Exhibit 1

How ‘Landfarms’ For Disposing Drilling Waste Are Causing Problems In Texas

Dave Fehling

AUDIO

November 12, 2012 | 6:45 AM

By

Dave Fehling/StateImpact

Wildlife officer Jim Yetter led a criminal investigation of a site in Jefferson County

Landfarms are privately-owned but state-regulated fields where “low toxicity waste” is thinly spread then tilled into the soil. The tainted waste is supposed to degrade naturally.

In Texas, landfarms are used to dispose of the drilling fluid used to reduce friction as the drill chews through thousands of feet of rock and sand.

But a criminal case involving the operation of a landfarm near Beaumont raises questions about how the Texas Railroad Commission (RRC) is enforcing the state’s pollution laws.

A Criminal Case

The Texas Environmental Enforcement Task Force, run out of the Travis County District Attorney’s Office but with statewide jurisdiction, recently won a criminal conviction and a $1.35 million fine against the company that had operated the landfarm, Pemco Services, Inc.

“For over a decade the company was out of compliance with their permit and there was little done to regulate them,” said Patricia Robertson, the task force’s environmental crimes prosecutor.

Robertson credits the efforts of a couple officers from Texas Parks and Wildlife for investigating the site and then alerting her office.

Dave Fehling/StateImpact

A culvert pipe where investigators took samples of stormwater runoff from the site

“I don’t know why (the Railroad Commission) allowed them to operate for that many years,” said Jim Yetter, a game warden with the department’s Environmental Crimes Unit who became the lead investigator on the case.

Back in 2005 another game warden had checked the site and found what later was determined to be “the pumping of unauthorized stormwater from the landfarm into nearby Peveto Bayou” according to a court document. Tipped by that game warden, the Railroad Commission sent a letter to the site operators telling them to stop the discharge.

A few years later, Yetter decided to check the site himself to see if the discharges had, in fact, ceased.

“So in 2009 I came back to follow up and we were suspicious things had not been corrected,” Yetter told StateImpact.

The discharge was still flowing and things were far from corrected, according to prosecutor Roberterson.

Ignoring the Railroad Commission

“The company pretty much ignored the Railroad Commission,” she said.

The task force would later allege that from 2002 to 2009, a total of nearly 57 million gallons of drilling fluids were deposited on the landfarm in violation of the permit issued by the Railroad Commission. Yet the Commission, which has the power to take “enforcement action,” never did.

In 2010, the Texas Environmental Enforcement Task Force got search warrants to go on the site and take water samples. Prosecutors said lab tests confirmed the site was causing water pollution. They headed to court and eventually got a conviction and then earlier this month, a judge in Travis County imposed the big fine on Pemco Services, Inc.

The Commission Tells a Different Story

StateImpact Texas asked to interview officials of the Railroad Commission. No interview was granted but Commission spokesperson Ramona Nye emailed a response.

Nye said the Railroad Commission tries to get voluntary compliance to correct violations “before enforcement action is sought.” In the case of the Pemco site, Nye said the RRC staff fully supported the efforts of the task force and while the RRC had reserved the right to pursue enforcement on its own, Nye said the the Commission’s staff chose not to “as long as Pemco complied with Commission directives to stop accepting waste at the facility and to take actions necessary to close this site.”

Nye said that’s exactly what happened. She said RRC inspectors visited the site this past October and verified that the landfarm had been closed and cleaned up (prosecutors say the company spent $1.1 million on remediation and that despite the water pollution violations, there were no reported kills of animals or plants).

The Arkansas Experience

In 2009, problems with landfarms in Arkansas prompted an investigation there by the state’s Department of Environmental Quality (ADEQ).

The ADEQ looked at 11 landfarms and found that at all 11, drilling fluids had been “improperly applied” and were endangering the environment by causing runoff to the state’s waterways.

The ADEQ said it took enforcement action against all the sites, including revoking some sites’ permits to operate. What’s more, Arkansas toughened its regulations, adding requirements for periodic water and soil testing to be done “in the presence of an ADEQ inspector.”

What Texas Requires

In Texas, no permit is required as long as drilling fluids are disposed on the same site as the drill site. But in the case of commercial landfarms that accept waste from multiple sites, the Texas Railroad Commission says it has rules to ensure that runoff doesn’t threaten waterways.

These include testing the fluids as they arrive at the site to be sure they conform to state rules and then reporting the results quarterly to the RRC. The site is supposed to have monitoring wells to detect any migration of pollution. Well tests are the responsibility of the private operator who is expected to report results to the RRC, according to an explanation provided to StateImpact Texas.

Only when the site is closed do stricter rules kick in. The RRC says these include soil tests that must be conducted by “an independent, third party laboratory” to verify that the site can “support the future growth of vegetation.”

Exhibit 2

Tiny Nordheim Sues State Over Drilling Waste Dump

A tiny South Texas town is continuing its fight against an oil and gas waste site half its size, even after regulators gave its developer the go-ahead. Residents of Nordheim, population 316, are suing the Texas Railroad Commission.

BY **JIM MALEWITZ** AUG. 2, 2016 3 PM CENTRAL **SHARE**

A tiny South Texas town is continuing to fight plans for an oil and gas waste site half its size, even after state regulators gave developers the go-ahead to build it.

