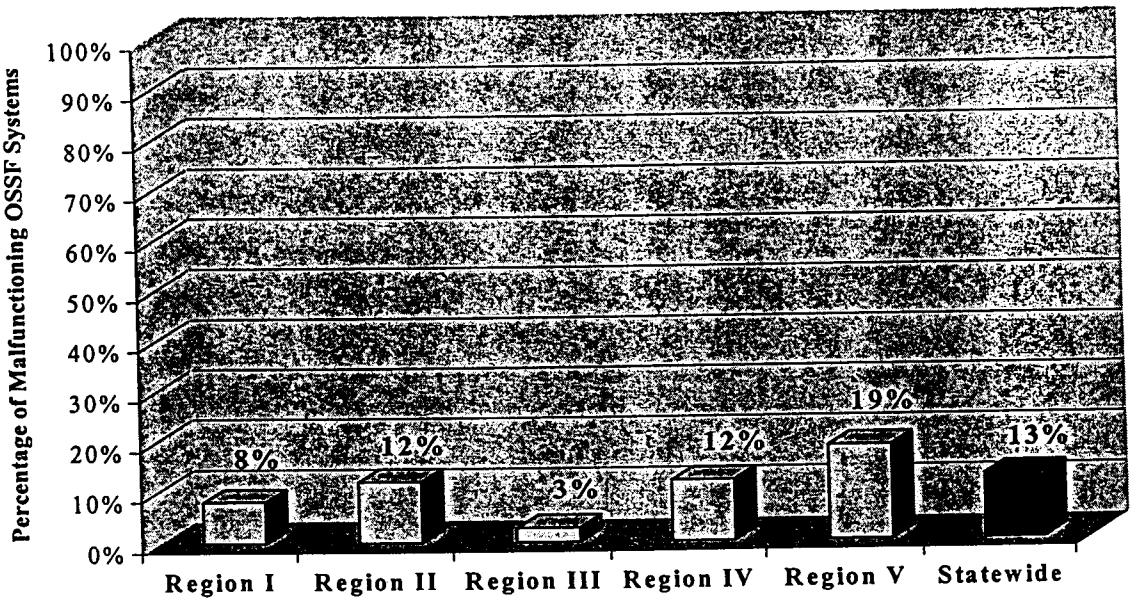
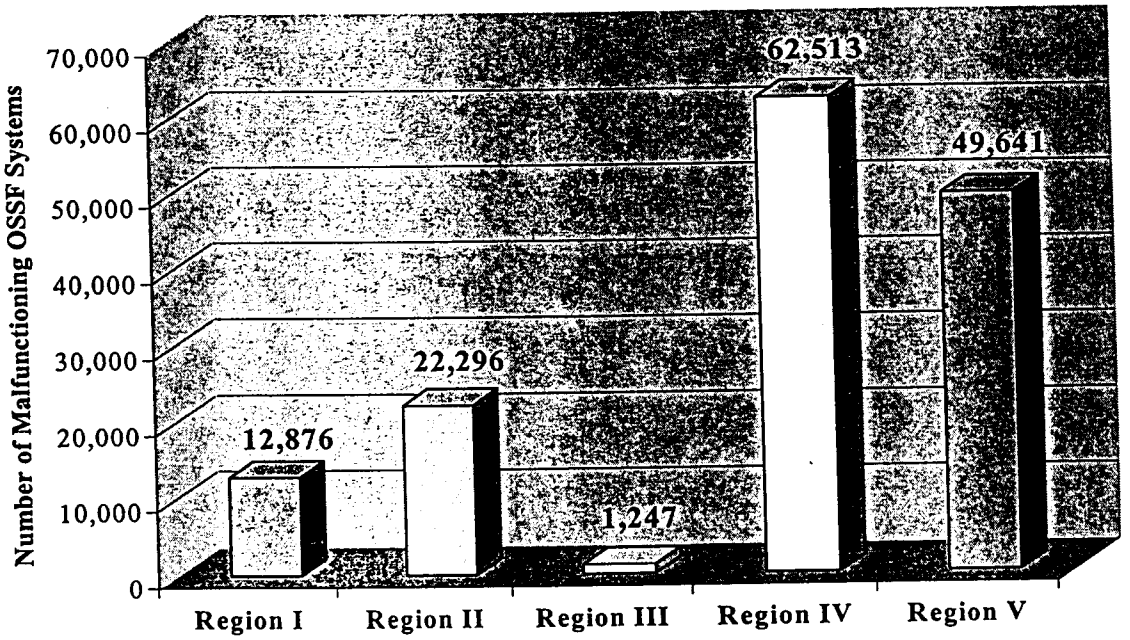


Chart A.1 shows the percentage of OSSF systems that were reported to malfunction chronically in each region of the State. Statewide, approximately 13% of the OSSF

systems in the reporting jurisdictions were reported to be chronically malfunctioning. Although Region V reported the highest rate of malfunction with 19%, Region IV has the larger number of reported chronically malfunctioning systems, with approximately 62,513, as illustrated in Chart A.2. Region III reported the lowest number of malfunctioning systems in the State, with approximately 1,247. However, it is important to consider the low regional response rate for Region III when interpreting this reported number of malfunctioning systems. The total number of chronically malfunctioning systems for all reporting jurisdictions in the State is approximately 148,573.

Chart A.2 Total Number of Chronically Malfunctioning Systems per Region



The actual total number of malfunctioning OSSF systems in Texas is certain to be higher, as the survey's response rate was less than 100%. However, the rate of OSSF malfunction for the entire State is still unknown and cannot be projected based on survey responses. The project team determined that it would not be statistically valid to use the regional rates of chronic OSSF malfunction for the jurisdictions that responded to the survey, and extrapolate those figures to determine the rate of malfunction for all OSSF systems across the State. Although it might be a useful exercise for the purposes of antidotal discussion, it would not necessarily be representative of the opinions and situations in the remaining jurisdictions.

OSSF Systems by Soil Classification (Tables D)

The State of Texas has a high variation of soil textures and soil structures. Soil type is a critical factor when deciding which type of OSSF system to install. Additionally, soil type is a large determinant of how well a system will function over time. The breakdown

of the State into five regions was based on soil and climatic conditions; however, there is still a significant amount of soil variation within each region. In order to determine what soil types are the most common medium for OSSF systems, Designated Representatives were asked to estimate the percentage of OSSF systems that were installed in each soil type.

Region V reported having the highest percentage of OSSF systems installed in soil classes that are unsuitable for conventional septic systems. Approximately 55% of the OSSF systems in Region V are installed in unsuitable soil types, followed closely by Region IV with 53%. Additionally, these two regions reported poor soil conditions as being a significant factor in the malfunction of OSSF systems. Region I and Region III reported the highest percentage of OSSF installations in soil types that are deemed suitable for conventional septic systems. Correspondingly, Region I did not report significant problems with poor soil conditions. Region III did however find poor soil conditions as a moderate contributor to malfunction relative to other factors.

Ranking of Factors in Malfunctioning OSSF Systems (Tables E)

Region I, Region II, and Region III consistently ranked the age of the OSSF systems as having the highest impact on the malfunction of OSSF systems. The age of the OSSF systems was ranked as the second highest factor in Region IV and the third highest factor in Region V. Designated Representatives from all regions consistently reported that pre-regulatory "grandfathered" systems were a significant factor in OSSF malfunction.

The factors of system age and pre-regulatory "grandfathered" systems were considered to be essentially the same issue when analyzing the data. Pre-regulatory systems are by definition older OSSF systems. This issue of older, pre-regulatory systems is the one factor that proved to be an important concern for each region in the State.

Region IV and RegionV reported that soils were the factor that had the highest impact on OSSF malfunction. The ranking for second place was different for all regions. The second place factors include operation and maintenance in Region I, small lot size and population density in Region II, system design in Region III, system age in Region IV, and high water table in Region V.

Contributing Factors to the Malfunction of OSSF Systems (Tables F)

Designated Representatives reported pre-regulatory "grandfathered" systems as the greatest contributor to malfunction. Each region, with the exception of Region V, had a higher percentage of respondents reporting severe contributions to malfunction from grandfathered systems than any other factor. Region V reported that soils were the most severe contributor to malfunction, but grandfathered systems was the second most severe contributor in the region. Consistent with the question regarding the ranking of factors, once again system age and grandfathered systems were reported as the factors that most severely affect the functioning of OSSF systems.

Lack of education for OSSF system owners was another issue that was ranked as either the second or third highest factor that severely contributes to OSSF malfunction in every region except Region III. These results are reinforced by the answers presented in Tables K, which inquire about the adequacy of OSSF owner education. All regions except Region III had a majority of respondents report that education for OSSF owners is not sufficient.

Effects of Soil, Design, Climate, and Operation/Maintenance (Tables G)

Factors that contribute to OSSF malfunction under the broader categories of soil, design, climate, and operation and maintenance produced a high amount of variation in the responses from region to region. Soils were reported as being an issue for each region with the general exception of Region I. Region IV and Region V reported soil problems, specifically tightly-packed clay soils that do not allow for proper leaching, as the most important factor that contributes to malfunction.

System design issues were reported mainly in Region III, Region IV, and Region V. The three regions reported the three same issues as significant contributors to malfunction. These issues include the installation of OSSF systems that are not appropriate for the soil type and/or climate, OSSF systems that are too small for the sewage load from the facility, and lot sizes and/or drainfields that are too small.

Climate may be eliminated as a significant factor in malfunction for Region I, Region II and Region III; however, Region IV and Region V reported the same two climate issues as being problematic. Frequent rainfall that causes ground saturation and increased rainfall and less evaporation during winter months were two issues that are closely related and were both reported as being factors in OSSF malfunction for these two regions.

Operation and maintenance issues also varied from region to region. One common problem for most regions was OSSF systems not being pumped often enough. Region IV and Region V had similar issues with operation and maintenance related to surface irrigation/aerobic systems, such as a lack of maintenance contracts and the improper addition of disinfectant to the OSSF system.

Functionality of Different Types of OSSF Systems (Tables H & I)

The approval rating for standard trenches/beds was consistently high for Region I, Region II and Region III; however, it diminished for Region IV and Region V. Conversely, the approval rating for surface irrigation technology was consistently high for Region IV and Region V; however, it diminished for Region I, Region II and Region III. Additionally, Region IV and Region V reported extremely high approval ratings for aerobic systems, which is a necessary component of surface irrigation.

The poor soil conditions for conventional OSSF systems, the high approval ratings for surface irrigation and aerobic technology, and the high rate of operation and maintenance problems related to these technologies, make it apparent that aerobic/surface irrigation systems are being installed at a much higher rate in Region IV and Region V than in Region I, Region II, or Region III. Sand filters, trickling filters, and constructed wetlands are apparently not well-utilized and/or not functioning well in general across the State, according to survey responses.

1997 Rule Changes (Tables J)

The survey responses regarding the 1997 rule changes were overwhelmingly favorable, with 74% of respondents statewide reporting that they agreed or strongly agreed that the changes resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained. Additionally, in survey questions that provided the option of naming regulations as a significant contributor to OSSF malfunction, none of the regions reported the factor as a significant problem.

