

Hydrostatic Test Water Treatment and Disposal Options For Liquid Pipeline Systems

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Hydrostatic Test Water Treatment and Disposal Options For Liquid Pipeline Systems

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ABSTRACT

This research study was initiated to provide the liquid pipeline industry with credible data and information relative to hydrostatic test water so that reasonable treatment technologies, permit discharge limitations and other management options could be assessed and evaluated. This information will be utilized to assist the industry in discussing and negotiating appropriate discharge permit limitations and control technologies with both state and federal agencies. This study was conducted from February 1997 to December 1997 and involved data provided by 15 pipeline companies. The companies participating in this study represent approximately 45% of the national liquid pipeline system mileage. Data was received for 172 hydrostatic tests consisting of 40 crude oil, 113 refined product, 4 highly volatile liquids (HVL), and 15 other pipeline tests. Data was received for tests conducted from 1990 through the first quarter of 1997. This data was characterized in 26 charts and graphs, treatment technologies and costs were reviewed for both existing and alternative treatment options, and other hydrostatic test water management options were evaluated. The primary results and conclusions of this study found that activated carbon adsorption was the single most frequently utilized treatment technology for existing pipelines representing 30.5% of the hydrostatic tests on existing lines. However, this treatment technology was used by only six of the 15 companies. Approximately 70% of all the tests for existing lines utilized either hay bales, hay bales in combination with additional treatment, other treatment technology, or no pipeline discharge treatment at all. Pre-pigging and/or pre-washing of existing pipelines was utilized in 68% of the tests. Reported costs for treatment on a per-gallon basis vary significantly with total volume treated and type of treatment used. The average treatment costs for the majority of volume discharged and types of treatment ranged from \$0.02 to \$0.15 per gallon. Removal efficiencies for benzene and benzene-toluene-ethylbenzene-xylene (BTEX) were the highest with activated carbon adsorption and were typically in the range of 95 - 100%. Alternate water treatment technologies, beyond activated carbon adsorption, hay bales and air stripping, were also evaluated for cost and practicality. These

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alternatives include dissolved air flotation and ultraviolet light oxidation. Neither of these options proved viable for use in the pipeline industry due to cost, performance or practicality of implementation. Compliance with permit discharge conditions was reported for 84 tests. Of the 329 permit conditions contained in these 84 tests, 327 (99+%) demonstrated compliance. This is an overall excellent compliance history for the liquid pipeline industry.



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EXECUTIVE SUMMARY

This report presents the results of a research study to define acceptable and cost effective hydrostatic test water treatment and disposal methods that will enable compliance with DOT requirements for testing of liquid pipelines, while meeting regulatory agency permitting requirements for disposal and/or discharge. This study was conducted from February 1997 to December 1997 and involved data provided by 15 pipeline companies. The companies participating in this study represent approximately 45% of the national pipeline system mileage.

This study was undertaken to provide the industry with credible data and information relative to hydrostatic test water so that reasonable treatment technologies, permit discharge limitations and other management options could be assessed and evaluated. This information will be utilized to assist the industry in discussing and negotiating appropriate permit limitations and control technologies with both state and federal agencies.

Data was received from 172 hydrostatic tests consisting of 40 crude oil, 113 refined product, 4 highly volatile liquids (HVL), and 15 other pipeline tests. Of the 172 tests, 131 tests were on existing lines and 41 were on new lines. Data was received for tests conducted from 1990 through the first quarter of 1997. This data was characterized in 26 charts and graphs, treatment technologies and costs were reviewed for both existing and alternative treatment options, and other hydrostatic test water management options were evaluated.

The primary results and conclusions of this study found that activated carbon adsorption was the single most frequently utilized treatment technology for existing pipelines representing 30.5% of the hydrostatic tests on existing lines. However, this treatment technology was used by only six of the 15 companies. Approximately 70% of all the tests for existing lines utilized either hay bales, other treatment or no pipeline

discharge treatment at all. Pre-pigging and/or pre-washing of existing pipelines was utilized in 68% of the tests.

Treatment costs reported by the membership ranged from \$0.00 to \$0.85 per gallon; with activated carbon adsorption being the most expensive option for water treatment overall. Reported costs for treatment on a per-gallon basis vary significantly with total volume treated and type of treatment used. The average treatment costs for the majority of volume discharged and types of treatment ranged from \$0.02 to \$0.15 per gallon.

Removal efficiencies for benzene and BTEX were the highest with activated carbon adsorption and were typically in the range of 95 - 100%. Activated carbon adsorption appears to be a viable option for the smaller projects of 100,000 gallons or less but may have significant limitations for larger projects due to flow volume limitations and logistical considerations for equipment.

Alternate water treatment technologies, beyond activated carbon adsorption, hay bales and air stripping, were also evaluated for cost and practicality. These alternatives include dissolved air flotation and ultraviolet light oxidation. Neither of these options proved viable for use in the pipeline industry due to cost, performance or practicality of implementation.

Other test water management options that are potentially available to the liquid pipeline industry were also identified. These options include pre-treating the influent water, routing hydrostatic test water to fixed waste water treatment facilities in a refinery, terminal, or plant, use of an oil and water separator with air sparging, use of dilution water to reduce the concentration of contaminants, discharge to a Publically Owned Treatment Works (POTW), water re-use, land disposal, and pigging and/or pre-washing of pipelines.

Inadequate data or cost information was available to evaluate these options but they may be valuable options to consider depending on the specific circumstances of the discharge.

Compliance with permit discharge conditions was reported for 84 tests. Of the 329 permit conditions contained in these 84 tests, 327 (99+%) demonstrated compliance. This is an overall excellent compliance history based on these tests.

Section 1

INTRODUCTION

BACKGROUND

The environmental considerations related to the regulations, characterization, treatment and disposal of water discharged from the hydrostatic testing of liquid pipelines is an area of considerable importance to the liquid pipeline industry. There are approximately 169,000 miles of liquid gathering and transmission pipeline in the United States (O&GJ, 1997). These liquid systems include gathering (32,000 miles), crude oil (57,000 miles) and refined products (80,000 miles) pipelines. Every year, this national network is modified to some degree through new pipeline extensions, pipeline rehabilitations and other changes.

Federal and state laws require that the integrity of these pipeline systems be maintained. The U.S. Department of Transportation (DOT) and selected state agencies are the governing bodies that regulate hydrostatic testing. Hydrostatic testing is regulated under 49 CFR 195, Subpart E and is conducted when there is a new pipeline installation, a pipeline relocation, replacement of existing pipeline segments, or when there are other changes to a pipeline system which may impact integrity.