A citizen's group in Nordheim — population 316 at last count — is suing the Texas Railroad Commission, challenging the petroleum regulator's decision to permit a facility that would store waste including drill cuttings, oil-based muds, fracking sand and other toxic oilfield leftovers.

Filed late last month in Travis County district court, the lawsuit argues that the commission's three members erred in May when they unanimously approved the development by San Antonio-based Pyote Reclamation Systems.

It's the DeWitt County community's last-ditch effort to thwart the site, prolonging one of the first organized protests against industry activity in South Texas' Eagle Ford Shale. Residents say the project threatens their way of life.

"I'm hoping it'll stop it," said Paul Baumann, a retiree of the DuPont chemical company who owns ranch land bordering the waste site. "I was happy to see we had another option. I think the railroad commission was wrong."

Ramona Nye, a spokeswoman for the commission, said she could not comment on pending litigation but that "it is important to know that protection of public safety and natural resources is our highest priority."

Nordheim's yearslong protest has gained attention in state energy circles, if only because of residents' persistence.

It has also highlighted gaps in bureaucracy that prevented the commission, charged only with evaluating groundwater effects, from taking into account residents' other quality-of-life concerns. Those include the site's possible foul smell, new trucks expected to rumble down already cracked local roads and the facility's proximity to a school.

> "I'm hoping it'll stop it ... I think the railroad commission was wrong."
>
> — Paul Baumann, DeWitt County rancher

The waste site would include a mix of lined disposal pits and land treatment cells where more benign waste would be scattered and allowed to mix with soil.

Pyote says thick clay lies beneath the land, providing an extra layer of protection for the groundwater, and it calls the spot in question, which nudges Nordheim's border, ideal for waste disposal.

But folks in Nordheim don't want it. Over the past two years, more than 200 people — including local state lawmakers and DeWitt County Judge Daryl Fowler — have asked regulators to reject the permit.

Several times over the saga, dozens of residents — often wearing matching t-shirts — drove two hours north to Austin to voice their opposition before the commission. At one meeting, that included most of the Nordheim High Pirates senior class.

When the commissioners finally granted approval, Commissioner Ryan Sitton said he did not like the site, what with its proximity to residents. But he had no other choice but to approve it, he said, because experts at the agency determined that safeguards at the facility would properly protect groundwater in the area and because they could not evaluate other concerns.

George Wommack, Pyote's CEO, said that the facility, slated for construction in mid-2017, will be safe.

"We have taken great lengths to ensure our company has designed a facility that exceeds all of the regulatory requirements, and the Railroad Commission has ruled that we have done so," he said Tuesday. "We're very confident that the district court will uphold that ruling."

The 16-page lawsuit alleges that the commission erred in several ways when granting the permit — including by allowing Pyote to revise its application multiple times over the permitting process.

Allowing too many supplements violates agency rules, the lawsuit alleges.

Jim Bradbury, an environmental lawyer who has been involved in cases concerning other solid waste facilities, said Pyote's "fairly extraordinary set of amendments and supplements" suggested that its application was "a pretty big mess."

Still, the lawsuit would be hard to win, he said. "They have a slim chance of getting something based on procedural irregularities, but this is an administrative appeal of an agency decision, which carries with it a very powerful standard of deference to the agency."

Baumann said he was optimistic that the judge would side with his community, though he admitted he's not schooled in the case's finer legal points.

"It's just something to see how our legal system works," he said.

Exhibit 3

Nordheim loses fight as Railroad Commission OKs oil field landfill

Jennifer Hiller

While talking with state Rep. Geanie W. Morrison, R-Victoria, (right) Margie Hull of Nordheim (center) gets emotional Tuesday after the Texas Railroad Commission granted a permit for the Pyote Reclamation Systems of San Antonio oil field landfill on the outskirts of Nordheim in DeWitt County. More than thirty Nordheim residents attended the meeting. On the left is Janice Level.Jerry Lara /San Antonio Express-News

AUSTIN — The tiny town of Nordheim lost a key battle against the oil industry Tuesday morning when the three elected officials of the Texas Railroad Commission voted to approve the permit for an oil field landfill on the outskirts of their community.

The commission, which regulates the oil and gas industry, granted a permit for the landfill near the city limits of Nordheim in DeWitt County, one of the busiest parts of the Eagle Ford Shale oil field.

“Does your client understand the social license to operate they have asked for here?” Commissioner Ryan Sitton asked the attorney for the company that wants to build and operate the site. “I’ll be candid. I don’t like the site.”

But Sitton said the site met the state’s technical requirements, adding, “Don’t screw this up.”

Residents vowed to keep fighting.

The landfill would accept oil-based mud, soil contaminated by oil spills, and drill cuttings, as well as broken bits of rock and dirt that get drilled through on the way to finding oil and gas.

Nordheim, population 307, had put up a fight few others communities have managed to wage, with technical arguments that questioned site engineering.

The small town’s residents have held up the approval process for three years with their lobbying. They say the site is potentially hazardous and is too close to their city and just a half mile from their school, which has about 170 students. They also have raised questions about whether a big rain would send water from the site, which would be on a high point called Pilot’s Nob, into creeks and onto neighboring properties, and argued that the soil onsite could not be used to build berms that would hold water during a flood.