Owner Education and Designated Representative Training (Tables K)

Statewide, approximately 73% of Designated Representatives believe that OSSF owners are not receiving adequate education regarding their systems. Region III is the only region where the majority of the Designated Representatives did not report that additional education was an important issue. Conversely, all regions had a majority of Designated Representatives report that they are receiving adequate training from TNRCC regarding the responsibilities and duties of the job. Region V reported the highest rate (41%) of Designated Representatives that would like to see more training made available.

SECTION 4: POLICY ISSUES AND RELATED RECOMMENDATIONS

The purpose of this section is to address policy issues that have impacted the functionality of OSSF systems throughout the State of Texas. Based on research completed for this study, several key factors were identified that have a significant impact on how OSSFs function. The project team has sought to provide insight into areas where policy initiatives would be an effective means of addressing issues pertaining to OSSF malfunction. The project team would like to emphasize, however, that this discussion is based on the results of this study and is not intended to be a comprehensive discussion of all problems related to OSSFs in the State of Texas.

The development of these policy issues was based primarily on research initiatives undertaken as a part of this study. Through the process of performing a thorough literature review, interviewing Designated Representatives and other OSSF professionals, and analyzing and interpreting the survey results, the project team has compiled a set of policy issues and recommendations for the Council's consideration.

For each policy issue discussed in this section, the project team has developed a related recommendation. These issue-specific recommendations are the foundation for the project recommendations that are presented in Section 5.

Issue 1: Malfunctioning OSSFs are a Significant Problem

The survey results from the reporting jurisdictions reported approximately 148,573 chronically malfunctioning OSSFs in Texas, which represents about 13% of all systems. Because the survey did not have a response rate of 100%, the actual number of chronically malfunctioning systems in the State is likely to be much higher. Problems with malfunctioning OSSFs are particularly troubling in the central and eastern portions of the State, as there are approximately 112,154 reported malfunctioning OSSFs in Region IV and Region V. These malfunctioning OSSFs have the potential to become a significant threat to public health and the environment. Increases in the number of malfunctioning OSSF systems will occur since approximately 50,000 new systems are installed each year and there are chronic problems with many of the existing OSSFs in the State.

Recommendation: Due to the number of malfunctioning OSSFs in the State, there is a need for officials at the state and local levels of government, as well as individuals and organizations, to recognize and address the problems related to OSSF system malfunctions. Until officials and citizens are willing to prioritize this issue as a significant health and environmental problem in Texas, there is a likelihood that these malfunctions will continue to occur. Addressing these problems may require substantial financial and personnel resources and a political willingness to make difficult decisions regarding issues such as the replacement of malfunctioning OSSF systems and taking enforcement action against owners of failing systems.

Issue 2: OSSF Systems Installed in Improper Soil Classes

OSSF malfunctions related to soil conditions are a significant problem for many systems in the State. Soil related problems are typically the result of the wrong type of system being installed in the wrong soil class. For the most part, TNRCC rules have evolved since 1989 to significantly reduce the number of cases in which OSSF systems can be legally installed in problematic soil types. In addition, new technologies have been researched to develop OSSF systems that are appropriate for various soil conditions.

However, soils are still a significant reason for OSSF system malfunction in several areas of the State, especially in Region IV and Region V. This may be due to the fact that many of the OSSF systems across the State were installed prior to TNRCC regulations and are not in compliance with today's standards. In other words, there are still many existing older systems that have been installed in soils where they are prone to malfunction.

Recommendation: In many of these cases, the most effective approach to reducing the rate of malfunction requires the replacement of the OSSF systems. Soil-related problems are an example of the types of problems encountered with older or "grandfathered systems." This issue of replacing older OSSF systems is further addressed in the next section, "System Age and "Grandfathered" Systems."

Issue 3: Malfunctions Related to System Age and "Grandfathered" Systems

OSSF system age was consistently reported as a significant concern for each region of the State. Phone interviews and survey commentary provided by the Designated Representatives confirmed that this is a very significant factor in OSSF system malfunction. The OSSF system malfunctions attributed to the system age are not necessarily related to one specific factor, but rather an array of possible contributors that affect the functionality of OSSF systems.

Many of the problems presented in the survey analysis and phone interviews that were related to system age hinged on the fact that these systems were installed before regulations were developed and implemented. This has resulted in many OSSF system installations that do not comply with today's standards. Problems with pre-regulatory OSSF systems typically include the following factors:

- The soil class is not appropriate for the OSSF system type
- The OSSF systems are too small for the sewage load or strength
- The OSSF systems are installed with insufficient drainfields
- Climate, due to issues such as frequent rainfall causing ground saturation, contributes to the malfunction of pre-regulatory "grandfathered" systems

- Wear and tear that is inevitable after years of use has affected the performance of OSSF systems

Problems associated with older OSSF systems are challenging and would often best be remedied by complete system replacement. The preferred solution for many communities is replacement with centralized wastewater disposal connections. However, financial constraints, due to the need for infrastructure and the typically isolated locations of households with OSSF systems, often limit this option. Another option is to replace existing OSSF systems with ones that would function properly. Once again, this option is often infeasible for many households due to the cost of repairing or replacing an OSSF system.

Recommendation: Communities or subdivisions that have chronically malfunctioning OSSF systems must be a high priority for OSSF remediation. If the age of the system and/or problems associated with age are the main reasons for the malfunctions, then the likely solution is OSSF replacement.

The first step must be to prioritize the areas in most need of OSSF replacement. A helpful tool in the prioritizing process would be a comprehensive listing of voluntary and regulatory programs that can determine the degree to which OSSF systems would need to be replaced in a community. These programs can help local communities evaluate the significance of the problem of malfunctioning systems in their area. Examples of these programs include the following:

Source Water Protection (SWP) Program: SWP is a voluntary, pollution prevention program. It was created by the 1996 Safe Drinking Water Act Amendments and is an expansion of the Wellhead Protection program. Public water supply systems that participate in the program receive information that can prevent drinking water contamination. All public water supply systems are eligible to participate in the program. The TNRCC provides free technical assistance and public education to local communities wanting to develop and implement a source water protection program.

The inventory of all potential sources of contamination inside a source water protection area provides a participating community with the information it needs to protect its public water supply. The results of this inventory form the foundation of the Source Water Protection report and determine which best management practices should be implemented by the participant. To the degree necessary, these best management practices can address problems with malfunctioning OSSF systems.

Total Maximum Daily Loads (TMDL): Local communities should also be aware of an existing program to improve water quality conditions in the State's most impaired or polluted water bodies. This process, known as Total Maximum Daily Load (TMDL), is being implemented by the TNRCC, as required by the federal government through the Clean Water Act. A TMDL is:

- The maximum amount of a pollutant that a lake, river, stream, or estuary can receive without seriously harming its beneficial uses (swimming, drinking, aquatic life, other).

- A detailed water quality assessment that provides the scientific foundation for a watershed action plan. A watershed action plan outlines the steps necessary to reduce pollutant loads in a certain body of water to restore and maintain human uses or aquatic life.

There are several watersheds in the State of Texas that will need to undergo a TMDL where there are high pollutant levels that could potentially contribute to problems with malfunctioning OSSF systems. In these communities, depending on the results from a TMDL assessment, there could be a need to replace malfunctioning OSSF systems.

This resource information could also reference resources that identify state and federally funded programs that provide financial assistance to communities in need of OSSF system remediation or replacement. One such reference is a project funded by the Council, which was completed by the Texas Water Resources Institute to detail various funding sources for organizations as well as individuals seeking assistance. The title of this document is "Resources to Replace On-Site Wastewater Treatment Systems in Texas."

Issue 4: System Operation and Maintenance

The most important operation and maintenance problems reported by the survey results were specifically related to aerobic systems. This is especially true for OSSF systems installed in Region IV and Region V. These two regions reported very high rates of failure to renew maintenance contracts and failure to correctly add the required disinfectants to the OSSF system. Both of these issues involve aerobic/surface irrigation systems. As long as these systems are used in the State, there will be a need to ensure that they are operating effectively and being properly maintained.

Installers of new OSSF systems are required to provide information to the homeowners regarding the proper operation and maintenance of the systems according to §285.39 of the OSSF Rules. This is an especially important issue for homeowners who install aerobic systems due to the more stringent maintenance requirements. Maintenance for aerobic/surface irrigation systems is more complicated than for conventional systems because of the required disinfectants and the complexity of the parts that may break over time, such as pumps and spray nozzles.

In order to ensure that homeowners correctly maintain their aerobic systems, they are required to show proof of a maintenance contract before the newly installed system is approved for use according to §285.7(c)(2) of the OSSF Rules. Additionally, to ensure continued compliance, homeowners are required to continuously maintain a signed

contract with a maintenance company according to §285.7(c)(2)(B) of the OSSF Rules. However, the question remains of how to implement an administrative program that ensures the guidelines set forth in the OSSF Rules are executed.

Based on discussions with several Designated Representatives, it appears that there are several areas of jurisdiction where the authorized agent is not effectively ensuring that maintenance contracts are being renewed. Some Designated Representatives commented that reasons for this problem include: not having adequate personnel and financial resources to implement an oversight program; a lack of political will to support implementing a program; and not knowing how to properly develop and implement a program.

Additionally, it was reported from several jurisdictions that the TNRCC is not always supportive of the authorized agent in dealing with the complexities of enforcement in general. Some Designated Representatives perceive that the TNRCC has expectations of the authorized agent that are inconsistent with the less stringent expectations placed on TNRCC Designated Representative staff. It is therefore the perception of some Designated Representatives that the TNRCC is not sensitive or responsive to the challenges most jurisdictions face in enforcing the rules.

Recommendation: There is a need for many Designated Representatives to develop and implement an effective program to ensure that required maintenance and operation activities are being completed. There are several jurisdictions that have effective programs in place. These programs could serve as case studies for others. By obtaining information about successful efforts to operate such a program, other Designated Representatives will gain valuable insight.

This information could involve identifying several key steps Designated Representatives can take to develop and operate an effective oversight program to ensure that all maintenance requirements are followed. These programs need to include direct oversight of OSSF system maintenance requirements, as well as educational and enforcement components. Designated Representatives need a system that allows them to track and ensure that maintenance contracts are renewed. There is a need to educate property owners on how to operate and maintain their OSSF systems. In cases where property owners fail to follow required operations and maintenance requirements, there may be a need for enforcement action. Both education and enforcement issues are addressed later in this section. However, the issue is worthy of more specific discussion due to the prevalence of the problem, according to survey results.

This information could also discuss jurisdictions that have developed effective programs to ensure that proper maintenance requirements are completed. These communities could serve as models on how to implement a successful program. For example, a telephone interview with the Designated Representative of one county revealed some of the challenges that face those individuals who are responsible for consistently enforcing the OSSF Rules related to maintenance contracts. In this county, staff believe that

maintenance contracts are a necessity due to the relative complexity of maintaining an aerobic system, as well as the health hazards that result from a malfunctioning system. They have developed an effective system for following up on maintenance issues before they become health hazards.