Hydrostatic testing is conducted by isolating the pipeline segment, and filling the system with water. After the pipeline is full, the pressure is increased to the desired level using a high pressure pump system. The pressure is then held for a pre-set time to check the integrity of the pipeline. The pipeline may be pigged and pre-washed prior to hydrostatic testing to remove residual product and scale. Fill water is typically obtained from a surface water body, such as a lake or stream, a municipal water source or a groundwater well.

Following hydrostatic testing, the pressure is removed and the pipeline is dewatered by pushing a pig or spacer through the line; typically with product or crude. In some

cases, test waters are staged in tankage prior to treatment and discharge. Test waters may contain some residual oil and grease, BTEX and suspended solids and, therefore, must be properly managed.

Test water may be discharged to surface waters (rivers or streams), municipal POTWs or it may be managed through a refinery, terminal, or plant water treatment system.

The discharge of hydrostatic test water is typically regulated at the state level, through requirements under the National Pollutant Discharge Elimination System (NPDES) program. The management option ultimately selected will depend on the types and levels of constituents present, the site-specific regulatory discharge limits, the location of the discharge and the overall pipeline system design.

RESEARCH OBJECTIVE

The objective of this research project is to identify reasonable, acceptable and cost effective hydrostatic test water treatment and disposal methods that will allow for compliance with DOT requirements for testing of pipelines, while meeting regulatory agency permitting requirements for disposal and/or discharge.

SCOPE

This research involved conducting a literature search and industry survey to establish industry demographics and existing treatment technologies, characterization of discharge water, evaluation of treatment technologies, performing an economic analysis of treatment options and reviewing other hydrostatic test water management options available to the industry. These tasks are described in more detail below:

Literature Research and Industry Survey

An electronic survey questionnaire was distributed to members of the Hydrostatic Test Water Treatment and Disposal Operations Workgroup and the full API Committee On Environmental Health and Safety. This questionnaire was in a spreadsheet format which is attached in Appendix A. Data was gathered for tests from 1990 to the 1st

Quarter of 1997 for both new and existing pipeline hydrostatic test water discharges. A total of 172 tests (131 Existing and 41 New) were evaluated. Reports from several other hydrostatic test water research projects such as those conducted by the Gas Research Institute (GRI) were also reviewed.

Characterization of Water

The industry survey and literature research produced a very sizable database from which to characterize the test water quantity and quality. Following development of the database and evaluation of the data, twenty-six (26) summary graphs and tables were generated to characterize the discharge waters. These graphs and tables are discussed in Section 2 and 3.

Evaluation of Treatment Technologies

Treatment technologies which were identified through the industry survey and through the literature search were evaluated on several factors, including among others:

- Practicality
- Mobility
- Set-up Time Requirements
- Power Requirements
- Storage Requirements
- Amounts and Types of Wastes Generated
- Impact/Ability to Meet Various Potential Discharge Limits
- Treatment Discharge Rates
- Water Storage/Tankage Requirements

A summary of these evaluations is contained in Table 27.

Economic Analysis

Capital and operating costs were developed based on published data, vendor quotes, cost information from member pipeline companies, and best professional engineering judgment.

Recognizing that several site specific factors are pertinent to operations of this nature, the cost evaluation included considerations of the following factors:

- Mobilization/Demobilization Mileage to Site
- Site Constraints: Space, Surface, Distance to Discharge Point
- Climatic Conditions: Seasonal Considerations
- Site Preparation: Clearing, Surface Preparation, Power Requirements
- Waste Disposal: Pre-Pig Fluids, Solids, Spent Carbon, Used Hay bales, etc.
- Fees: Easement Access, Construction, Permitting
- Treatment Throughput Rate
- Water Storage Requirements and Containment

A summary table of the capital and operating costs for each technology was prepared and is contained in Section 5.

Test Water Management Options

Pipeline operating procedures that could be employed prior, during or after a test are identified in this section. These procedures were identified in part through the results of the industry survey, through a review of available technical studies such as GRI's hydrostatic test water reports, through the operating experience of the staff and through individual discussions with the members of the Committee. Options such as pre-pigging or pre-washing of pipelines, pre-treating fill water, discharging to a municipal POTW and other options were reviewed and summarized.

Section 2

LITERATURE RESEARCH AND INDUSTRY SURVEY

APPROACH

Members of the Hydrostatic Test Water Treatment/Disposal Options Workgroup and the full API Committee on Environment, Health & Safety (CEHS) were sent an information request packet on February 19, 1997. The packet contained a set of written guidelines on the type of information sought and a diskette with a formatted spreadsheet for reporting the requested information. Spreadsheets were the chosen tool for reporting members' data because of their simplicity to use and ubiquitous nature. A copy of the data gathering spreadsheet is included in Appendix A. A summary of the information requested follows.

DATA SOURCES

Data was gathered for 172 hydrostatic tests conducted on both new and existing pipelines, from 1990 to the first quarter of 1997. Parameters requested were:

- the year the test was completed;
- the source of the test water;
- the total volume of discharge;
- the maximum discharge rate;
- the State in which the water was discharged;
- the type of discharge;
- the type of receiving body (lake, river, POTW, ground surface, etc.);
- an indication if the location was remote (rural);
- an indication if the pipeline was new or existing;
- the type of product transported in the pipe;
- the pre-treatment method selected (pigging, pre-washing, or combinations, etc.);

- the type of treatment used prior to discharge (activated carbon adsorption, hay bales, etc.);
- an indication if the results met permit requirements;
- the unit cost of treatment;
- analytical data for both before treatment and after treatment, including benzene, BTEX, biochemical oxygen demand (BOD), dissolved oxygen (DO), iron (Fe), Methyltertiary-butyl-ether (MTBE), diesel range organics (DRO), gasoline range organics (GRO), Oil & Grease, pH, and total suspended solids (TSS).

After the diskettes were returned from member companies, they were virus scanned, the spreadsheets printed and the results loaded to Microsoft Access[®] for efficient analysis. The data were checked for completeness and consistency. Information which seemed anomalous was confirmed with the submitting company. All data was maintained on a confidential basis and appropriately coded to ensure its confidentiality.

OTHER DATA SOURCES

Numerous reports from the Gas Research Institute were reviewed along with articles from the Oil and Gas Journal and other sources. A complete listing of literature reviewed is contained in the References.