George Wommack, whose San Antonio-based Pyote Reclamation Systems hopes to build the waste facility, said the company took the concerns of residents seriously and designed a safe landfill. “It’s all about best practices. We’ve designed the best facility in South Texas,” Wommack said.

More Information

He would like to start construction to start in 2017. “We have two projects in the Permian Basin we’re focused on right now,” he said.

In the hallway outside the hearing, Nordheim residents gathered to commiserate, though they had expected the commissioner would not vote their way, and talk about their next move.

“We plan to go further,” said Lyn Janssen, who lives on Hohn Road, where the facility would be built.

The attorney for Nordheim residents, Marisa Perales, said they will file a motion for rehearing before the commission, and failing that, could consider going to district court in Travis County.

The fight has been waged since residents first heard about the project three years ago.

They wrote nearly 200 protest letters. They founded a group called Concerned About Pollution, the only one of its kind in the 400-mile oil field, and hired attorneys, geologists and chemical engineers to help them fight the application process in Austin. They have taken charter buses and showed up by the dozens at Railroad Commission hearings wearing bright yellow shirts that say in red letters, “Citizens Against Pyote Reclamation.” At one hearing, nearly all of their senior class, 11 students out of 14, showed up, too.

After residents raised questions about whether the site could handle catastrophic floods, the design was changed so that the stormwater ponds on site could handle hurricane-level amounts of rain, about 10.1 inches of rainfall in 24 hours.

In the last few months, residents also questioned the safety of a pipeline that crosses the site. They pointed out in a December hearing before an administrative judge that the pipeline company had never been notified about the project.

But the pipeline company earlier this year sent a letter to the agency, saying it had no issues with the landfill.

Many of the possible safety issues most upsetting to residents — the chance for increased truck traffic on a narrow road, the ability of its volunteer fire department to respond to a fire at an oil field landfill or the proximity of the site to Nordheim’s only K-12 school — are things that the state agency has said is beyond its purview.

State Rep. Geanie Morrison, R-Victoria, attended Tuesday's hearing to support residents and oppose the site, and said she was proud of Nordheim for putting up a technically complex fight against the permit. She told commissioners she understood that they couldn’t consider the ramifications of permits — an issue she said should be tackled in the next legislative session while the agency is under Sunset Review.

“It’s going to cause this community some real problems,” Morrison said.

Sitton visited Nordheim late last year, spending about a half day visiting with residents and seeing the site where the landfill would be located.

"He wanted to see the community himself to understand it," Morrison said. "Also, he was saying, 'This is our role. This is what we do.'"

The problem of waste in the Eagle Ford and where to put it has been a difficult one for communities, several of which have said they are worried that they will get a reputation as being a dumping ground. Drilling in the Eagle Ford generates a lot of water and solid waste that must go somewhere, but no one wants it to end up next to them.

Environmental engineers for Pyote said the land is close to ideal for this sort of facility — it's covered in a thick layer of clay, is not in an aquifer recharge area and has no wetlands. Under the terms of the permit, it would not be allowed to impact groundwater or surface water — all water would be contained on-site.

If it weren't for the protests, the facility long ago would have sailed through an administrative approval process with the Railroad Commission staff because it met the agency's technical requirements.

jhiller@express-news.net

Twitter: @Jennifer_Hiller

This report was updated to correct that the commission met Tuesday.

May 3, 2016|Updated May 3, 2016 10:53 p.m.

Photo of Jennifer Hiller
Jennifer Hiller covers the Eagle Ford Shale, the massive oil and gas field in South Texas. She previously covered real estate, development and architecture for the Express-News. Jennifer has worked at several newspapers across Texas, as well as at the Honolulu Advertiser and Arkansas Democrat-Gazette. She's a Houston native and a graduate of the University of Texas at Austin, where she received a degree in journalism.

Exhibit 4

Railroad Commission of Texas
Oil and Gas Division
Field Operations

Inspection Report
Inspection Request, Notification ID 326966
Inspection ID 1123207

Operator	Mcbride Operating, LLC (538006)	**Drilling Permit**	
Lease/Facility	Waskom STF Facility [06-STF - 0149]	**Pit Permit**	
Field		**UIC Number**	
County	HARRISON		
Complainant			
GPS Coordinates	Geodetic Datum: WGS 84, 32.4894 N, -94.1371 W		

Statewide Rules Inspected
Lease Level Inspection

SWR Rule	Compliance	Compliance Description
SWR 2(a), Access to Property	Compliant	
SWR 3(1), Entrance Sign	N/A	
SWR 3(3), Battery Sign; Commingling Permit	N/A	
SWR 8, Compliance with Permit Conditions	Non-compliant	McBride Operating, LLC is in violation of Permit Condition IV.E. 400 bbls saltwater tank leaking saltwater in the tank battery firewall.
SWR 8, Compliance with Permit Conditions	Non-compliant	McBride Operating, LLC is in violation of Permit Condition IV.D. Waste is placed in an unapproved location. Fluid separating tank and frac tanks.
SWR 8, Compliance with Permit Conditions	Non-compliant	McBride Operating, LLC is in violation of Permit Condition V.M.5. Collecting/Drying Pit (P012803C) has freestanding fluids.
SWR 8, Compliance with Permit Conditions	Non-compliant	McBride Operating, LLC is in violation of Permit Condition IV.D. Unpermitted collecting pit holding fluid waste. The pit is approx 5 feet x 5 feet x 3 feet.
SWR 8, Compliance with Permit Conditions	Non-compliant	McBride Operating, LLC is in violation of Permit Condition IV.D. Waste is placed in an unapproved location. New washout pit & catch basin.
SWR 8, Compliance with Permit Conditions	Non-compliant	McBride Operating, LLC is in violation of Permit Condition IV.D. Unpermitted collecting pit holding fluid waste. The pit is approx 3 feet x 20 feet x 2 feet.
SWR 8(d)(1), Unpermitted Disposal of Oil and Gas Wastes	Non-compliant	An unknown amount of saltwater was released on the ground from the new unpermitted pit. The saltwater traveled approximately 335 feet or more, north from the origin of the spill in a wooden area or possibly in a nearby creek.
SWR 36(c)(5)(B), Storage Tank Warning Sign	N/A	
SWR 91(d)(1), Remediation of Soil	N/A	