This county maintains a comprehensive database that has tracked all OSSF system installations since 1975, and this database can query all homeowners with aerobic installations that have an expired maintenance contract. Once the Designated Representative is made aware of a system that has an expired contract, a letter is sent to the homeowner as a reminder. The letter notifies the homeowner that the installed system requires a maintenance contract to be in place at all times and provides notification of a 30-day grace period for compliance. While the letter seems to be an effective reminder, some homeowners are either unwilling or unable to comply with the rules. It has been the county's preference to work with homeowners at this point to resolve the problem rather than pursue legal action. However, within the past year the county has become more committed to taking cases to court if necessary to ensure compliance with the Rules.

Pursuing legal action against homeowners presents another set of challenges for the county. The time, paperwork, and expense of pursuing litigation against a homeowner can result in a considerable strain on the county's staffing and financial resources. This is a significant disincentive for some counties, which often have very limited budgets and resources to allocate to many different funding priorities.

Issue 5: Need for Public Education of OSSF Owners

The majority of Designated Representatives indicated a strong dissatisfaction with the information and education presented to OSSF owners regarding their OSSF systems. A lack of adequate information and education about the basics of owning an OSSF system can result in higher rates of malfunction due to poor operation and maintenance practices. Lack of homeowner education regarding OSSF systems is a problem that affects households with older systems as well as properties with new installations. For existing homes, there is a need to ensure that homeowners know they have an OSSF system and are aware of the related responsibilities. In the case of newer homes or ones that are being built, there is a need for property owners to know what type of system can be installed and what the associated responsibilities are. Educational efforts may yield better results in the case of newly constructed homes and/or homes with newly installed OSSF systems since there is an opportunity to ensure for their effective operation and maintenance from the beginning.

There is an on-going need for property owners with OSSF systems to obtain information about their system. For instance, it is common for rural and/or older homes that were once used as weekend/vacation homes to become permanent residences. It is also common in certain communities for houses to shelter more people than the OSSF system was initially designed to accommodate. In these instances, the OSSF systems may be

inadequate to effectively treat the load from the residence. Homeowners in these cases would need to be educated about the necessary steps for rectifying the problem. Furthermore, it is unlikely that a Designated Representative would be aware of the situation and would thereby be unable to assist the homeowners in addressing the issues.

A similar scenario may result when a second-generation property owner, or the purchaser of an older home, is not familiar with the maintenance requirements of an OSSF system. This can be especially common when urban dwellers that may have never had to think about OSSF functions, move into suburban or rural communities that rely on OSSF systems for wastewater treatment. These new homeowners often have no opportunity to become educated on the operation and maintenance requirements for OSSF systems. Additionally, properties may be bought and sold and the new owner may be unaware of the necessity for a maintenance contract on aerobic systems, despite the OSSF Rules that state a continuous contract is mandatory.

Recommendation: Several Designated Representatives in the State have, on their own, developed successful public education programs for owners of OSSF systems. In these areas, Designated Representatives encourage property owners to properly operate their OSSF systems within State requirements. Methods used to educate property owners include direct mailings to property owners and site visits as opportunities to discuss voluntary compliance issues. However, many Designated Representatives in the State either lack the resources or are not aware of what steps could be taken to develop an effective education program in their area. By having easy access to information on how to design an effective program, Designated Representatives would have a greater opportunity to develop and implement successful public education programs in their own jurisdictions.

Issue 6: Lack of Enforcement

An issue that was not specifically addressed in the survey questionnaire, but was commonly mentioned through phone interviews and discussions with OSSF professionals, was the problem of enforcing OSSF system owner compliance with the OSSF Rules. This is a critical issue because without an effective enforcement plan, problems related to OSSF malfunction might go unresolved and thereby result in a lack of incentive to address these problems.

Section 366.032 of the Health and Safety Code requires Designated Representatives to take several steps related to enforcement when applying to the TNRCC to serve as an authorized agent. For example, in its resolution requesting designation, a local government must meet the TNRCC's minimum requirements for on-site sewage disposal systems and include a written enforcement plan.

In addition, the TNRCC's OSSF Rules are comprehensive and specific on topics including local administration of the program, planning and installing an OSSF system, registration and certification, and OSSF enforcement. It is also important to note that

based on survey responses, 74% of respondents statewide reported that they agreed or strongly agreed that "the 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained."

However, the actual enforcement of the rules is a difficult issue that has many factors to consider. First and foremost, in order for any OSSF problem to be rectified, it must be reported. It is understandable that malfunctioning OSSF systems may go unreported because of the potential repercussions. For example, the first person to become aware of a malfunctioning OSSF system is usually the property owner, and the second would likely be a neighbor. This may be a dilemma because reporting a neighbor's malfunctioning OSSF system may cause tension and resentment between the two parties. Additionally, several Designated Representatives reported that the majority of complaints are received when neighbors are feuding. Therefore, the challenge of detecting and reporting OSSF system malfunctions is an issue to be explored.

There may also be other cases where a Designated Representative is simply unaware of how many existing OSSF systems are in his/her jurisdiction. These situations have occurred due to the following types of reasons:

- Historical records of OSSF systems may not have been maintained or are not in an easy to use format for the Designated Representative to access
- A Designated Representative has only been on the job for a short period of time and is unaware of previously installed systems

Even in cases where malfunctioning systems are reported, there are other dynamics that may prevent enforcement actions. When local officials and/or Designated Representatives are presented with the opportunity to take enforcement actions against a property owner for an OSSF violation, there may be many potentially discouraging factors to consider, such as political dynamics and financial/time constraints.

For instance, in many cases the ultimate authority for OSSF violations is The County Justice of the Peace Court, which is an elected office. Assessing fines or other administrative penalties upon the voting members of the public could jeopardize the political life of the elected official. This might be especially true if the jurisdiction has many malfunctioning OSSF systems to address. Other factors that may discourage enforcing the rules could be financial/time constraints. Designated Representatives often "wear many hats" and the duties related to OSSF systems may be just one of several job responsibilities. These authorized agents may not have the financial flexibility to hire the necessary staff to address OSSF issues thoroughly. Additionally, if a Designated Representative has many and various job duties, then it may not be possible to devote the necessary time and attention to OSSF functions.

Recommendation: There is a significant need to encourage Designated Representatives in the State to develop and implement an effective enforcement program. This can be

done through the development of a "model enforcement program." This could save the authorized agent's time and resources while providing them with a useful and effective tool that benefits both the jurisdiction and the State as a whole.

This information could discuss programs that have effectively utilized their enforcement capabilities. For example, one jurisdiction has implemented an enforcement system that has successfully addressed problems of non-compliance. The county has developed a specific set of procedures that are followed and supported by the county commissioners and the community at large.

The process begins with the filing of a complaint regarding a malfunctioning OSSF system. This complaint is logged and assigned a number to make the follow-up procedures easier to track. Once a complaint has been filed, an inspector is sent to the reported site to determine the validity of the complaint and assess the nature of the problem. If the OSSF system is determined to be malfunctioning, the homeowner is notified that actions to correct the problem must be completed within 30 days. When the homeowner reports back to the inspector that the problem has been resolved, the inspector returns to the site for a final inspection.

If the site has not been properly remediated, or the homeowner has disregarded the 30-day notice to comply, the case is then turned over to the County Attorney's Office. The County Attorney then notifies the homeowner that the case has been brought to his/her attention and the homeowner is given an additional 10 days to remediate the malfunctioning system before court action is taken. If the homeowner does not resolve the problem of the malfunctioning OSSF system to the satisfaction of the inspector, or chooses to ignore the 10-day grace period, then the case is placed on the docket and scheduled for a court hearing.

The Designated Representative for this county reported that the possibility of facing the court often provides the homeowner with sufficient incentive to address the problem, and the cases are usually resolved before reaching the court hearing date. However, for the cases that are not resolved and are brought before the District Judge, the consequences assessed upon the homeowner include an injunction to turn off water to the home, and/or a fine of up to $200 per day.

These enforcement procedures have proven to be effective in addressing the problem of malfunctioning OSSF systems in the county. However, one critical factor in the success of this program is reported to be the support and activism of the community at large. The residents of the county are concerned about the water quality in and around one of their prized resources, a lake. The community has determined that the quality and safety of the waters in their county are a high priority, and they have made their concerns known to their elected officials. This translates into a receptive and committed Commissioner's Court that is willing to follow through with enforcement measures when necessary.

What makes the system implemented in this county worthy of recognition is not only the clear and concise set of procedures that are followed to address system malfunction, but that it has engendered the support of the community and elected officials. This is a critical factor in the success of any enforcement program.

Issue 7: Need for Records Regarding Existing OSSF Systems

In order for a Designated Representative to fulfill the responsibilities of the job, it is important to have a complete understanding of the number and location of the OSSF systems within his/her jurisdiction. It would be difficult to anticipate areas at risk for OSSF malfunctions, monitor maintenance practices, and ensure that the systems are operating properly if the Designated Representative does not know which households have OSSF systems and which do not. This basic information would also allow the Designated Representative to adequately monitor trends in OSSF malfunctions and complaints within certain communities, as well as trends in the effectiveness of different types of OSSF system technologies.

It might be taken for granted that this information is readily available given the importance of the issues surrounding OSSF malfunction, but this is not the case. Based on the survey responses, many Designated Representatives do not have a very complete understanding of the number of OSSF systems in their jurisdiction.

The 1990 Census did compile information on the number of septic tanks in each county. In fact, the Census figures were the data set used to determine the number of systems in each jurisdiction for the purposes of this survey. However, it became apparent through the course of phone interviews with many of the Designated Representatives that they were not aware of the 1990 Census figures, and several inquired about where to locate this sort of statistical information. Although the Census figures from 1990 are an important resource and probably the most accurate data available on the subject, they are not necessarily the true number of systems in the State. Addition, the Census data only provides information in an aggregate format, which would not assist in identifying which properties have OSSF systems.

Historical data relating to OSSF systems is non-existent in many areas because OSSF installations were not regulated, and therefore not tracked in many areas, until 1989. Another factor that makes it difficult to track the number of OSSF systems is the 10-acre exclusion clause, which allows OSSF installations on property of 10 acres or larger to occur without a permit, and therefore they are not tracked. Ideally, all OSSF installations, alterations, repairs, and extensions since 1989 would have been tracked and accounted for in a database in each jurisdiction.

However, there are many potential reasons why this has not occurred. Counties or cities can apply to be an Authorized Agent, creating a new jurisdiction out of an existing jurisdiction. This transition of authority can result in a loss or non-transfer of OSSF records to the new authorized agent. Staff turnover may be high in some areas, resulting

in a lack of historical knowledge about the jurisdiction. Additionally, not all Designated Representatives have equal access to computer databases, which may result in inconsistent and difficult to track record keeping. It is therefore easy to understand how such data may not have been diligently recorded or maintained throughout the years.