Section 3

CHARACTERIZATION OF WATER

APPROACH

One hundred seventy-two (172) usable test results were received from the member companies. Of those 172 tests, 131 were conducted on existing pipes (76%), 41 were conducted on new pipes (24%). Seventy seven (45%) of the 172 reported cost information. Fifty-seven tests (33%) reported both before-treatment and after-treatment data for a particular test, enabling an assessment of removal efficiencies. Data were evaluated in 26 tables and were categorized into five main sections. These sections include test demographics, treatment methods, treatment effectiveness, treatment costs and treatment analysis.

DATA EVALUATION

Test Demographics

Eleven tables and graphs were constructed to examine distributions of test date, test location, test volume, water sources, receiving water body types, and type of material transported.

- Table 1 is a listing of the miles of interstate liquid pipelines owned by respondent companies in comparison to the total U.S. liquids pipeline mileage (August 4, 1997 Oil & Gas Journal Special Report).
- Table 2 is a plot of hydrostatic tests grouped by year for both new and existing pipes (all 172 test points were used to create this plot).
- Table 3 is a plot of the number of discharges grouped by state for existing pipes (131 test points were used to create this plot).
- Table 4 is a plot of the number of discharges grouped by state for new pipes (41 test points were used to create this plot).
- Table 5 is a plot of hydrostatic tests grouped by discharge volume range for both new and existing pipes (all 172 test points were used to create this plot).

- Table 6 is a plot of distribution of receiving body types (no discernment was made between new and existing pipes; all 172 data points were used to create this plot).
- Table 7 is a plot of test water sources indicating the total volume used and number of uses from a particular source (all 172 test points were used to create this plot).
- Table 8 is a plot of the distribution of the liquids transported for new and existing pipelines (crude, refined products, HVL, or other; all 172 data points were used to create this plot).
- Tables 9, 9A and 9B are listings of the sum and average discharges for particular receiving bodies, grouped by USEPA Region and receiving State. Table 9A is a summary of discharges by USEPA Region. Table 9B is summary of discharges by receiving State.

Treatment Methods

Three tables were created to examine the relationship between the type of pipe (new versus existing), the liquids being transported and types of pre-treatment and discharge treatment.

- Table 10 is a listing of the distribution of pre-treatment methods (e.g., pre-pigging) used for various products transported (separated by type of pipe) all 172 data points were used to create this plot.
- Table 11 is a listing of the distribution of treatment methods used for the liquids being transported (separated by type of pipe); all 172 data points were used to create this plot).
- Table 12 is a listing of all the combinations of pre-treatment and discharge treatments reported for this study.

Treatment Effectiveness

Nine tables were created to present the before and after treatment data reported, and examine the removal efficiencies.

- Tables 13, 13A and 13B are listings of the removal efficiencies and discharge treatment costs for 57 tests on new and existing lines which reported both before and after treatment analytical data. Table 13A is grouped by receiving State, Table 13B is grouped by test.
- Tables 14 and 15 are summary tables of the removal efficiencies and discharge treatment costs for 57 tests on existing (55) and new (2) pipes, respectively. These tables were based upon tests which reported both before and after treatment analytical data.
- Tables 16, 17, 18 and 19 are listings of the raw analytical data reported for existing and new pipes before and after treatment. These tables show averages, maximums and minimums for selected constituents.

Treatment Costs

Four tables/graphs were created to describe the costs associated with treatment of hydrostatic discharge water.

- Table 20 is a summary table showing discharge volumes and weighted average costs for ranges of treatment costs (we have assumed reasonable groupings of <1 cent, 1 to <5 cents, etc.) for new and existing pipelines.
- Table 21 is a graph of the distribution of cost information for new and existing pipelines.
- Table 22 is a graph of the average discharge volumes for various cost groupings, for new and existing pipelines.
- Table 23 is a graph of the economies of scale for different cost ranges.

Treatment Analysis

Three tables were developed to assist decision-makers in drawing conclusions regarding the use of various methods of treatment and the success of those methods in meeting permit requirements.

- Table 24 is a summary of costs by treatment technology for existing lines.
- Table 25 is a summary of pre-pig/pre-wash data.
- Table 26 is a summary of permit compliance data.

DATA VALIDITY, COMPLETENESS AND REPRESENTATIVENESS

Confidence in the validity and representativeness of the data is high. There were very few results which appeared anomalous and required confirmation. Respondents answered the questions as completely as possible, however, some data gaps exist as some of the requested information was simply not available. Of the 21 companies represented on the CEHS, 15 companies (71%) provided data for this study. As described below, the respondents operate nearly 45% of all the liquid pipeline miles in the U.S. which represents a significant portion of the nation's liquid pipeline system.

The data were received from the membership in electronic (spreadsheet) format. Upon receipt, the diskettes were scanned for viruses. If found, the virus was eradicated and the respondent was notified. The spreadsheets were then printed and checked for information which appeared anomalous. Those pieces of information were then confirmed with the respondent.

Some careful interpretation of the data was necessary to develop a consistent database. Changes included consistency in units and analytical parameter spellings. Where no answer was given, with the exception of the analytical data, a designation of "N/R" (Not Reported) was entered for that piece of information. In cases where respondents reported information other than the requested abbreviations (such as use

of "Ref. Prod." instead of "RP" to denote refined product), those answers were interpreted to comply with requested formats/categories.

The data was converted from spreadsheet format to MS Access, a database software package which allowed quick querying and data reporting. A series of queries were developed to report the desired data. The final report graph and tabular formats were developed in Excel in part to meet API formatting requirements.

SUMMARY COMMENTS - DATA PRESENTATION

According to the August 4, 1997 Oil and Gas Journal Special Article, "Pipeline Economics Construction Plans Jump; Operations Skid in 1996," 169,435 miles of interstate liquid transmission pipeline were reported in 1996 by major and non-major companies on US FERC annual reports. Of the mileage reported, approximately 45% (80,421 miles) was owned by member companies who provided the information requested. This information is summarized in Table 1.

Table 2 indicates that the number of tests conducted peaked in 1995 with a total of 45 tests reported, 33 of which were on existing pipelines, 12 on new pipelines. The number of tests conducted on new pipes appears to be increasing, since the first tests, which were reported in 1993. Due to the timing of the canvass, the number of tests reported for 1997 covers only the first quarter.

Table 3 indicates that Louisiana, Texas, Oklahoma, Indiana and Pennsylvania accounted for 71 (54%) of the total number of tests (131) conducted on existing pipelines. Twenty-eight different states (including the District of Columbia) were reported to receive test waters from existing pipes.

Table 4 illustrates that Louisiana, Montana, Oklahoma and Arkansas accounted for 27 (66%) of the total number of tests (41) conducted on new pipelines. Fourteen different states were reported to receive test waters from new pipes.