Comments

At the Northern side of McBride Waskom where the new unpermitted pit is located observed runoff saltwater that traveled further north from the pit into the wooden area. The salinity readings obtained from the free fluids are 20,000 ppm and higher. The salinity probe does not read extremely high readings of salinity. Joed McBride is aware of the pollution caused by operating the unpermitted pit. Mr. McBride has (2) operators and (1) dump truck working on the saltwater spill path. He was advised to clear the spill path on the wooden area, locate the end point of the contamination, and the creek for a back-check inspection the next day.

Inspector Information and Certification

I certify that the data included in this inspection is true and complete.

		Mileage	Time	Lunch
Inspector: Allan Barahona	**Start:**	41897	07:00	0 (Min)
Date: 07/27/2023	**End:**	41985	11:15	

Office Review

Reviewed By MICHAEL SORENSEN (182) **Reviewed Date** 07/28/2023

RAILROAD COMMISSION OF TEXAS
Oil and Gas Division/Field Ops
Site Remediation

District Office
INSPECTION REPORT
SITE MAP

D-A

ICE ID # 326966
DISTRICT 06

OPERATOR McBride Operating LLC **LEASE/FACILITY#** STF-0149

LEASE/FACILITY Waskom STF Facility **FIELD** N/A

COUNTY Harrison

I CERTIFY THIS DATA IS TRUE AND COMPLETE:

Allan Barahona

TECH NO. ______ DATE 07/27/23 Page ______ of ______

RAILROAD COMMISSION OF TEXAS
Oil and Gas Division/Field Ops
Site Remediation

District Office
INSPECTION REPORT
SITE MAP

D-A

ICE ID # 326966
DISTRICT 06

OPERATOR McBride Operating LLC

LEASE/FACILITY# STF-0149

LEASE/FACILITY Waskom STF Facility

FIELD N/A

COUNTY Harrison

I CERTIFY THIS DATA IS TRUE AND COMPLETE:

Allan Barahona

TECH NO. ________ DATE 07/27/23 Page ______ of ______

RAILROAD COMMISSION OF TEXAS rev. 11/21

Oil and Gas Division

Field Operations

Inspection Report Picture(s)

ATTACHMENT SHEET

NOTIFICATION NO. 326966

DISTRICT 06

OPERATOR **McBride Operating LLC**

LEASE /FACILITY # **STF-0149**

LEASE/FACILITY **Waskom STF Facility**

FIELD **N/A**

WELL NUMBER **N/A**

COUNTY **Harrison**

Vacuum trucks were unloading saltwater at the new unpermitted pit catch basin.

North view of the new unpermitted pit.

Fluids inside the new unpermitted pit appears to be saltwater.

The salinity probe does not read extremely high readings of salinity.

NAME: **Allan Barahona** **DATE:** **07/27/23**

RAILROAD COMMISSION OF TEXAS rev. 11/21

Oil and Gas Division

Field Operations

Inspection Report Picture(s)

ATTACHMENT SHEET

NOTIFICATION NO. 326966

DISTRICT 06

OPERATOR **McBride Operating LLC**

LEASE /FACILITY # **STF-0149**

LEASE/FACILITY **Waskom STF Facility**

FIELD **N/A**

WELL NUMBER **N/A**

COUNTY **Harrison**

saltwater spill path appears to originate from the unpermitted pit.

The salinity probe does not read extremely high readings of salinity. The readings were taken outside the unpermitted pit berm wall on the saltwater spill path.

The saltwater spill path north from the unpermitted pit (origin of the spill).

Image taken approximately 215 feet north from the origin of the spill looking south.