Recommendation: In order for a Designated Representative to properly complete his/her responsibilities, it is critical that he/she knows how many systems there are and where they are located. While some Designated Representatives have computer databases for OSSF tracking purposes, this is a relatively new technology and it is likely that many jurisdictions have not made the conversion from paperwork to computer. There is a need for many areas of jurisdiction to obtain information about how they can identify all of the OSSFs in their area and then develop and operate a database to track needed information. Through the use of databases, Designated Representatives can have a useful tool that they can use to track issues like maintenance contract renewals, schedules for inspections and general public education messages. With a well-used database system, Designated Representatives can often effectively leverage their resources.

Issue 8: Need for Further Regional Research

To a significant degree, the project team has met the project objectives of determining the magnitude and reasons for malfunctioning OSSF systems in the State based on the survey response rate and analyses of survey results. However, due to a relatively low response rate of 44% in Region III, the project team could not determine reasons for malfunction in this region of the State with the same certainty as can be done for the other regions.

Recommendation: Based on the health and environmental problems that frequently occur in this region of the State, the project team believes that there is a need to further research the magnitude of, and reasons for, chronically malfunctioning OSSF systems in Region III. This research could be conducted through a combination of case studies, interviews and/or surveys. This additional research could identify issues specific to this region that would further satisfy the Council's objectives. In addition, research findings from this region could serve as a basis to pursue financial assistance from State and Federal programs specifically designed to assist environmental infrastructure needs along the Texas-Mexico border region.

SECTION 5: RECOMMENDATIONS FOR FUTURE COUNCIL RESEARCH PROJECTS

In this section, the project team has developed a set of recommendations based on the policy issues discussed in Section 4. The purpose of these recommendations is to highlight actions that the Texas On-Site Wastewater Treatment Research Council (Council) could take as a result of the findings of this study. These recommendations have also been developed to help identify and prioritize potential future Council research projects based on the major reasons for malfunctioning OSSFs. The project team would like to emphasize that this recommendation discussion was formulated from the results of this study, and is not intended to be a comprehensive set of solutions for all problems related to OSSFs in the State of Texas.

Recommendation 1: Inform State and Local Officials about OSSF Problems

Prior to this study, information documenting the extent of malfunctioning OSSFs in Texas did not exist on a comprehensive basis. Through the results of the survey analysis, there is now a better understanding of the number of chronically malfunctioning OSSFs in Texas. The total number of chronically malfunctioning systems in all reporting jurisdictions in the State is approximately 148,573. Because the survey response rate was not 100% and therefore the rate of chronically malfunctioning systems in non-responsive jurisdictions is not included in this figure, the actual total number of chronically malfunctioning systems in the State is certain to be much higher. Based on these results, it is apparent that there is a significant statewide problem of chronically malfunctioning OSSF systems. In order to develop solutions to this important issue, there is a need for the Council to inform state and local officials about the magnitude of the problems associated with OSSF malfunction.

The results of this research project can serve as a reference resource for the dissemination of information regarding the magnitude of, and reasons for OSSF malfunction in Texas. By providing information about these issues to state and local officials, there is a greater likelihood that they will have an interest in allocating sufficient resources to address problems related to malfunctioning OSSFs in Texas.

Recommendation 2: Use this Study to Help Prioritize Future Council Projects

Through the completion of this study, the Council now has regional and statewide information that details the extent of malfunctioning OSSFs and the primary reasons for these malfunctions. The results of this project also provide insight into areas needing further research, as well as the severity of issues facing the various regions of the State. The Council could use the information provided by this study as a guide to decision-

making and prioritizing future research projects. For example, the Council could prioritize the need for future research projects based on key findings for malfunction that are discussed for each region of the State in Section 2 and for the State as a whole in Section 3.

Recommendation 3: Develop a Comprehensive Resource Guide

Based on the key findings included in the policy issue discussions of Section 4, there is a need for multiple technical assistance resources or guidance manuals to be developed to help Designated Representatives in their responsibilities. Critical topics could be researched and compiled in a comprehensive resource guide that would be developed as a Council research project.

The resource guide could be provided to Designated Representatives throughout the State, and could also be made available on the Council's web site. The resource guide should be developed in such a manner that the Designated Representatives can use individual sections independent of information from other sections. The resource guide should also include specific recommendations on the steps that should be taken by Designated Representatives to implement successful measures that address each topic. In addition, recommendations should be based on case studies of other Texas communities that have effectively developed and implemented programs to solve the problem.

Based on the findings included in Section 4, the topics to be included in the resource guide would include the following:

- How to Replace Older, Malfunctioning OSSF Systems: In this section, the guide should discuss steps that communities could take to assess whether there is a need to replace large numbers of OSSF systems in their area. For cases where there is a real need to replace OSSF systems, the guide should include potential resources and programs that could assist in these efforts. In addition, the section should highlight case studies where communities have successfully recognized, evaluated and replaced failing systems.

- How to Include Elected Officials in the Process: An effective program must have the support of local politicians and senior level management within a city and/or county. This section should discuss steps that Designated Representatives can take to gain the support of these officials, which can affect program funding, personnel and political support. For example, one technique could be to explain the potential health and safety threats that are created by malfunctioning OSSFs. This example could be enhanced by organizing field visits for elected officials to show cases where OSSFs are discharging untreated waste into a water body.

- How to Develop and Manage an Effective Operation and Maintenance Oversight Program: This section should help Designated Representatives develop and implement a program that would allow them to monitor compliance with

maintenance requirements for OSSF systems. This section would be especially helpful for Designated Representatives with a significant number of aerobic systems in their area of jurisdiction. This information could also include case studies of communities that effectively track maintenance records to ensure continued compliance with State regulations regarding OSSF maintenance.

- How to Develop and Implement an Effective Public Education Program: Public education can be a critical part of efforts to ensure that OSSF systems function properly. In this section, information should be provided on how Designated Representatives can develop an effective public education program. This section should also highlight successful programs put into place by other communities. For instance, the section could include examples of effective educational materials, such as brochures and informational posters, as well as discussions of how to encourage community support through organizations such as neighborhood associations.

- How to Establish and Operate an Effective Enforcement Program: An effective enforcement program is a vital part of efforts to ensure that OSSF systems are properly functioning. This section should provide direction on how to develop an enforcement program that would help ensure OSSF systems are operated in compliance with applicable laws. This section should also address the roles and responsibilities of law enforcement personnel, prosecutors, judges and the TNRCC from an enforcement perspective.

- How to Develop, Maintain and Use an Information Tracking System: In order to ensure that OSSF systems are functioning properly, Designated Representatives need to know the number and location of OSSF systems in their jurisdiction. This section should provide direction on steps Designated Representatives can take to determine the number and location of existing properties with OSSF systems, as well as how to receive information about newly-developed properties with OSSF systems. This section would be especially helpful for Designated Representatives in areas where there is a need for a maintenance oversight program.

Recommendation 4: Conduct Further Regional Research

In order to understand the magnitude and reasons for malfunctioning OSSF systems in Region III, which includes the area of South Texas know as the Lower Rio Grande Valley, the project team recommends that the Council fund additional research in this area of the State. This research is needed because the survey response rate for this region was significantly lower than the response rates for the other four regions of the State. This research would ideally build from the work completed during this study.

This future research could be conducted through a combination of case studies, interviews and/or surveys. This additional research could be especially helpful in determining potential infrastructure or other resource needs in this area of the State.

Information gathered through the additional research would be valuable and useful for Region III since there are several state and federal programs that can provide financial assistance only for water and wastewater infrastructure problems in the border region.

Appendix A

TEXAS ON-SITE WASTEWATER TREATMENT RESEARCH COUNCIL

Improving On-Site Wastewater Treatment and Reducing Costs
By Enhancing Technology Transfer and Facilitating Research

SURVEY TO DETERMINE THE STATE OF ON-SITE SEWAGE FACILITY (OSSF) SYSTEMS IN TEXAS

January 29, 2001

Administered by:

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Please return this survey by February 28, 2001

CONFIDENTIAL

INSTRUCTION SHEET

The enclosed survey is being conducted by the Texas On-Site Wastewater Treatment Research Council (Council) and Reed, Stowe & Yanke, LLC (RS&Y). The purpose of this survey is to gain a greater understanding of OSSF system issues facing the regions of Texas and the state as a whole. The survey will be analyzed by region and no jurisdiction specific information will be shared with the Council or the Texas Natural Resource Conservation Commission (TNRCC).

All information you provide in the survey will be confidential. None of the individual survey responses will be reported to the Council or to the TNRCC.

In completing the survey, please take the time to obtain the most accurate information available. When no documentation exists regarding a specific question, please use your best estimation. We recognize that the information you provide is based on your current knowledge and understanding.

When you have completed the survey, please use the enclosed stamped envelope to return it to RS&Y no later than Wednesday, February 28, 2001. If it is more convenient, you may fax the completed survey to the number below. Please do not hesitate to call or e-mail Mr. Scott Pasternak with any questions. Once again, thank you for your participation in this important survey.

Reed, Stowe & Yanke, LLC
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Austin, Tx 78731
Phone: (512) 450-0991
Fax: (512) 450-0515
Email: spasternak@rsyllc.com

Please return this survey by February 28, 2001 **CONFIDENTIAL**

Survey Completed By: _____
Jurisdiction: _____

Please read this statement prior to completing survey.

For the purpose of this survey, a malfunctioning OSSF system will have **one or more** of the following problems:

- Sewage is backing-up anywhere in the system.
- Sewage is surfacing in the yard or flowing into waterways.
- System is not functioning as designed due to structural damage.
- System has to be pumped more than 4 times per year.