Table 5 indicates that 78 (59.5%) tests of over 1,000,000 gallons and 20 (15%) tests of less than 100,000 gallons were conducted on existing pipelines. Conversely, 26 (63%) tests of less than 100,000 gallons and only 5 (12%) tests of over 1,000,000 gallons were conducted on new pipelines.

Table 6 shows that surface water bodies, rivers/streams and lakes/ponds were the most frequently used receiving body, accounting for 122 of 172 tests (71%).

Table 7 indicates that municipal sources were used most frequently as sources for water used in hydrostatic testing, accounting for 75 of 172 tests (43.6%). However, rivers/streams and lakes/ponds provided more total volume than did municipal sources (221,082,307 gallons versus 113,758,704 gallons).

Table 8 illustrates that refined product was reported as the liquid transported in nearly 66% (113 of 172) of the total number of tests conducted and in nearly 76% (99 of 131) of the tests conducted on existing pipelines. Refined product pipelines comprise just over 50% of the total miles of pipeline owned by respondent companies.

Tables 9, 9A and 9B demonstrate that USEPA Regions 6, 5 and 3 received the most water from tests on existing pipes. Region 6 received the largest quantity of water discharged and the most frequent discharges from existing pipelines. Region 5 received the highest average discharge for existing pipelines. Region 8 received the smallest total volume of water discharged from existing pipelines. Regions 8 and 1 both had only one discharge from existing pipelines. Wisconsin received the highest total discharge and had the highest average discharge from existing pipelines. Louisiana had the most discharges and the second highest total volume discharged. Montana received the smallest total volume discharged and had only one discharge from existing pipelines.

Also from Tables 9, 9A and 9B, USEPA Regions 3, 5 and 8 received the most water from tests on new pipes. Region 3 received the largest quantity in a single discharge from a new pipeline. Region 9 received the smallest quantity of water discharged and the smallest average volume of discharge for new pipelines. Pennsylvania, North Dakota and Minnesota received the greatest volume discharged from new pipelines. Louisiana and Montana had the most discharges reported for new pipelines. California received the smallest average volume discharged from new pipelines. Pennsylvania had the highest average discharge.

Table 10 indicates that pre-washing and pigging used separately or in combination are the most common forms of pre-treatment (treatment prior to hydrostatic testing) for new and existing pipelines carrying crude, refined products and HVLs. Of all existing lines, 32% were pigged, 33.5% were pre-washed and 2.2% used a combination of pigging and pre-washing. Of all new lines, 21.9% were pigged, 12.2% were pre-washed and 2.4% used a combination of pigging and pre-washing.

Table 11 illustrates that activated carbon adsorption was the most frequently used treatment (at time of discharge) for existing pipelines transporting refined products or crude. For existing lines, 30.5% used activated carbon adsorption, 1.5% used activated carbon adsorption in combination with hay bales or other treatment, 7.6% used hay bales, 13% used other treatments, 23.7% used no treatment, and 23.7% did not report the treatment type. Hay bales, which minimize erosion, oxygenate water, and remove suspended solids, appear to be the treatment technology used most frequently for new pipelines.

Table 12 describes the combined use of pre-treatment and treatment technologies. Pigging and activated carbon adsorption was the most commonly used treatment combination for existing pipelines. For existing lines, 16% of all tests used a combination of pigging and activated carbon adsorption for treatment. Existing pipelines carrying crude were most frequently pre-treated by only pigging or pre-

washing. It appears that new pipelines receive either pre-treatment or treatment, but rarely receive both technologies, with the exception of new pipelines which transport highly volatile liquids. The new HVL pipelines were reported to be treated by pigging and hay bales.

While activated carbon adsorption was the most frequently used treatment, it was utilized by only 6 out of 15 different companies as a treatment for a total of only 40 tests on existing lines (40/131, 30.5%). Pigging and activated carbon adsorption were used in combination on 25 different tests (25/131, 19.1%), but by only 3 different companies. Pre-washing and activated carbon adsorption were used by only one company on one test.

Tables 13, 13A and 13B present the water contaminant level prior to treatment and after treatment for individual samples, estimated removal efficiencies and treatment cost ranges for tests where both before treatment and after treatment analytical results were reported. A total of two tests for new lines and 55 tests for existing lines reported both before and after treatment data.

The removal efficiencies are summarized separately for existing and new pipelines in Tables 14 and 15, respectively. Those tables indicate that removal efficiencies for activated carbon adsorption, where calculable, are nearly 100% for both benzene and BTEX. The costs associated with these technologies appear to range from less than one cent per gallon to \$0.85 per gallon.

Tables 16 through 19 are listings of analytical data reported and selected summary statistics. For existing pipelines, the average before-treatment and after-treatment concentrations were approximately: benzene (before = 12,452 ug/L; after = 9.3 ug/L); BTEX (before = 38,176 ug/L; after = 139 ug/L); Oil & Grease (before = 180.8 mg/L; after = 2.74 mg/L); TSS (before = 62.6 mg/L; after = 20.7 mg/L). And for new pipelines, the average before-treatment and after-treatment concentrations were approximately :

benzene (before = 3 ug/L; after = 11 ug/L); BTEX (before = < 2 ug/L; after = < 2 ug/L); Oil & Grease (before = 2.3 mg/L; after = 3.3 mg/L); TSS (before = 54.7 mg/L; after = 44.8 mg/L). In calculating the average, where a compound was not detected, one half the detection limit was used for summary statistics. In some cases, use of one-half the detection limit produced artificially high statistics as noted above for benzene and oil and grease in the average "after treatment" numbers.

Table 20, indicates that member companies reported treatment by activated carbon adsorption anywhere from less than one cent/gallon to over 50 cents/gallon. The average weighted cost for testing new pipeline (corresponding to treatment only by removal of suspended particles) is less than one cent (0.16 cents) per gallon.

Table 21 indicates the most frequently reported cost for both new and existing pipelines was less than one cent/gallon. Table 22 indicates that the average discharge volume in the cost range of 1 to <5 cents/gallon is almost 5,500,000 gallons. Table 23 shows the economies of scale for treatment technologies with a best-fit line drawn through the data.

Table 24 presents test frequency, average discharge volume, cost average and cost range information for tests conducted where cost information was reported for existing pipes. The table is grouped by the type of liquid transported and the treatment technology used.

Table 25 lists the range and average concentrations for selected compounds and an indication if permit requirements were met for tests where pigging, pre-washing, or pigging and pre-washing were used as the only treatment technology. This table reflects only existing pipelines where refined product was transported. This table was prepared to evaluate if pigging or pre-washing or a combination of just these two options clean the pipeline such that the effluent meets permit limits. Overall, this technology provided very encouraging results relative to permit compliance.