NAME: **Allan Barahona** **DATE:** **07/27/23**

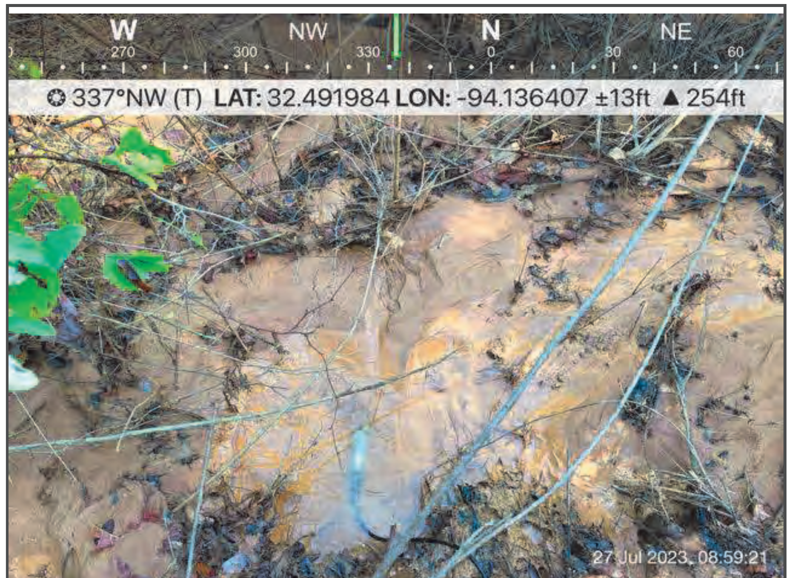
RAILROAD COMMISSION OF TEXAS rev. 11/21

Oil and Gas Division — **Inspection Report Picture(s)** — **NOTIFICATION NO.** 326966

Field Operations — **ATTACHMENT SHEET** — **DISTRICT** 06

OPERATOR	**McBride Operating LLC**	LEASE /FACILITY #	**STF-0149**
LEASE/FACILITY	**Waskom STF Facility**	FIELD	**N/A**
WELL NUMBER	**N/A**	COUNTY	**Harrison**

Image taken at the saltwater spill path entering the wooden area. The brush limbs and vegetation on the spill path appears to be death. Brush limbs black in color.



Freestanding fluids located approximately 335 feet north from the origin of the spill.

Freestanding fluids has a salinity reading of 20,100 ppm.

McBride operators are working on the saltwater spill path.

NAME: Allan Barahona **DATE:** 07/27/23

Exhibit 5

YSI 30 Conductivity Salinity Temperature Rental

Measures conductivity (0 to 200 mS/cm), salinity (0 to 80 ppt), and temperature (-5 to +95°C).

10ft. cable length.

Powered by 6 AA batteries, up to 100 hours of operation.

Product Overview

Downloads

Measurement	Range	Resolution	Accuracy
Conductivity	0 to 499.9 µS/cm 0 to 4999 µS/cm 0 to 49.99 mS/cm 0 to 200 mS/cm	0.1 µS/cm 1.0 µS/cm 0.01 mS/cm 0.1 mS/cm	±0.5% FS ±0.5% FS ±0.5% FS ±0.5% FS
Salinity	0 to 80 ppt	0.1 ppt	±2%, or ±0.1 ppt
Temperature	-5 to +95°C	0.1°C	±0.1°C ±1 LSD

Material	ABS, Stainless Steel, and other materials.
Power	6 AA-size Alkaline Batteries (included) Approximately 100 hours of operation from each new set of batteries Automatic shutoff after 10 hours operation without a key press
Water Tightness	Meets or exceeds IP65 standards
Probe Operating Environment	Fresh, sea, or polluted water and most other liquid solutions
Depth	0 to 10 feet
Meter Ambient Operating/Storage Temperature	-10 to +50°C
Adjustable Conductivity Reference Temperature	15°C to 25°C
Adjustable Temperature Compensation Factor for Conductivity	0% to 4%
Temperature Compensation	Automatic
Range	User selected or Autoranging for Conductivity

Exhibit 6

TEXAS STATE REVIEW

State Review of Oil and Natural Gas Environmental Regulations, Inc.

August, 2003

FORWARD TO THE REPORT OF THE TEXAS FOLLOW-UP REVIEW

The Oil and Gas Division of the Texas Railroad Commission (RRC) was initially reviewed in 1992. The report of that initial review, entitled Texas State Review, was published in April 1993 and contained specific findings and recommendations for action.

At the time of the initial Texas review, the RRC's general waste management standards were codified in 16 Texas Administrative Code (TAC) Chapter 3, §3.8 (known as “Rule 8”). This follow-up review was begun in June, 2002. Earlier in 2002, the RRC had published notice and had initiated rulemaking to adopt new comprehensive rules referred to in this report as Subchapter B, "General Waste Management" and to repeal Rule 8. Because the new Subchapter B rules appeared to address many of the recommendations of the 1993 initial review, and because adoption of the new rule appeared to be imminent, the STRONGER Board requested that the Review Team evaluate the RRC’s programs as if the new Subchapter B had been adopted at the time of the review. Pursuant to the Board’s direction, the Review Team reviewed the RRC’s programs and drafted its report as though the new Subchapter B rules had been adopted.

By October, 2002, the new Subchapter B rules had not been adopted, and it appeared to the STRONGER Board that adoption would not occur before the Texas follow-up review report was ready for publication. In November, 2002 the STRONGER Board requested the Texas Review Team to reconvene and re-write the draft report based upon the recommendations of the 1993 initial review, the current Guidelines and Rule 8. The Team re-convened in January, 2003 to re-write the report. The re-written draft report was circulated to the RRC and official observers for comment, was revised based on the comments received, and was submitted to the STRONGER Board in June, 2003.