Survey Questions

****Note: The survey questions refer to OSSF systems within your area of jurisdiction only.**

1. How long have you been a Designated Representative?

   _____ Less than 1 year _____ 1 year to 3 years _____ More than 3 years

2. Select **all** sources of information you used to provide answers for this survey.

   _____ Personal knowledge _____ Files/paperwork _____ Computer database

3. Estimate the total number of OSSF systems in your jurisdiction? _____

4. a.) Estimate the average number of OSSF systems that malfunction in a typical year. _____

   b.) Estimate the percentage of the total number of OSSFs in your jurisdiction that **continue to malfunction from year to year.** _____%

5. Estimate the percentage by soil category where OSSF systems are most typically installed in your jurisdiction? **(all percentages should total 100%)**

Percentage	Soil Categories
	Soil Class I-a (sandy-texture soils that contain more than 30 % gravel)
	Soil Class I-b (sandy soils that contain 30 % gravel or less)
	Soil Class II (course loamy soils that include sandy loam and loam textures)
	Soil Class III (fine loamy soils that include silt, silt loam, silty clay loam, clay loam, sandy clay loam and sandy clay textures)
	Soil Class IV (fine-textured soils that generally contain more than 40 % clay-sized particles)

6. Rank the impact that the following categories have on the malfunction of OSSF systems in your jurisdiction. (Each number should only be used once: **1=greatest impact; 10=lowest impact)**

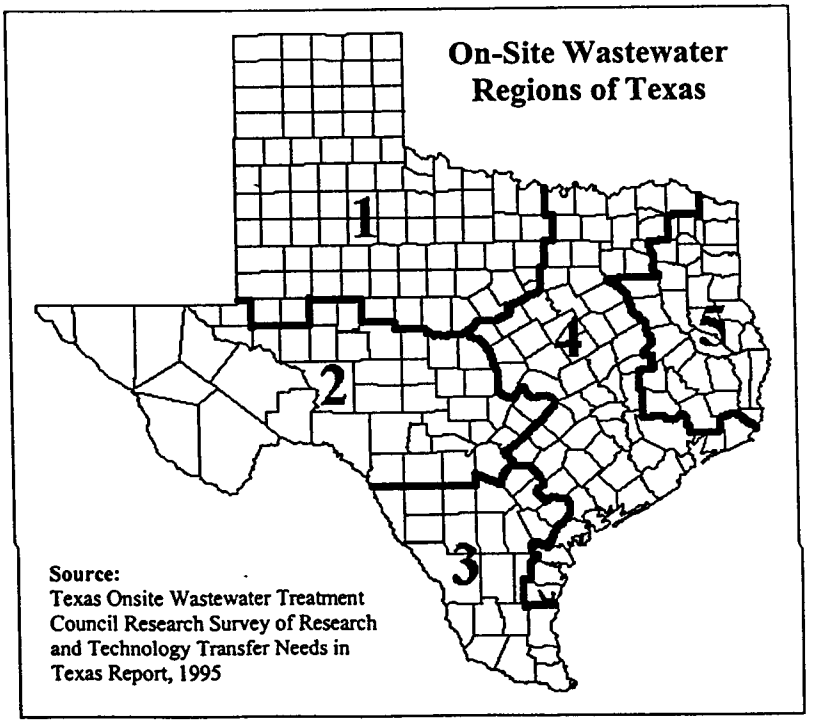
_____ Age of the system
_____ Climate
_____ Design
_____ High water table
_____ Installation/construction
_____ Lack of education/public awareness
_____ Operation and maintenance
_____ Regulations
_____ Small lot size and population density
_____ Soils

7. Indicate to what extent the following categories contribute to the malfunction of OSSF systems in your jurisdiction by placing checkmarks in the appropriate boxes.

Category	Severe	Moderate	Minimal	None
Climate				
High water table				
Improper installation/construction				
Improper operation and maintenance				
Improper system design				
Lack of education for OSSF owners				
Lack of training for designated representatives				
Lack of training for designers				
Lack of training for OSSF installers				
Pre-regulatory "grandfathered" systems				
Small lot size				
Soils				

8. Indicate the location of your jurisdiction by choosing one of the five regions on the map below.

Region 1 _____
Region 2 _____
Region 3 _____
Region 4 _____
Region 5 _____



9. Place a check next to the factors that moderately or severely contribute to the malfunction of OSSF systems in your jurisdiction for each category below. If there are no or minimal problems with an item, leave it blank. If there are no problems with a category, check "No or Minimal Problems".

A. Soil

Tightly-packed clay soils do not allow proper leaching.	____ moderate	____ severe
Rocky soils allow sewage to drain too quickly through the system.	____ moderate	____ severe
Fractured limestone soils allow sewage to flow directly into the ground.	____ moderate	____ severe
Solid rock subsurface makes it difficult to construct an adequate drainfield.	____ moderate	____ severe
Soils are too naturally saturated to absorb effluent. (marshy/high water table).	____ moderate	____ severe
No or minimal problems with soils.	____ **No or Minimal problems**	

B. Design

Improper classification of soil type.	____ moderate	____ severe
OSSF system is not appropriate for the soil type and/or climate.	____ moderate	____ severe
Drainfield is too close to traffic areas, resulting in damage from vehicles.	____ moderate	____ severe
Location of drainfield causes drainage problems due to topography.	____ moderate	____ severe
OSSF system is too small for the sewage load from the facility.	____ moderate	____ severe
OSSF system is too small for the sewage strength from the facility.	____ moderate	____ severe
Water runoff from rooftops, patios and driveways is not properly diverted.	____ moderate	____ severe
The lot size and/or drainfield is too small.	____ moderate	____ severe
No or minimal problems with design.	____ **No or Minimal problems**	

C. Climate

Flooding... Systems are located in a floodplain.	____ moderate	____ severe
Frequent rainfall causes ground saturation.	____ moderate	____ severe
Cold winters cause soils to freeze.	____ moderate	____ severe
Increased rainfall and less evaporation during winter months.	____ moderate	____ severe
No or minimal problems with climate.	____ **No or Minimal problems**	

D. Operation and Maintenance

OSSF systems or parts are worn out or damaged and not replaced.	____ moderate	____ severe
OSSF system is not pumped as often as necessary.	____ moderate	____ severe
Improper disposal of solvents, grease, and other substances into OSSF.	____ moderate	____ severe
Residents fail to renew their maintenance contracts.	____ moderate	____ severe
Required disinfectant is either incorrectly added or not added to OSSF.	____ moderate	____ severe
Roots from trees or shrubs are interfering with drainfield lines.	____ moderate	____ severe
Driving over drainfields with vehicles.	____ moderate	____ severe
Paving over or constructing facilities on drainfield.	____ moderate	____ severe
No or minimal problems with maintenance.	____ **No or Minimal problems**	

Please return this survey by February 28, 2001 **CONFIDENTIAL**

10. List the total number of OSSF systems in your jurisdiction by age:

Category	System Age		
	0 to 5 years	6 to 12 years	Over 12 years
Total Number of OSSF Systems			
Total Number of Malfunctioning Systems			

11. Place checks next to the type(s) of OSSF systems listed below that **function well** in your jurisdiction.

_____ Absorptive Mounds _____ Graveless Pipe _____ Standard Trenches/Beds

_____ Drip Emitters _____ Leaching Chambers _____ Surface Irrigation

_____ Evapotranspiration Beds _____ Low Pressure Dosing _____ Other: _____

12. Place checks next to the OSSF system(s) listed below that **consistently malfunction** in your jurisdiction. **If there are no problems, please leave this question blank.**

_____ Absorptive Mounds _____ Graveless Pipe _____ Standard Trenches/Beds

_____ Drip Emitters _____ Leaching Chambers _____ Surface Irrigation

_____ Evapotranspiration Beds _____ Low Pressure Dosing _____ Other: _____

13. Place checks next to the types of treatment technologies that **function well** in your jurisdiction.

_____ Aerobic systems _____ Constructed wetlands

_____ Sand filters _____ Septic tanks

_____ Trickling filters _____ Other: _____

14. Indicate whether you agree/disagree with the following statement:

"The 1997 rule changes have resulted in a significant positive impact on how OSSF systems are selected, designed, installed and maintained in my area of jurisdiction."

____Strongly Agree ____Agree ____Neutral ____Disagree ____Strongly Disagree

15. In your opinion, do owners of OSSF systems receive sufficient information to have a fundamental understanding of how to properly care for and operate their OSSF system?

_____Yes _____No

16. Do you believe that you are receiving adequate training from the TNRCC regarding the responsibilities and duties of a Designated Representative?

_____Yes _____No

Appendix B

LITERATURE REVIEW

The project team conducted a literature review of OSSF related articles and research projects completed in the State of Texas. The purpose of this review was to document previous findings with regard to the extent and severity of malfunctioning OSSFs within the state. The results of the literature review are divided into three categories. These categories include (1) statewide article and publications, (2) articles and publications for each of the five regions and (3) ongoing research. The literature review also provided insight for research methodologies, which helped the project team develop its survey and methodology.

The project team would like to note that this literature review was not conducted in a traditional manner. Due to a relative lack of existing publications and research, this literature review focused on identifying newsletter articles and studies or reports that have been created by entities such as local, regional and state governments. A summary of the literature review follows.

Statewide Articles and Publications

- *1999 Annual Report Texas Nonpoint Source Pollution Management Program.* Texas Natural Resource Conservation Commission and the Texas State Soil and Water Conservation Board. Austin, Texas. SFR-66/99. October 2000.

This annual report includes an overview of key water resource issues facing the State of Texas. Problems related to OSSFs are among the issues included in the report. The report states that roughly 45 percent of the impaired water bodies in Texas have concentrations of fecal coliform bacteria that exceed contact recreation standards. Sources of these bacteria include failing OSSFs, agricultural operations, urban stormwater runoff, and waterfowl and wildlife population. The report also highlights other studies that address OSSF-related water quality problems. Many of these other reports have been included in this literature review.

- *Committee on Natural Resources, Texas House of Representatives, Interim Report 1996.* A Report to the House of Representatives 75th Legislature. David Counts, Chairman. January 1997.

The House Committee on Natural Resources was given the opportunity in reviewing the goals of the Texas' OSSF treatment program, identifying measures to decentralize state authority, and increase local government participation. Public testimony at the hearings raised concerns about the "recent dramatic increases in the number of on-site sewage facilities throughout the state, problems with administering the program at both the state and local levels, serious public health and environmental concerns resulting form failing

OSSFs, and the financial inability of low-income residents to comply with OSSF rules and regulations."

The report states that one-third of the Texas' population depends on OSSFs and approximately 38,000 applications were submitted in 1995 for new OSSFs. There are problems in the eastern regions of the state with soil saturation due to the low permeability of clay soils. Improper installation and maintenance is also noted as a problem throughout the state. This data led to a review of the current OSSF program structure and proposed rule changes, such as better site evaluation requirements, technical improvements, education and certification requirements, increased program funding, and stricter enforcement procedures.

- *Designated Representative Survey Results*. Texas Natural Resource Conservation Commission. Flood Management and Groundwater Programs Section On-Site Wastewater Team. May 3-17, 1993.

This survey was administered by TNRCC in order to assess the extent of problems with OSSFs across Texas and how the On-Site Wastewater Team could better assist the recipients of the survey. The survey inquired about various possible problems with OSSFs, such as improper installation, lots too small, surfacing sewage, inadequate enforcement, need for education, etc. The most frequent problem reported was lots too small, followed by surfacing sewage and lack of knowledge of installed systems by homeowners.

Inquiries into the percentage of systems not working correctly resulted in a wide range of responses. Areas with an equal number of systems reported a range of one percent to 98 percent of systems malfunctioning. The survey also provided an opportunity for written responses and comments on problems with OSSFs.

- *Summary of Onsite Systems in the United States, 1993*. National Small Flows Clearinghouse. Morgantown, West Virginia.

This publication by the National Small Flows Clearinghouse (NSFC) contains information on each state's on-site system permitting, inspection and maintenance procedures as well as OSSF functioning/repairs and costs. Information was collected by mailout questionnaires, which also included introductory information on the NSFC and a postage paid envelope.