Table 26 is a summary of the reports for permit compliance for particular chemical compounds, grouped by product type and treatment method.



Section 4

EVALUATION OF TREATMENT TECHNOLOGIES

APPROACH

This section of the report covers the procedures used in evaluating the available technologies for the treatment of wastewater resulting from hydrostatic testing of pipelines used for the transport of crude oil, highly volatile liquids, and refined products. The evaluations were carried out with respect to present practices as identified in the industry survey and with the consideration of alternate technologies that are available to the industry.

The following tasks were performed to address the issues of volume and frequency of test water discharges; water characteristics such as BTEX, TSS, and Oil & Grease; treatment effectiveness; and cost estimates.

An industry survey was performed of pipeline companies which have conducted hydrostatic testing. Information requested from these companies included such items as:

- Treatment Technology used;
- Product carried in the pipeline;
- Volumes of water used in the test;
- Pre-test treatment, if any;
- Water quality, before and after testing, i.e. hydrostatic test water characterization for constituents of concern;
- Number of tests conducted per year; and
- Cost per gallon of water treated.

Data from 172 tests were received from the companies contacted, and the data submitted by them were compiled and are contained in Sections 2 and 3. These data, together with other information which was reviewed, such as the Gas Research Institute

Report: "Environmental Aspects of Hydrostatic Test Water Discharges: Operations, Characterization, Treatment and Disposal", 1996, were evaluated and form the basis for this section of the report.

Hydrostatic test water treatment data were collected and classified into a Technology Summary, which examines the treatment effectiveness with respect to expected required discharge limits.

Possible alternate treatment technologies for the hydrostatic water treatment were also examined with respect to the parameters of concern to the liquids pipeline industry. Recommendations were made for treatment of the hydrostatic test water from crude oil pipelines, highly volatile liquid pipelines and refined product pipelines. These recommendations were based mainly on the effectiveness of the treatment technologies as observed in the data and from the referenced reports.

Finally, cost estimates of the existing and alternate treatment technologies were prepared and are detailed in Section 5.

TECHNOLOGY SUMMARY

The industry survey supplied information for the following treatment technologies:

Pipeline Pre-Cleaning

Pigging. This treatment consists of pushing a pig through the pipeline with air or natural gas before filling it with test water for hydrostatic testing. Various types of pigs such as squeegee, brush, and others may be used individually, or in combination. A single or multiple pass may be used. It should be noted that not all pipelines are equipped for on-line pigging operations. For this reason, it may be necessary to install pig launchers and receivers to conduct pipeline cleaning and hydrostatic testing activities.

Pigging and Pre-Washing. In addition to pigging, this approach includes the use of a cleaning solution to remove BTEX and other residuals before filling the system with test water. This cleaning solution, typically consisting of water and a detergent solution, is pushed through the system with a pig and is collected, tested and properly disposed of.

Pipeline Treatment

Activated Carbon Adsorption. This treatment consists of pumping the hydrostatic test water through a column or several columns in parallel packed with activated carbon. This technology is primarily effective in removing Benzene and BTEX. An oil/water separator is typically installed in front of the packed column to remove free product from test water.

Air Stripping. Air stripping involves the transfer of volatile compounds contained in the water to air, via mass transfer across a gas-liquid interface created by counter-current contact of air and water streams. In the process, the water flows downward through packing against an upward air flow. From the packed column, the air flows to the atmosphere.

Hay Bales/High Rate Of Treatment. This treatment consists of a round or rectangular structure of bales of hay onto which the test water is discharged in order to remove TSS and Oil and Grease. VOCs are driven out of the water to some extent because of the splashing caused by the impact of the water on the hay bale structure. An example of a hay bale structure designed for a high rate of treatment (HRT) is contained in figure 1. This technology includes a filter cloth, splash plate, and absorbent boom to improve effectiveness.

Combinations of Carbon Adsorption, Air Stripping, and Hay bales. Combining activated carbon adsorption with air stripping or hay bales was also noted in some cases.

PERFORMANCE OF EXISTING TECHNOLOGIES

The performance, or effectiveness, of the technologies described in the industry survey is summarized below, in relation to hydrostatic test waters from several different types of pipelines. A summary of the positive aspects (+) and negative drawbacks (-) of each technology as it relates to specific evaluation criteria such as practicality, mobility, discharge rates, etc., is contained in Table 27. These assessments are based on the evaluation of the effectiveness of the technologies as per the data contained in Section 3. These assessments of the positive attributes and negative drawbacks represent general conclusions and may vary depending on the type of pipeline system and volume of discharge.

Pigging

Inadequate data was available to assess the effectiveness of pigging as a treatment technology, in and of itself. Preliminary information obtained in the industry survey indicates that pre-pigging combined with pre-washing, activated carbon adsorption or other treatment may be necessary to meet permit discharge limits in many cases.

Pigging and Pre-Washing

As with pre-pigging, inadequate data was available to assess the effectiveness of pre-pigging combined with pre washing. Based on the limited available data, however, this option does appear to be satisfactory for crude oil pipelines with respect to oil & grease and TSS, but may not be satisfactory for benzene and BTEX without additional treatment. This option may be satisfactory for refined product pipelines based on the results illustrated in Table 25. Further test results are necessary to verify this conclusion, however.

Hay Bales/High Rate Of Treatment

This treatment and an improved version, the High Rate Treatment (HRT) System, are easily constructed, and the materials are readily available. No large equipment is needed, and there are no pumps, blowers, nor other related equipment. This option

should be effective for TSS and oil and grease removal. Additionally, the splash plate in the HRT aerates the water and removes VOCs and the haybales are effective for erosion control. The HRT System includes primary components used in hay bale structures (i.e., hay bales, oil adsorbent boom, splash plate), along with an additional level of filtration, which is provided by using filter cloth. The water from testing is routed to the center of the system, where the velocity of the discharge water is reduced upon impacting a splash plate. A diagram of this design is contained in Figure 1.

Inadequate data was available to assess the effectiveness of hay bales as the sole treatment technology. Table 26 illustrates that oil and grease are effectively controlled but inadequate data is available to judge performance for benzene and BTEX. After both pre-pigging and pre-washing, hay bale treatment may provide a viable option but the pipeline may also need additional treatment for removal of benzene and BTEX.