TABLE OF CONTENTS

TEXAS FOLLOW-UP AND SUPPLEMENTAL REVIEW FINAL REPORT

INTRODUCTION

This document reports a review of the environmental regulatory programs of the State of Texas as the programs apply to wastes generated from oil and gas exploration and production (E&P) activities. The focus of the review was on the Oil and Gas Division (OGD) of the Texas Railroad Commission (RRC, or Commission) as the primary regulatory authority concerning oil and gas exploration and production activities in the State of Texas. The review also considered the other state regulatory programs administered by the Texas Department of Health (TDH) and the Texas Commission on Environmental Quality (TCEQ). In this report, references to the RRC include its legal support staff.

The Texas program was initially reviewed during 1992 pursuant to the 1990 EPA/IOGCC Study of State Regulation of Oil and Gas Exploration and Production Waste, otherwise known as the "IOGCC Guidelines." The report of that initial review, entitled Texas State Review, was published in April 1993 (the "1993 Review"). It contained specific findings and recommendations for action.

The IOGCC Guidelines were updated and revised by the Interstate Oil and Gas Compact Commission (the "IOGCC") in 1994. In 1999, administration of the state review program devolved to a non-profit, multi-stakeholder organization named State Review of Oil and Natural Gas Environmental Regulations, Inc. ("STRONGER"). STRONGER again revised, expanded and updated the Guidelines, which were accepted by the IOGCC and published in June 2000 as Guidelines for the Review of State Oil and Natural Gas Environmental Regulatory Programs (the "2000 Guidelines"). The current review was conducted pursuant to the 2000 Guidelines. The review covers RRC's responses to the recommendations of the 1993 review (contained in the Questionnaire Responses, attached as Appendix A), and the RRC's program as compared with the 2000 Guidelines.

At the time of the current review, Section 8 of the Guidelines (Performance Measures) was in the process of revision by the STRONGER Board. A draft version of the revised Section 8 was prepared prior to the review, and the RRC volunteered that its performance measures could be reviewed under the draft Section 8. That draft Section 8 is included in this report as Appendix B.

In June, 2002, an eleven-person team appointed by STRONGER conducted a follow-up review to evaluate progress made in the Texas program since the initial review, and to evaluate the adequacy of the program compared to the 2000 Guidelines. The eleven-person Team consisted of six members and five observers. Don Neeper of the New Mexico Citizens for Clean Air and Water; Terri Lorenzon of the Wyoming Environmental Council; Michael Schmidt of the Oklahoma Corporation Commission; Allan (Skip) Dees of ChevronTexaco; Bill Stevens of the Texas Alliance of Energy Producers; and Ilan Levin of Henry & Levin, Attorneys at Law; served as team members. Dan Derkics of the U. S. EPA Office of Solid Waste; John Ford of the U.S. DOE National Petroleum Technology Office; Mark Carl representing the IOGCC; and A. Scott Anderson of the Texas Independent Producers and Royalty Owners Association participated as observers. Three Team members, Terri Lorenzon, Michael Schmidt, and Skip Dees, had served on the initial review.

The in-state portion of this review was conducted in Austin, Texas at the offices of the Oil and Gas Division on June 18 through 20, 2002. Ms. Leslie Savage, Advisor/Planner, Planning and Administration of OGD, and members of the OGD staff responded to questions from the team and observers. Following the interviews and review of the written materials and backup documentation provided by the RRC, the review team compiled this report.

This report is presented in the order of the sections of the 2000 Guidelines. Each section of the report includes a follow-up review of the initial recommendations applicable to that section, and new findings and recommendations based on the 2000 Guidelines.

At the time of the initial Texas review published in 1993, the RRC's general waste management standards were codified in 16 Texas Administrative Code (TAC) Chapter 3, §3.8 (Rule 8). The RRC relied on Rule 8 in conjunction with informal guidelines, referred to as "rules of thumb", which were developed using the expertise of RRC staff, to implement its permitting, inspection, and enforcement program for waste management facilities. The 1993 review report included several recommendations that advised the RRC to adopt more specific standards for its regulated facilities.

At the time of the current review, Texas proposed to repeal Rule 8 and adopt new comprehensive rules referred to in this report as Subchapter B, "General Waste Management." The proposed Subchapter B rules included new siting, construction, operation, closure standards and many of the provisions of Rule 8, as well as new regulations. Along with the proposed Subchapter B rules, the RRC proposed to continue to use its own guidelines to supplement the new rules. Many of the "rules of thumb" were incorporated into the proposed new rules. Others have been incorporated into manuals and guidance documents that are readily available to the regulated community and the public.

On November 19, 2002, the Commission officially withdrew the proposed Subchapter B rule amendments from consideration. The RRC staff states that the proposal will be resubmitted to the Commission for consideration at a later date. The review team also considered amendments proposed on February 8, 2002, to Rule 94, Disposal of Oil and Gas NORM Waste, during its interview. That proposal was officially withdrawn on August 8, 2002, but re-filed on August 23, 2002. The Commission adopted the Rule 94 amendments, recodified as 16 Texas Administrative Code, Chapter 4, Subchapter F, Oil and Gas NORM, in February of 2003. These new rules became effective on March 3, 2003.

In this report, rule numbers refer to Rule 8 unless specifically cited as Subchapter B proposal. Rule 8(b) states: "No person conducting activities subject to regulation by the Commission may cause or allow pollution of surface or subsurface water in the state." The RRC relies on this language to impose requirements on site-specific conditions and to cite in enforcement actions. Texas regards this language as a baseline standard for all regulated facilities. If the RRC does not have a standard that specifically addresses a waste management issue, the RRC regards Rule 8(b) as the authority to pursue remedial action and penalties. The review team encourages the RRC to ensure the enforceability of this language in any revision or replacement of Rule 8.