Approximately 50 percent of the health departments contacted in Texas responded to the survey. In 1993, 8,892 new OSSFs were permitted. The majority of these permits were in the counties of El Paso, Harris, Hays, Williamson, and the City of Fort Worth. The total number of failing systems reported was 1,260. Main reasons for the failures include poor soils, owner neglect, age, heavy rainfall, crushed or collapsed systems, water leaks and improper design or installation. The 1990 Census reports that the State of Texas has

over seven million homes, of which 1.27 million have septic tanks and/or cesspools. General comments reported from local health departments include:

- "Saturation of drainfield due to increased sewage load without adding to size of system" is one reason given for OSSF failure.
- Repair/failure records are only kept for substantial modifications (50% or more.)
- The majority of systems replaced were withered old systems that were installed before codes were enforced or old cesspools and boreholes.
- Flooding and sprinkler systems contribute to failure.

- "Texas STEP 'Self Help' Program Used to Remedy Failing Systems Near Eagle Pass, Sunset, Colorado County." *Texas On-Site Insights*. Volume 5. Number 4. January 1997.

Details of efforts by the Texas Small Towns Environmental Program (Texas STEP) to aid border communities in improving their wastewater infrastructure are featured in this newsletter article. This program combines the resources of several state agencies and the sweat equity of local residents to replace failing OSSFs. The project coordinator from the Texas Department of Health describes the conditions in the small town of Pueblo Nuevo in Region 3 that contribute to septic system failure such as tight soils, high groundwater tables, and prohibitively small lot sizes. Additionally, many of the homes in the area use cesspools for wastewater treatment rather than approved OSSFs. Texas STEP facilitated and coordinated the connection of Pueblo Nuevo to centralized wastewater treatment services from the nearby city of Eagle Pass.

The community of Sunset in Montague County in Region 1 has faced similar challenges. Local OSSFs would often overflow with untreated sewage in times of heavy rains. Staff of the USDA Natural Resources Conservation Service describe part of the problem as improperly installed systems that were likely placed too far below ground for proper functioning. Colorado County in Region 4 has problems with old OSSFs collapsing and flooding the ground with effluent. This concerns local residents because many homes rely on water wells that are relatively shallow which increased the possibility of contamination due to failing OSSFs. Texas STEP has helped each of these communities address their problems with failing systems.

Region 1 Articles and Publications

- "Hood County Leaders Investigate Feasibility of Replacing Failing On-Site Systems with a Regional Sewer System". Texas On-Site Insights. Volume 9. Number 1. February 2000.

This newsletter article discusses a feasibility study to determine whether water quality in the Lake Granbury area could be improved by eliminating failing OSSFs through the installation of a regional sewage system. In 1999, over 100 complaints were filed about failing OSSFs. The Brazos River Authority (BRA) estimates that 27% of OSSFs are too small and have inadequate drainfields. Approximately 75% of the OSSFs around the lake have been installed in soils considered "severe" by the USDA's Natural Resource Conservation Service. The BRA and Hood County worked together to identify subdivisions that have the highest potential for growth and therefore may be in need of a regional system. Projections will be calculated for population growth, water use and wastewater flows in order to determine the costs and benefits of a regional system.

- "Texas Panhandle is Site of Many Innovative On-Site Systems." *Texas On-Site Insights.* Volume 6. Number 2. June 1997.

OSSF conditions in the Texas Panhandle and some of the solutions that were implemented to address the community's problems, are discussed in this newsletter article. The Panhandle region has dry, hot summers, a deep groundwater table, and sandy-loamy soils that provide ideal conditions for OSSF systems. This area has ample land that allows for large lot sizes and plenty of drainage. However, certain areas, including parts of the Palo Duro Canyon and other small towns in the region, face some unique septic challenges.

The freezing winters may hinder proper septic functioning due to soil freezes. As a result, some counties now require that leaching chambers be placed at least five feet below ground. Many lakefront homes were built on lots too small to accommodate OSSFs. These systems may drain into sensitive lakes, although no studies have been performed to determine whether these systems are failing and contaminating local waterways. Another problem in the area is high number of "boreholes" in which wastewater is sent down a deep hole in the ground to dissipate without treatment. This has posed a health hazard in the past when fecal bacteria contaminated local drinking water supplies. Local residents have worked to together to resolve some of these issues. Some solutions include the construction of one large septic tank in place of several boreholes, increased use of various leaching chamber technologies, and the use of evapotranspiration ponds in combination with conventional systems.

Region 2 Articles and Publications

- "Southwest Texas State University Survey Examines Experiences of LPD System Users." *Texas On-Site Insights.* Volume 7. Number 1. March 1998.

This newsletter article describes a study that investigated the performance of low-pressure dosed (LPD) OSSFs in Travis County. Suraiya Murray of Southwest Texas State University performed her Master's research project on the necessity of TNRCC's

1997 rules that required more extensive plumbing for LPD systems. Ms. Murray developed a survey instrument and administered it by telephone to 72 county residents.

The study revealed information about LPD system malfunctions in central Texas. Of the households surveyed, 81 percent had wastewater saturating backyard soils and 25 percent had experienced sewage backup into their homes. "In most cases, survey respondents attributed the problem to pump failure." Maintenance and operations were also problematic, illustrated by the 25 percent of respondents who said they had never received any instructions on how to operate their systems. The survey showed that "many users want more information on how to maintain and operate non-engineered LPD systems and would likely use it if it were available."

- "UGRA Monitors Streams to Detect How On-Site Systems May Affect Water Quality in Springs, Seeps, Streams." *Texas On-Site Insights*. Volume 8. Number 3. August 1999.

This newsletter article describes the Upper Guadalupe River Authority's (UGRA) efforts to protect water quality in Kerr County. UGRA has sampled ground and surface water in an attempt to identify OSSFs that may be polluting local waterways. The UGRA maintains a database on the performance of local OSSFs. Problems with OSSFs have occurred in Kerr County in part because of shrink-swell clay soils in some areas and caliche rock covered by shallow soils in others, as well as systems built on property too small for proper OSSF functioning. The UGRA continues to monitor water quality in hopes of identifying problematic areas that should be converted to centralized systems.

- "Unincorporated Areas, Mix of Regulations, Pose Challenges." *Texas On-Site Insights*. Volume 5. Number 1. March 1996.

OSSF challenges that were facing officials in San Angelo and Tom Green County are discussed in this newsletter article. There was confusion as to the appropriate and legal OSSF system to install in new single-family and mobile home communities. As a result of the various and differing regulations in place over the years, neighboring residents were falling under different rules. Other OSSF issues facing the area include the use of undersized tanks, OSSF installation on lots too small, clay and fissured limestone soils, and high water tables.

- "UT Studies if Increasing Number of On-Site Systems May Contaminate Barton Springs." *Texas On-Site Insights*. Volume 6. Number 2. June 1997.

A study entitled, "Current and Potential Impacts of Septic Systems on a Karst Aquifer" is described in this newsletter article. The study was performed by the UT Center for Research in Water Resources in 1996. The goal was to evaluate the potential effects of an increasing number of OSSFs in the Edwards Aquifer recharge zone.

Water quality was monitored at Barton Springs, various water wells, and Barton Creek. Historical data was also used to determine nitrogen levels in the water. Nitrogen can enter the water through OSSF effluent, urban and agricultural runoff, and leaking sewer pipes. At the time of the study there were approximately 5,900 OSSFs in the Barton Springs recharge zone. The study found that of all the contributors of nitrogen to the aquifer waters, on-site systems were the smallest, accounting for approximately 10 percent. It was also found that significantly increasing the number of OSSFs to over 5,000 units would only have a small effect on overall changes in the nitrogen load.

Region 3 Articles and Publications

- "UTPA Efforts Identify Colonia Wastewater, Water, Needs; Help Families Obtain Aid to Connect to Central Systems". Texas On-Site Insights. Volume 8. Number 3. August 1999.

This newsletter article discusses a survey performed by the University of Texas-Pan American (UTPA) to help families in colonias access centralized wastewater systems. Texas has approximately 1,495 colonias and the TWDB estimates that 392,188 people live without adequate water and wastewater systems. Hidalgo County is the highest, with over 34 percent of Texas' colonias. The goal of the survey includes identification of families that would be willing to pay for connections and families that were using Texas Water Development Board (TWDB) financial assistance.

The survey also included questions regarding water and wastewater issues. Of those responding to the survey, results showed that 96 percent of residents are connected to a public water system and that 57 percent have been connected for five years or less. Approximately 30 percent of households rely on septic tanks, cesspools, and/or outhouses, and 46 percent of residents that have centralized wastewater service have been connected for less than one year.

Region 4 Articles and Publications

- "A&M-Commerce Researchers Evaluate Use, Performance, of Recirculating Sand Filters". Texas On-Site Insights. Volume 7. Number 2. September 1998.

A research project that will evaluate the performance of sand filters as a cost-effective alternative to aerobic systems around Commerce, Texas is the topic of this newsletter article. The study is needed because conventional systems are not appropriate for many sites due to heavy clay soils and shallow groundwater tables. Additionally, high levels of fecal coliform have been found in surrounding waters. This has heightened the awareness of the need for improvements in wastewater treatment for the area. Recirculating sand filter OSSFs are one possible alternative to failing conventional systems and the more expensive aerobic systems.

- *City of Bonham: A Public Water Supply Protection Strategy.* Project funded by Texas Natural Resources Conservation Commission and United States Environmental Protection Agency Region VI, Draft, February 2000.

This draft report describes the efforts made by the city, county and state governments to develop a comprehensive strategy for surface water protection through the Source Water Assessment Protection (SWAP) Program. The City of Bonham volunteered to be the pilot city studied for the development of an effective surfacewater protection strategy. The Lake Bonham watershed was the guide for the boundaries of the study. "An important part of this study was to determine the method of sewage disposal for the area nearest the city's Public Water Supply sole source, Lake Bonham, and acquire any septic system inspection information from the county health department."

Information gathered would be used to develop a method for surface water protection, to create a potential source of contamination inventory list, to generate a wellhead protection report, and to provide potential funding sources. The research found a total of 378 OSSFs were located in class IV soils in the study area. These soils are considered unsuitable for conventional OSSFs. The report recommends that "renovation of these systems to an appropriate design for the Lake Bonham soils should decrease the likelihood of contamination due to failing septic systems." Evapo-transpirative drainfields, drip irrigation systems, low pressure dosed drainfield, and surface irrigation systems are recommended as alternatives to the conventional OSSFs commonly used in the region.

- *Characterization of Selected Public Health Issues in Galveston Bay.* Jensen, Paul and Su, Y.C. Espey, Huston & Associates, Inc. Galveston Bay Estuary Program. Webster, Texas. Publication GBNEP-21. August 1992.

The purpose of this project was to characterize public health issues associated with bay use activities such as shellfish consumption and contact and non-contact recreation. A section of the report estimates the volume of partially treated wastewater from failing septic systems. The report states that the Harris County Sanitation Office receives 30 to 45 complaints per month regarding malfunctioning septic tanks. Many of the problems stem from the shrink-swell clay soils, small lot sizes, and heavy amounts of rainfall. Site inspections in unincorporated areas of Harris County identified more than 1,900 cases where septic tanks might be leaking. In Galveston County, the County Health District estimated that there were approximately 4,500 septic tanks in its area. During a one-and-half year period, the district received 70 OSSF related complaints.