Activated Carbon Adsorption

This is a well known technology that has been used often to remove organic constituents from water. However, there is a flow rate limitation which can be a significant drawback for some pipeline operations. Because of the large volumes of test water from some hydrostatic tests, treatment flow rates of 2000 to 3500 gpm may be necessary to keep system downtime to a minimum. At present, one of the largest activated carbon adsorption canisters available is limited to a maximum water throughput of 550 gpm. To obtain a total throughput rate of 2000 gpm will require four such canisters in parallel; resulting in significant capital costs. Also, for a system of this size, when the carbon is spent, a waste slurry of 80,000 pounds of carbon in water is generated. Access and transport are also difficult for this treatment option under certain circumstances. In some cases, the hydrostatic test water from the pipeline may have to be stored in temporary tankage. Results of the effectiveness of activated carbon adsorption are very good, however, as illustrated in Tables 14 and 26. Overall assessments for crude oil and refined products were as follows:

Crude Oil Pipelines. After pigging pretreatment, activated carbon adsorption appears to be suitable for hydrostatic test water from crude oil pipelines. Results from the data presented in section 3 were as follows for input vs. output:

- BTEX: 27 mg/L to < 0.004 mg/L
- O&G: 300 mg/L to < 4.0 mg/L
- TSS: 22 mg/L to < 2 mg/L

Refined Product Pipelines. After pigging pretreatment this technology also appears to be suitable for refined product pipelines. The results of tests were:

- BTEX: 153 mg/L to < 0.001 mg/L
- O&G 3500 mg/L to < 5.5 mg/L
- TSS: 160 mg/L to < 6 mg/L

HVL Pipelines. Inadequate data was available to assess the effectiveness of activated carbon adsorption on HVL Pipelines.

Activated Carbon Adsorption Followed by Air Stripping

Refined Product Pipelines. After pigging, this combination technology appears to be suitable for benzene and BTEX. Oil and grease and TSS were not measured, but would have likely been removed by the activated carbon adsorption step.

Activated Carbon Adsorption Followed by Hay bales

Refined Product Pipelines. After pigging, this combination technology appears to be suitable for benzene and BTEX. Oil and grease and TSS were not measured, but would have likely been removed by the activated carbon adsorption step.

Air Stripping

This is also a widely used and well known treatment for removing VOCs from water but generally not at the discharge rates required for a pipeline system. Other problems can arise because temporary storage of test water may also be necessary. Use of this

technology may also require air permitting, utilization of control technology, and will impact a facility's emission inventory. Transport of equipment and access to remote sites are also an issue that make this technology very limited in application. Very limited data was available to assess this technology, yet after pre-pigging on a combined crude oil and refined products pipeline the following results were obtained:

- Benzene: 4.4 mg/L to 0.024 mg/L
- BTEX: 12.7 mg/L to 0.039 mg/L
- O&G 666 mg/L to 35 mg/L
- TSS: not measured

Oil/Water Separator With Air Sparging

The use of an oil/water separator may be a viable option in some cases where equipment mobility, siting, and throughput capacity are not a limitation to the discharge. This option may have limited effect on BTEX depending on the contaminant level but it may be effective in some circumstances. Suspended solids will need to be addressed with hay bales or another filtration approach to utilize this system. Disposal/recycling of separated oil must also be managed properly with this system. Some state air divisions may also require notification or a permit prior to venting BTEX from the test water via the air sparging operation. Insufficient data was available to assess the effectiveness of this treatment technology.

OTHER TREATMENT TECHNOLOGIES

There are other well-known treatment technologies for the removal of oil, grease, benzene, BTEX and solid materials from wastewater. Some of these technologies include filtration, dissolved air flotation, and ultra-violet oxidation. These technologies are not currently used by the pipeline industry in most cases but are presented here as options for consideration and evaluation.

Filtration

Filtration is useful for removing suspended solids, and can also lower the concentration of non-emulsified oil and grease. There are many types of filters available, such as fixed multimedia, moving bed sand filters, plate and frame filters, rotary vacuum filters, belt pressure filters and centrifuges. Every type of filter will produce a sludge that must be dewatered and the filter must be cleaned periodically; therefore, filtration is labor intensive.

Most filters can be made mobile. However, throughput is a definite drawback to their use in treating hydrostatic test water; 2,000 to 3,500 gpm is out of the question as a processing rate in most cases. Another drawback is that filtration does not address the problem of BTEX nor other light hydrocarbons which are present in the wastewater. Additional treatment would be required.

For these reasons, filtration, in and of itself, is most likely not a viable alternative technology except possibly on new pipeline systems with limited volumes of discharge.

Dissolved Air Flotation (DAF)

This technology is an effective way to remove suspended solids and emulsified oils from wastewater streams. Air bubbles are produced and attach themselves to the suspended particles, which gives the particles a net buoyancy, and form clusters. The clusters of particles and air bubbles rise to the surface of the water, forming a float which is removed by skimming. The solids concentration of the skimmings ranges between 3% and 10%. Thus de-watering of the skimmings is necessary before they can be removed for disposal.

Removal rates of up to 97% are obtained, resulting in effluent TSS and oil and grease concentrations of less than 100 mg/L.

The technology does not, however, meet requirements with respect to BTEX and other VOC's; additional treatment would be required.

If improved effluent quality with respect to TSS and oil and gas is required, chemical pre-treatment including neutralization, coagulation, and flocculation can be beneficial.

DAF systems are available in standard sizes to handle 600 gpm of wastewater. A 600 gpm unit is 62 feet long by 12 feet wide, which is large and essentially makes it unacceptable for the pipeline industry due to mobility. At 600 gpm, a 100,000 gallon discharge of hydrostatic test water would require a run time of 2.8 hours, and a 1 million gallon discharge would require 28 hours.

A 600 gpm unit would cost approximately \$200,000 which results in a capital cost that exceeds that of many other treatment technologies.

Ultra-Violet Light Oxidation

This is a process in which dissolved organic compounds are oxidized by the application of high intensity ultra-violet (UV) light with the presence of hydrogen peroxide. The UV light converts the hydrogen peroxide into hydroxyl radicals (OH-) which are powerful oxidizers. The combination of light and hydroxyl radicals promotes the rapid breakdown of the organics to carbon dioxide and water. Any halogens present are converted to halides. One of the advantages for the process is that there are typically no hazardous air emissions released.

However, if the wastewater contains TSS and/or oil and gas, some pretreatment is required, and this results in a requirement for solids removal and handling. The presence of iron or calcium in the wastewater requires pH adjustment and precipitation to prevent scaling on the UV tube lamps.

This process might have very limited applications on light, clean refined product pipelines, and on highly volatile liquid pipelines. However, flow rates are low and costs are high, making it overall impractical for the liquid pipeline industry.