PROGRAM OVERVIEW

History of the Texas Railroad Commission

EDITOR'S NOTE: Material supplied by RRC, and the 1993 initial review.

The Texas Railroad Commission (RRC) was created by the Texas State Legislature in 1891 to correct abuses and prevent unjust discrimination and extortion in the rates of freight and passenger tariffs on the different railroads in the state. By the time the RRC was created in 1891, the Texas oil industry had been developing for many years. L.T. Barrett struck oil at 106 feet in the first oil well near Melrose in Nacogdoches County, Texas, in 1866. Oil had been found in Texas before, but it was either through surface leaks or when drilling for water. The first known gas production was recorded from a well near Graham in 1872.

In 1894, the beginnings of the Texas age of oil were realized by the first major discovery—Corsicana in the east-central part of the state. The first true boom came from the 1901 Spindletop gusher of Anthony Lucas. The next cluster of discoveries was in North Central Texas between 1902 and 1920—Petrolia, Electra, and Burkburnett—and, during that same period, and a little further south – Breckenridge and Desdemona in 1918.

In 1901, when the first great gusher came in at Spindletop, the oil industry changed and so did the impetus for regulation of the industry. In the two years that followed the Spindletop discovery, 1,200 wells were drilled on the 200-acre Spindletop salt dome. Production from the first well was so enormous, approximately 100,000 barrels per day, that the price of oil in the small Texas oil market dropped to an all time low of $0.03 per barrel. The production frenzy that followed exceeded the capabilities of the limited pipeline and oil storage facilities. Thousands of barrels of oil were wasted while oil was stored in huge lakes supported by earthen dikes. Water pollution became a serious problem in the oil fields and fires were common.

Throughout these early years, whenever a well came in, oil seemed to cover the surrounding lands. The pressure of some of these wells was so great that it was days before the flow could be controlled. In the meantime, oil soaked into the ground, or ran off in nearby creeks and gullies, or was directed into nearby pits that were hastily dug. Even after the flow was controlled, pits or vast open tanks were used for storage. The results were inevitable—waste and pollution. While pollution may not have been a concern in those early days (oil was a sign of wealth and adventure even if it was in a creek), waste was. And, a fire roaring from one well to the next, engulfing one tank after another, was an all-too-frequent occurrence.

While the Texas Legislature in the 1800s and early 1900s had passed several bills relating to the use or conservation of the state's oil and gas, these laws were not enforced. In 1905, the legislature declared a state of emergency over the drilling, operation, and abandonment of oil, gas, and water wells. Subsequent to this declaration, other laws were enacted with the intent of preventing waste, but the legislature provided no effective way to enforce these laws.

Finally, in February of 1917, the RRC was given authority to regulate the oil and gas industry when the legislature declared oil pipelines to be common carriers. By this time, the power of the pipeline operators had grown to a level equivalent to that of the railroads when the RRC was created. In 1917, the pipeline operators had the same control over well operators that the railroads formerly had over farmers and ranchers who had to transport their goods to market.

In 1919, the Texas Legislature passed a law prohibiting waste and giving the RRC broad enforcement powers. The RRC created the Oil and Gas Division and issued rules that same year, including Rule 20, which required protection of fresh water. These rules continue to be a part of the oil and gas regulatory program today and they cover every phase of oil, gas, and geothermal field operations – from the permit to drill to the final authority to plug and abandon a well.

Regulation did not truly take hold until the 1930s and it was a struggle all the way. The East Texas Oil Field was discovered in 1930. Unlike many other fields at this stage of industry development, the East Texas Field was taken over by a multitude of small independent operators, each racing to put up a rig. Derrick touched derrick. Each well was produced wide-open. The price of oil crashed. More critically, the natural water drive of the field was being lost. When the RRC tried to step in and cut back production, action began in the courts and, at one point, State military forces were called in to regain order. It was several years before the courts and the State Legislature were able to settle on the position that the RRC had the right to prorate production—to conserve the state's natural resources, to protect correlative rights, and to prevent pollution.

Since the 1930s, the RRC has held the leading role in the regulation of oil and gas, and its responsibilities have increased significantly. Today, the RRC regulates energy, transportation, public safety, and environmental protection. To implement these programs, the RRC has the following regulatory divisions:

(1) Oil and Gas Division;
(2) Gas Services Division;
(3) Surface Mining and Reclamation Division; and
(4) Rail Division.

These divisions oversee the Texas oil and gas industry, natural gas utilities, pipeline safety, safety in the liquefied petroleum gas industry, surface mining of coal, uranium and iron ore, and reclamation of mined lands. Additional divisions provide services such as data processing, legal support, investigation support, alternative fuels research and education.

Oil and Gas Production in Texas

Texas is the leading oil producing state and the leading gas producing state. Texas provides 27% of the domestic onshore oil production, and 36% of the domestic onshore gas production in the United States. Based on latest available information from the United States Energy Information Administration, Texas has remaining proven oil reserves of 4.9 billion barrels and proven gas reserves of 40.8 trillion cubic feet.