- "City of Waco Waives $900 Connection Fee for Households Switching from On-Site Systems to Centralized Sewers." *Texas On-Site Insights.* Volume 8. Number 4. October 1999.

This newsletter article describes the City of Waco's plan to get homeowners to convert from troublesome and failing OSSFs to a centralized wastewater treatment system by waiving the connection fees. The City of Waco has had problems with OSSFs failing and flooding lawns with partially treated wastewater. Having fewer OSSFs to manage should benefit the area by easing the city's inspection and enforcement responsibilities while potentially reducing water quality concerns. Mike Jones of the Water Utilities Division stated that "taking people off on-site systems which have failed or may be likely to malfunction may reduce the risk that nutrients and fecal bacteria could impair water quality in the area."

- *Corpus Christi Bay National Estuary Program: Study of On-Site Sewage Facilities.* Submitted by Naismith Engineering, Inc. to Texas A&M University at Corpus Christi, Texas. March 1998.

This study compiled available OSSF information from the coastal counties of Nueces, San Patricio, Aransas and Refugio for the purpose of determining the specific problems and needs of the area relating to OSSF malfunctions. Key issues for each county were identified such as outdated subdivision ordinances, maintaining compliance with low-income homeowners, local government OSSF staffing constraints, and limited information on health or water quality problems associated with failing septic systems.

The study reports that roughly 20 percent of the OSSF systems in Nueces County are failing due in large part to flooding and/or poor drainage. Other issues include improper operation and infrequent pumping of the tanks. Much of the soil in San Patricio County is unsuitable for OSSFs due to low permeability and high "shrink-swell" potential. Other problems in the county include improperly designed systems and systems located in floodplains. Most residents of Aransas County are served by OSSFs. Many of the problematic systems are located near the coast, potentially contributing to water pollution. Causes of failing systems in this area include small lot sizes, high water tables, and flooding. Refugio County also has large areas of unsuitable soils, high groundwater tables, and areas located in floodplains. Additionally, many of the OSSFs are old and/or improperly installed or designed.

Recommendations include implementing management strategies that revise subdivision ordinances, increasing public information programs and compliance enforcement, and promoting non-conventional systems where appropriate. Various alternatives for the funding of wastewater improvements are presented. Additionally, the study recommends enhancing staffing for enforcement, improving data management systems, promoting regional cooperation for funding opportunities, and improving surface and groundwater monitoring.

- *Demonstration/Evaluation of Constructed Wetlands as an Alternative On-site Waste Water Treatment System.* Tillman, R.E. Lesikar, B.J. Maynard, C. Proceedings Galveston Bay Estuary Program State of the Bay Symposium IV,

January 28-29, 1999. Galveston Bay Estuary Program. Austin, Texas. CTF-09/GBEP T-3. January 1999.

This research paper was presented at the Galveston Bay Estuary "State of the Bay" Symposium in 1999. It discusses the need for adequate on-site wastewater treatment in the Galveston Bay watershed and Brazoria County, which directly effects the in-flow water quality and the ultimate water quality of the estuary. There are more than 90,000 permitted on-site wastewater treatment systems in Brazoria County. The heavy clay soils combined with periodic high ground water levels create an environment for frequent failure of traditional septic systems and for alternative wastewater treatment.

- *Evaluation of Existing Subsurface Drip Irrigation Systems in the Texas Coastal Plains.* Texas A&M University- Kingsville Environmental Engineering Department. Submitted to Texas On-Site Wastewater Treatment Council. Draft- February 2000.

This project evaluated subsurface drip irrigation systems used in OSSFs to determine the effects of swelling clay soils on system failure. Findings include a direct link between a high water table and clay "shrink-swell" and the surfacing of septic water around the system. In addition, the project team found that the size of the unsaturated drainage zone does affect the water quality of percolated effluent from the drip system. Recommendations include diversifying the tests used for soil type, increasing inspection for installation and operation, educating homeowners on proper use, and redefining system failure to include performance measures.

- *Galveston County Health District – Voluntary Inspection and Information Assistance Program to Reduce Bacterial Pollution Caused by Malfunctioning Septic Systems in Dickinson Bayou.* Galveston County Health District. Galveston, Texas. 1998.

This report tests the hypothesis that by providing inspections, information and technical assistance to residents with septic systems, improvements in system performance can be achieved. Reductions in fecal coliform concentrations in the surface waters of the Dickinson Bayou watershed were also predicted.

For this project, individual property owners in the project area were contacted by field investigators and asked to participate in the voluntary inspection of their existing septic systems. Each was also provided educational information on the proper care and maintenance of their septic system as well as information on the consequences of operating a malfunctioning system. Response of property owners was generally favorable even after the investigators found failure rates of 40 percent in the project area.

Although the discovery of malfunctioning septic systems was expected, the failure rate was higher than the district anticipated. Of the 90 systems surveyed, 36 showed some

degree of failure. Three communities were identified as having failing systems. One community of approximately 45 homes was discovered to have failures in 22 septic systems.

Many of the septic systems showing indications of a malfunction are located on property that may be difficult to perform corrective measures on. The restricting factors that make on-site correction difficult include the presence of heavy clay soils, individual drinking water wells, proximity to surface water, small lots, and other factors. There is some hope that a comprehensive solution, such as the construction of a community collection and treatment plant, may end septic system problems in each of the communities.

- "Grinder Pumps, Small Diameter Sewer, Replacing Failing On-Site Systems Near Lake Worth." *Texas On-Site Insights*. Volume 7. Number 2. May 1998.

This newsletter article describes a project designed to protect the water quality of Lake Worth. The EPA and the City of Fort Worth jointly funded a program to replace failing OSSFs with community wastewater systems. Many of the OSSFs in the area did not meet TNRCC regulations, and there were concerns that inadequate drainfields and faulty septic systems were diminishing the water quality of the lake. The project chose to use a low-pressure system that is designed to accommodate up to 146 residences to replace the failing OSSFs. This new system is believed to be more efficient and less expensive than other types of small community systems.

- "Harris County Engineer's Office Evaluates Field Performance of Low-Pressure Dosing Systems". *Texas On-Site Insights*. Volume 9. Number 2. May 2000.

The effectiveness of low-pressure dosing OSSFs in Harris County is discussed in this newsletter article. The Harris County Engineer's Office personnel interviewed OSSF owners about issues such as daily water use, system maintenance, and problems associated with the operations and maintenance of these facilities. County personnel also conducted field evaluations of each system and evaluated a total of 16 systems, looking for signs of failure such as surface effluent, foul odors, algae blooms, and mushy soils. Harris County has conditions that make OSSFs prone to failure, such as seasonal water tables that are less than 2.5 feet deep, flat landscapes making proper drainage difficult, and subsurface clay soils that restrict the flow of effluents. Results of the study found 6 of the 16 to be failing due to improper drainage, insufficient system size, improper maintenance, and/or shallow groundwater.

- *Identification of On-Site Disposal Facilities for the Lower Colorado River Authority*. G&W Engineers, Inc. Port Lavaca, Texas. August 1993.

The Lower Colorado River Authority (LCRA) performed a study of parts of Calhoun, Jackson, Matagorda and Wharton counties to inventory and identify OSSFs in the area

that may be "pollution prone." The information gathered in the study will be used to help identify funding for watershed management programs for areas in need under Section 319 of the Clean Water Act.

Sixteen sites were chosen from Calhoun, Jackson, Wharton, and Matagorda counties. Each site was surveyed for information on OSSFs, such as proximity to ground/surface water, age of system, density of housing, and frequency of use. An evaluation matrix was created, and the information was used to determine whether an area was pollution prone or not. For example, an acre of land with more than 2 or 3 OSSF systems was considered to be pollution prone. The evaluation matrix showed that the River Road subdivision in Matagorda county and Port Alto subdivision in Calhoun county were very pollution prone. The LCRA used this data to identify sites in need of OSSF remediation.

- "Managing and Enforcing On-Site Regulations in Harris County." *Texas On-Site Insights.* Volume 4. Number 2. Spring 1995.

This newsletter article discusses the extent, probable causes, and enforcement issues surrounding OSSF failures in Harris County. John Blount of the Engineering Department of Harris County stated that the county faced several complex challenges due to the high number of OSSFs in the area. Some of these challenges include improperly designed systems, fifty to sixty year old systems that were installed on small lots, high annual rainfall totals, soils unsuitable for conventional septic systems, and areas with seasonally high water tables. The article references a report from the U.S. Department of Agriculture that indicated "more than 85 percent of the soils in the county are unsuitable for conventional septic systems." In 1994, Harris County received approximately 700 complaints about failing OSSFs.

- *On-Site Sewage Target Communities.* Houston Galveston Area Council. Houston, Texas. 1999.

This report consists of information on 26 different communities in the Houston Galveston Area Council (H-GAC) region that need to have their OSSF systems replaced. County Designated Representatives and the TNRCC, Region 12 Office identified these target communities. Each of these communities have "documented on-site wastewater disposal problems attributable to failing conventional septic tank systems." Many of the communities in the Gulf Coast Planning region "are characterized by unsuitable soils, small lots, high ground water tables, and seasonal ground saturation which makes conventional septic tank systems unsuitable as a means of wastewater treatment and disposal." Information regarding each target community, such as lot sizes, housing density, property values, potential funding sources, and soil type, was used to provide an appropriate recommendation for addressing the problem of failing OSSFs in each area.

- "Subdivision Residents Near Dallas Choose Small Diameter Sewer to Remedy On-Site Wastewater Problems." *Texas On-Site Insights.* Volume 4. Number 3. Summer 1995.

This newsletter article discusses issues related to the need for residents of Point Royal Estates, which is an 80-home subdivision near Lake Ray Hubbard, to replace their failing OSSF systems with a regional sewer system. OSSF systems were failing on a regular basis due to soil problems caused by the "extremely tight clays." Residents reported failures such as foul odors, soils saturated with effluent, and possible contamination of Lake Ray Hubbard, even after installing additional field lines and/or pumping their systems as often as twice per year.

In order to address some of these challenges, the county began to use a standardized site evaluation process in 1994 that takes into account topography, groundwater and soil conditions, floodplain, and effluent loading data when designing and installing an OSSF system. The county has also improved enforcement measures. Fines and court action are possible consequences for failure to comply with OSSF regulations. Additionally, in 1991 the county implemented an automated system for permit management, fee collection, and inspections.

- "Septic Tank Effluent Pumps, Small Diameter Sewer, Will Replace Failing Septic Systems at Small Gulf Coast Community." *Texas On-Site Insights.* Volume 8. Number 3. August 1999.

A school district's efforts to remedy their failing OSSFs is the topic of this newsletter article. The community of High Island in Galveston County has addressed problems with their failing and undersized OSSFs and non-compliant treatment facilities by creating a wetland to help with wastewater treatment. The small community has a wastewater system that treats approximately 14 homes. Each OSSF dumps into an open-air ditch that runs through a bird-watching area. The sewage is a health concern and a public nuisance. It also does not comply with TNRCC regulations. The new solution includes individual pumps at each residence that carry the waste through a sewer line into wetland "cells."