TECHNOLOGY EVALUATION PROCESS

The above performance evaluation showed that the most promising technologies are pigging and pre-washing, activated carbon adsorption, hay bales or combination of these. These performances must be coupled with cost estimates to assess the total effectiveness of the technology for meeting the needs of the pipeline industry and the requirements of permitting agencies.

The results of the technology evaluation process is shown in Table 27, "Summary of Hydrostatic Test Water Treatment Technologies." Each technology was examined with respect to criteria, such as practicality, mobility, time requirements, power, related storage requirements, wastes generated, discharge rates, ability to meet discharge limits and cost. The positive aspects (+) and negative drawbacks (-) of each treatment technology were assessed against the evaluation criteria. For example, the Mobility of Carbon Adsorption was assessed as a negative, because of the size and weight of the adsorption columns, and because of the need for water storage. These assessments are based on the integrated consideration of the data presented in Section 3, the effectiveness of the technology presented in Section 4 and cost considerations presented in Section 5. Furthermore, these assessments are overall value judgments of all the above factors and are subject to exception under site specific circumstances. These evaluations are not intended to limit the utilization or application of any technology but rather to provide guidance to the industry in considering treatment alternatives which best meet the requirements for a particular discharge application.

Section 5

ECONOMIC ANALYSIS

APPROACH

Capital and operating costs were developed based on published data, vendor quotes, cost information from member pipeline companies, and best professional engineering judgment.

Recognizing that several site specific factors are pertinent to operations of this nature, the cost evaluation included considerations of the following factors:

- Mobilization/Demobilization Mileage to Site
- Site Constraints: Space, Surface, Distance to Discharge Point
- Climatic Conditions: Seasonal Considerations
- Site Preparation: Clearing, Surface Preparation, Power Requirements
- Waste Disposal: Pre-Pig Fluids, Solids, Spent Carbon, Used Hay bales, etc.
- Fees: Easement Access, Construction, Permitting
- Treatment Throughput Rate
- Water Storage Requirements and Containment

A summary of the capital and operating costs for each technology was prepared and is contained in Table 40.

ESTIMATED COSTS

Cost estimates were prepared for Pigging and Pre-washing, HRT System, Carbon Adsorption, Air Stripping, Dissolved Air Flotation and Ultraviolet Light Oxidation. Three values of hydrostatic waste water discharges were chosen for each cost estimate, 100,000 gallons, 1 million gallons, and 10 million gallons. The cost estimates are shown in Tables 28 through 39. To ensure a consistent means of relative cost

comparison between treatment operations, all cost estimates assume a one-time use of equipment with no reuse, amortization of costs, or depreciation cost recovery.

Pigging and Pre-Washing

Costs for the Pigging and Pre-washing technologies were based on the data from the referenced GRI Topical Report: Environmental Aspects of Hydrostatic Test Water Discharges: Operations, Characterization, Treatment and Disposal, April 1996. Tables 28 and 29 present these cost estimates which are based on actual test data, and are sufficient for the purpose of this report. These estimates assume that pig launchers and receivers are in place and do not need to be installed.

Hay Bales/High Rate of Treatment

The cost estimates for this system are shown in Tables 30 and 31. As with the above costs for Pigging and Pre-washing, the estimates for HRT were taken from the Reference GRI report.

Activated Carbon Adsorption

The cost estimates for the Carbon Adsorption technology are shown in Tables 32 - 35 and are based on vendors' quotes. One of the pertinent factors in the treatment of the hydrostatic test water is the treatment flow rate; for this study, a range of 2,000 to 3,000 gpm was selected. These high rates were selected to keep the treatment processing time to a minimum, especially with discharge volumes of up to 10 million gallons. However, the flow rate for the largest available adsorption canister is 550 gpm. This means that a flow rate of 3,000 gpm requires 6 canisters in parallel, which influences the capital cost adversely. Therefore, the following scenario was devised to keep the capital cost at acceptable levels.

100,000 Gallon Discharge. A processing rate of 2,000 gpm would require 4 canisters in parallel, with a processing time of 50 minutes. Table 32 shows the cost estimate for this case. But with one canister, and a processing rate of 550 gpm, the processing time

would be 3.03 hours, which is certainly reasonable. The cost of one canister is \$26,900 compared with the cost of 4 canisters at \$107,600. Table 33 shows the total cost estimate for the single canister alternative at \$79,375 compared to the total cost of \$258,706 for four canisters as reflected in Table 32..

1,000,000 Gallon Discharge. One canister was also used for this case, which increased the processing time to 30.3 hours or slightly more than one day. The operating labor is increased, but the capital equipment cost is the same as for the 100,000 gallon case. Table 34 shows the cost estimate for this case.

10,000,000 Gallon Discharge. In this case, a single canister requires a run time of 303 hours, which may not be acceptable in many circumstances. The use of 4 canisters in parallel, with a total rate of 2,200 gpm and a processing time of 75.8 hours or 3.1 days may be more appropriate at this total volume. This processing run time may still be considered too long from an operational standpoint in some situations. The cost estimate for this case is shown in Table 35.

Air Stripping

Cost estimates for the air stripping technology are based on vendor quotes and are shown in Tables 36 and 37. As in the cost estimate for Carbon Adsorption, the processing rate became an important design factor. Previous research conducted by GRI indicated that a 2,000 gpm rate was used for all three volume discharges, with a fixed stripping tower diameter and differing processing time durations. This approach results in a 50 minute processing time for the 100,000 gallon case, with a 9.5 foot diameter column. An alternative method is to use a reasonable processing rate and duration time, certainly for the 100,000 gallon case, and the higher rate for the one million to ten million gallon volumes. Air stripping will potentially require additional costs for permitting and the use of emission controls in certain circumstances. These costs have not been included in these estimates.

100,000 Gallon Discharge. The stripping column was designed for a processing time of 2.4 hours, and a rate of 700 gpm. This results in a tower diameter of 5 feet, and a more reasonable cost with respect to capital and labor. The cost estimate is given in Table 36.

1,000,000 and 10,000,000 Gallon Discharges. For these two cases the processing rate was set at 2,000 gpm. This gave a processing time of 8.33 hours for the 1 million gallon case, and 3.5 days for the ten million gallon case. The column diameter is 9 feet for both cases, and the capital is the same for both, but the operating labor is greater for the ten million gallon case. Table 37 gives the cost estimates for both of these discharge volumes. Note that separate operating costs are given for each volume.