Region 5 Articles and Publications

- *Cow Bayou Special Study - Subwatershed 1.02.* Sabine River Authority of Texas. August 31, 1999

The purpose of this water quality research project, which was prepared in coordination with the TNRCC, was to evaluate the Cow Bayou Subwatershed, which is an area of concern due to poor water quality. The results of the study indicate that the present wastewater systems in the Cow Bayou watershed are not adequately preventing water quality degradation in the stream. Probable sources of the problems include natural conditions exacerbated by numerous point sources from permitted discharges, runoff

from septic tanks, and other nonpoint pollution sources. The report adds, "much of the population utilizes on-site systems that have historically functioned poorly if at all."

- "Remediating Failed Septic Tanks Near Lake Livingston is Focus of Sam Houston State University Research." *Texas On-Site Insights*. Volume 5. Number 1. March 1996.

This newsletter article describes the efforts of the Trinity River Authority and Sam Houston State University (SHSU) to remedy the problems of failing OSSFs along the shores of Lake Livingston. Some experts say that as many as half of the systems in this area are malfunctioning. Causes of the failures are believed to be systems installed on lots that are too small, the clogging of drainfields, and heavy rains. In order to address these problems, Terry Hoage, a researcher at SHSU, is working to retrofit existing OSSFs with an aeration unit designed to facilitate bacterial digestion. Results show improved functioning after 14 weeks of monitoring.

- "News from the Longview TX Journal: Money Available for Septic." *Longview Texas Journal*. April 12, 2000. http://twri.tamu.edu/./septictalk/archive/2000-Apr/Apr-12.2.html

Gregg County was able to replace many aging septic systems due to the County's share of a $35 million pollution settlement. This newsletter article discusses the County's intent to use the money to replace OSSFs for those residents that have an income below 80 percent of the median family income. This article illustrates the difficulties facing homeowners in choosing to report their own failing systems for replacement. "If somebody already has a failing system, it's kind of awkward to report themselves." Ken Awtrey, Coordinator of the Resource Conservation and Development agency, stated that this kind of reporting would place the Gregg County Fire Marshall in an unusual position.

- "TRA Investigation Yields Information on Performance of Chlorinators Used with Aerobic Systems." *Texas On-Site Insights*. Volume 8. Number 4. November 1999.

This newsletter article discusses the problem of failing aerobic systems around the Lake Livingston area. Soils in the area are unsuitable for conventional OSSFs and the aerobic systems are the most popular alternative. There are approximately 600 spray irrigation units around the lake and roughly 25 percent of the effluent samples exceeded the fecal coliform criteria established by the TNRCC. The Trinity River Authority states that these failures may involve faulty chlorinators, inappropriate chemical use, or lack of maintenance.

- "TNRCC Uses Environmental Fines to Fund Repairs of Failing On-Site Systems in Southeast Texas." *Texas On-Site Insights*. Volume 6. Number 4. December 1997.

This newsletter article discusses TNRCC's new program that allows violators of environmental rules to pay their fines by contributing up to half of their fine to environmental clean-up projects. A failing OSSF in Orange County was one of the first projects to receive the benefit of the new program. According to the 1990 Census, there are approximately 12,000 OSSFs in the county. The TNRCC Beaumont office estimated that "as many as 8,000 of these may be failing because of the poor soils and high rainfall... and because many of the older homes were built on lots that are too small (often only 50' X 100') to properly treat and dispose of the wastewater."

The article discusses systems that work best in the county, including a septic tank followed by an aerobic treatment and spray irrigation. The costs to install this OSSF for the typical three bedroom house can range from $3,700 to $4,200. Another system that is not yet widely used in the area but that has potential to work well is an OSSF that includes intermittent sand filters and drip irrigation.

- "TNRCC STEP Program Helps East Texas Subdivision Fix Problems with Failing On-Site Wastewater Treatment Systems." *Texas On-Site Insights.* Volume 8. Number 2. June 1999.

The Gresham Oaks subdivision just south of Tyler participated in TNRCC's STEP program to address failing OSSF in their community. This newsletter article discusses the program and how it helps small towns finance wastewater improvements by contributing sweat equity to reduce costs. This area encountered problems, such as the flooding of homes and backyards with wastewater, after rains. This caused reoccurring odor problems and presented a public health concern. Organizers of the STEP program point to heavy rainfall and the clay soils as contributors to the failing systems. The community resolved the problem by connecting the neighborhood to a gravity system operated by a private utility company.

- *Water/Wastewater Engineering Appraisal Report.* US Department of the Interior, Bureau of Reclamation. September 1995.

This appraisal report provides options for water supply and wastewater treatment for the Caddo Lake region of Harrison County. Caddo Lake is an important natural resource both aesthetically and environmentally. The Bureau of Reclamation in conjunction with state agencies produced a study that focus on the water supply and water quality of the lake. The report was intended to identify specific water supply and wastewater service options for the local communities.

The study inventories the number of OSSFs in the lake's watershed and studies the soil of the area to assess its ability to accommodate conventional OSSFs. It is noted in the report that many homes in the region have OSSFs located in seasonal floodplains and on lots too small for proper OSSF drainage. The report states that nearly all the soils surrounding the lake are severely limited in their ability to accept effluent from

conventional septic tank absorption fields. "Many soils are prone to flooding, percolation rates are slow, surfacing of wastewater is likely, little filtration occurs, and high water tables are prevalent."

As a result of the unfavorable conditions for conventional OSSFs, local officials are concerned about fecal contamination of the lake. Additionally, many areas have no recorded on-site systems at all. The study reports that approximately 80 residences discharge raw or partially treated waste into Cypress Bayou or Caddo Lake. Many sites along the lake were found to have high levels of fecal bacteria. Recommended options for addressing the problems include linking homes to centralized wastewater treatment plants, developing smaller neighborhood treatment plants, and converting individual OSSF units to mound disposal systems.

Ongoing Research

There are a number of projects that are currently under way that may help provide further insight into the magnitude and scope of OSSF problems within the State of Texas. However, since these projects have not been completed, it is not possible to include them in this literature review. The project team would like to highlight some of these ongoing research projects, as they may provide valuable information in the future.

- "A&M-Corpus Christi Scientists Use DNA Tools to Determine if On-Site Systems Degrade Coastal Waters." *Texas On-Site Insights*. Volume 8, Number 3. August 1999.

This newsletter article discusses a research project designed to help scientists understand the sources of coastal pollution. Over 40 different segments of bodies of water within the TNRCC's Coastal Management Program were designated as impaired due to fecal contamination. As a result, Texas A&M-Corpus Christi has begun a three-phase project to develop DNA fingerprinting of the bacteria in the coastal waters to determine whether it originated from human or animal sources. Water samples are collected and the DNA of the bacteria is extracted. The "fingerprints" will then be tied to various warm-blooded animals along Texas' coastal waters. This information could then be used to determine the sources of the pollution such as on-site septic systems and agricultural or urban runoff. The results of this research could have policy implications for the protection of coastal water quality.

- "City of Austin Evaluates Management Structure for On-Site Wastewater Treatment Systems." *Texas On-Site Insights*. Volume 6. Number 3. August 1997.

The City of Austin undertook a study to create a management system that would address OSSF issues such as system design, operations and maintenance, certification of management professionals, and the rates customers would be charged. The goal of the

study discussed in this newsletter article is to create a system that is locally managed, will clarify roles in financial responsibility and regulation, and can manage OSSFs in Austin's extraterritorial jurisdiction. This proposed management system continues to evolve as it is reviewed by various committees and commissions. It will also need adopt to changes in TNRCC rules.

Included in the study were three case studies of OSSF operations in difficult environments. OSSF performance was studied in a subsurface wetland, lakefront property, and hilly ravine with nearby natural springs. These case studies are ongoing and the City of Austin anticipates completion within the next year. (Guzeman, Crespin. Telephone Interview on December 4, 2000 at 9:45am.)

- *Statewide Water and Wastewater Needs Survey*. Texas Water Development Board. June 15, 2000.

The Texas Water Development Board (TWDB) conducted a survey to identify areas of the state that are experiencing water or wastewater problems and to determine the type and magnitude of these problems across the state. TWDB intends to present the results of this survey to the Texas Legislature in 2001. The survey focused on community water/wastewater systems and individual water/wastewater systems. This survey included several questions about OSSF systems. In cases where respondents indicated problems with OSSF systems, the survey asked why these problems are occurring. Response categories included the following:

- Existing system poorly designed
- Soil conditions prevent proper operation
- High water table prevents proper operation
- Population or housing density too high
- Lack of proper maintenance
- Other problems

Of the 254 counties in the State of Texas, 155 responded to the survey. Results of the survey are in the process of being compiled by the TWDB. For the purposes of this study, the project team obtained the data from the TWDB survey and has compiled and analyzed the results. These results have been included in the Regional Results section of the report. In addition, the TWDB survey asked participants about any studies regarding problems with OSSF systems. As appropriate, the project team used this information in the literature review.

Other Potential Data Sources

The project team looked to identify a number of other potential data sources to determine if there would be any data that would assist in the effort to further understand the

magnitude and severity of OSSF problems in the State of Texas. A summary of this research follows.

Texas Water Development Board

The Texas Water Development Board (TWDB) is the state agency charged with statewide water planning. As a part of this responsibility, the TWDB assesses water and wastewater needs within the State. The TWDB maintains a database of areas in the State that need to replace water and wastewater systems. The database contains information provided to the TWDB by local governments and other state agencies; it is not intended to be complete statewide database. This database does include a list of some OSSFs that need to be replaced. However, it is not intended to be a comprehensive review of areas with OSSF problems. In addition, the database does not provide information on the reasons for problems with OSSFs.

Texas Real Estate Commission

The Texas Real Estate Commission (TREC) is responsible for regulating real estate transactions in the State of Texas. Property inspections are required for the sale of properties. Residential property inspections can, but are not necessarily required to, include an inspection of an OSSF. The TREC does not track data related to OSSF problems with regard to property inspections. TREC's Enforcement Division oversees the Real Estate License Act. The Enforcement Division does not track complaints for specific issues such as failing OSSFs.

Texas Natural Resource Conservation Commission

The Texas Natural Resource Conservation Commission (TNRCC) is responsible for oversight of OSSF systems in Texas. Much of this responsibility is delegated to either TNRCC's designated representatives or its regional offices. Regarding data on the OSSF systems, the TNRCC does receive reports on a regular basis from its designated representatives about issues such as permitting, complaints, and enforcement. While the TNRCC does use and maintain these reports, they are not compiled in a database. In addition, the level of detail reported by the different designated representatives can vary. Due to these factors it would not be feasible for the project team to use data submitted to the TNRCC for the analysis of OSSF problems by region in the State of Texas.

Texas Department of Health

At the state level, the Texas Department of Health (TDH) does not track problems related to OSSF systems. For the most part, the TDH considers the oversight of OSSF systems the responsibility of the TNRCC and its designated representatives. The TDH will typically refer all OSSF cases to the TNRCC.