Dissolved Air Flotation (DAF)

Table 38 shows the cost estimate for this technology. It is based on a vendor quote for a 75 gpm unit, while the largest standard unit has a processing rate of 600 gpm. The cost of the 600 gpm unit was estimated from the cost of the 75 gpm unit by multiplying by the size ratio raised to the 0.6 power. Table 38 shows costs for a 100,000 gallon discharge, and operating costs for the 1 and 10 million gallon discharges. The total costs for 100,000 and 1 million gallons differ only by a small amount; the total cost for 10 million gallons is about \$6,000 more because of higher operational costs.

The high capital costs of DAF relative to other technologies will likely make it unsatisfactory from an operational standpoint. Additionally, the need for additional treatment for BTEX and the long processing times for the 10 million gallon case are negative factors.

Ultra-Violet Light Oxidation

The cost estimate presented in Table 39 is based on a 400 gpm capacity unit and is based on vendor quotes. The capital cost of the unit is \$423,976 for the 100,000 gallon discharge application. No pretreatment costs for removing solid matter, grease, or

metals are included. This assumes that the technology is intended for use on only clean refined product pipelines or light hydrocarbons. The high costs of this treatment technology compared to other options will also likely make it unacceptable from an operational standpoint.

ESTIMATED CAPITAL/OPERATING COSTS

Table 40 is a summary of the estimated capital and operating costs of each technology, and for each of the three chosen hydrostatic test water discharge volumes. These cost estimates have an accuracy of +/- 30%. Also shown in Table 40 are figures representing cost per gallon of water treated. The costs in the column labeled "Estimated Costs" are based on the costs presented in Tables 28 through 39.

The following assumptions have been utilized in developing these costs:

- Cost estimates are based on a combination of existing published literature such as GRI's *"Environmental Aspects Of Hydrostatic Test Water Discharges: Operations, Characterization, Treatment, And Disposal"*, vendor quotes, and best engineering judgement.
- Unit cost estimates assume a one time use of the equipment with no reuse, amortization of costs, or depreciation cost recovery.
- All wastes associated with pre-pigging/pre-washing and haybale treatment are non-hazardous.
- No costs are included for installing pig launchers and receivers for pre-pigging/pre-washing.
- No costs have been included for disposal or regeneration of activated carbon.
- No costs have been included for the installation of air emission control technology for the air stripping treatment option.

Section 6

TEST WATER MANAGEMENT OPTIONS

Several alternative hydrostatic test water management options which are practical and logistically feasible were identified during the industry survey and literature search. Detailed research has not been conducted on these options but they may have potential benefit in evaluating alternatives to conventional end of pipe treatment approaches. These options are listed below for consideration in future hydrostatic test water projects:

PRETREATING INLET WATER TO THE PIPELINE SYSTEM

Inlet water to the pipeline system may contain significant contaminants such as suspended solids, high iron levels, and may even contain some oil and grease and other organics depending on the source. Many discharge permits do not take into consideration the inlet water loading level for a hydrostatic test with regards to permit compliance. Filtering the water or otherwise treating it to remove inlet contaminants may be of considerable value particularly if the source water has a high level of suspended solids. Where the permitting agency is agreeable and the inlet water and discharge water bodies are the same, discharge limits should be set based on the net contribution of the pipeline discharge rather than the absolute value of the discharge contaminants. This permitting approach addresses the contribution of the constituents in the pipeline and not those that are in the inlet water.

UTILIZING REFINERY, TERMINAL, OR PLANT WASTE WATER TREATMENT SYSTEMS

Avoiding an actual hydrostatic test water discharge all together may be the best alternative of all if accessibility to a refinery, terminal, or plant waste water treatment system exists operationally. Utilizing a fixed waste water treatment system and an existing NPDES permit greatly increases the chances of compliance since these systems can usually handle fluctuations in inlet concentrations much more effectively

than an end of pipe treatment in the field. Furthermore, this approach avoids the need for a separate NPDES discharge permit and thereby can reduce the overall project time by avoiding delays in the application process.

DISCHARGE TO A MUNICIPAL POTW

Another option for utilizing an existing NPDES permit is to discharge to a municipal POTW. This option is excellent where access to the system is possible and the municipality agrees to accept the discharge. This approach will typically require fees to be paid to the city based on the volume and contaminant level in the discharge. An analysis of the water will also be required by the city; therefore, some estimate will have to be given of the contaminant level based on past experience. This is another option that can reduce project time as long as arrangements with the city can be made effectively. Municipalities in some instances may also require a permit application which must be considered relative to other management options. Discharges to a POTW may have discharge rate limitations which must be considered in the overall project timing and tankage requirements.

USE OF DILUTION WATER

Some members indicated that dilution water had been used as an option under certain circumstances. This approach is not prohibited under the NPDES program and may be an effective alternative where dilution water is available and can be introduced into the discharge. Use of dilution water must be reviewed with each respective state jurisdictional agency to ensure that there are no restrictions against this alternative. This option will likely have very limited application but certain circumstances may make it a viable approach.

PRE-PIGGING/PRE-WASHING

Prepigging and prewashing of pipelines is primarily used for preconditioning of pipe prior to the introduction of hydrostatic test water. A pig(s) is/are run through the system in single or multiple passes to remove oil and grease and scale. A wash solution

typically of mild detergent or just water is then introduced into the system between two pigs to further clean the pipeline. Waste material is collected from the pipeline system and properly disposed of in accordance with regulatory requirements. Hydrostatic test water is then introduced into the system for testing. Based on the limited data provided by the industry survey, it appears that prepigging and prewashing may be a viable treatment alternative in and of itself in some cases. Section 4 and 5 discuss this option in more detail. Tables 25 and 40 present both effectiveness and cost summary data regarding pre-pigging and pre-washing

WATER RE-USE

Storing water for reuse is also an effective strategy for the management of hydrostatic test water where tankage is available and accessible in the portion of the pipeline system being tested. Staging water from one section of the pipeline system to the next can also be employed to minimize the amount of water volume required for storage and ultimate discharge. This water can be stored indefinitely if there is an ongoing need for hydrostatic testing in this portion of the system. Water quality after multiple reuse will degrade over time, however, as long as it is contained and properly managed at the time of discharge this should not be an issue.

LAND DISPOSAL

Management of hydrostatic test water through land disposal is an alternative that may be appropriate under certain circumstances where other acceptable options do not exist. Land disposal will likely require a disposal permit from the respective state agency. Utilization of this option must ensure that the disposal waters are not hazardous and that they are contained such that there is no discharge which would make them subject to the jurisdiction of the NPDES permitting program. Depending on the volume involved, this management option may require considerable planning for storage and controlled discharge to ensure that test waters do not leave the site.