Oil production in Texas peaked in 1972, when 1,263,412,000 barrels were produced from 167,223 wells. In 1999, crude oil production in Texas was 406.8 million barrels from approximately 162,620 oil wells. Average production was less than 7 barrels of oil per well per day. In 1999, Texas produced 5,539 billion cubic feet of natural gas from 59,088 wells.

Environmental Setting

The second largest state in the nation, Texas occupies 267,277 square miles (171,057,280 acres), about seven percent of the total water and land area of the United States. Of this total, approximately 167,624,960 acres is land and 3,432,320 acres is water. There are a total of 254 counties in the state, the majority of which have some production of oil and/or gas.

Extending from sea level at the Gulf of Mexico to over 8,000 feet in the Guadalupe Mountains of far West Texas and from the semitropical Lower Rio Grande Valley to the High Plains of the Panhandle, Texas has a natural environment best described as "varied." The geology and hydrology across the state is extremely variable. Even across much smaller areas such as a county, large differences occur.

Normal average annual precipitation range is from 58.3 inches at Orange on the Gulf Coast, to 8.8 inches at El Paso, in West Texas. Recorded temperatures range from a high of 120 degrees F in Monahans in 1994 to a low of –23 degrees F in Seminole in 1933.

Growing at a rate of 22.8%, Texas is the eighth fastest growing state according to the 2000 census. In 1999, Texas ranked first in states with the most farms and with the most land in farms.

Oil and Gas Division

The Oil and Gas Division of the RRC has responsibility for the prevention of pollution that might result from activities associated with exploration, development, and production of oil, gas, or geothermal resources of the State and to prevent operations dangerous to life or property. The RRC's environmental and safety programs cover drilling, operation, and plugging of wells; separation and treatment of produced fluids in the field or at natural gas processing plants; storage of crude oil before it enters the refinery; underground storage of hydrocarbons in salt caverns or natural gas depleted reservoirs; transportation of crude oil or natural gas by pipeline; drilling, operation and plugging of brine wells: and storage, hauling, reclamation, or disposal of wastes generated by these activities. Comprehensive regulations and programs covering these activities have been developed over the years. The RRC has revised and strengthened most of the major environmental and safety regulations within the last 10 years and has adopted several new regulations, such as rules for the protection of birds, disposal of NORM (Naturally Occurring Radioactive Material) waste, and management of hazardous oil and gas wastes. In addition, the RRC has a nationally recognized Waste Minimization Program to encourage and help industry reduce the amount and toxicity of the wastes they generate.

The RRC's environmental and safety regulations for oil and gas wastes are administered through the Environmental Services Section, the Site Remediation and Special Response Section, and the Field Operations Section, which includes the Well Plugging Section, of the Oil and Gas Division. Environmental Services administers the RRC's permitting programs for management of wastes which includes surface storage, disposal, enhanced recovery wells, underground hydrocarbon storage, and brine mining. The Environmental Services Section also coordinates with other state and federal agencies on environmental and safety matters. The Field Operations Section coordinates the activities of nine (9) district offices in inspecting oil and gas operations and enforcing the RRC's environmental and safety rules. Well Plugging and Site Remediation and Special Response Sections handle the plugging of abandoned wells and the cleanup of abandoned surface sites using a special Oil Field Cleanup Fund, which is supported by the oil and gas industry through various fees, taxes, and penalties. The Site Remediation and Special Response Section also administers the Operator Cleanup and Voluntary Cleanup programs and coordinates the RRC's response to large spills.

The RRC enforces its regulations through various mechanisms, including notices of violation, pipeline severances, sealing of wells, and penalty action. The RRC also has authority to pursue criminal action, particularly as a result of violation of the hazardous oil and gas waste regulations.

Waste Management Issues

One of the greatest responsibilities of the RRC is the protection of water resources. Water protection is a consideration in many of the RRC's Statewide Rules and is the primary purpose of Rule 8. The varied climate, topography, geology, and hydrology are just a few of the factors that make water protection on a statewide basis a complex problem.

Past efforts have been successful in eliminating major sources of pollution. Texas regulation of E&P wastes historically focused on management of the large volumes of produced water. Nearly all intentional discharges of oilfield salt water into surface waters have been eliminated. In 1969, the statewide elimination of pits for disposal of oilfield-produced saltwater greatly reduced the pollution. Yet, the effects of such pit disposal are still evident today.

Approximately 5.5 billion barrels of produced water were generated in Texas in 1999. Virtually all produced water is re-injected, either for enhanced oil recovery or for disposal. Enhanced recovery operations wells (39,281 wells at the end of 1999) accounted for over 75% of all injection wells (52,311 injection wells.) The small volume of produced water remaining is discharged under federal permits and RRC discharge permits issued under Rule 8. These discharges include discharges of produced water from four formations in Texas that are freshwater-bearing and which have been authorized under EPA Region 6, General Permit TX6290000, and discharges of produced water from wells in the territorial seas of Texas.

Wastes from oil and gas operations are managed on-site or treated or disposed at a wide range of off-site facilities.

At this time, there are 196 gasoline plants, three pressure maintenance plants, three cycling plants, and 1,275 dehydration, scrubber, compressor, separators, and drip facilities in Texas. Texas has 36 gas storage facilities and 160,000 miles of RRC-regulated pipelines.

PROGRAM HIGHLIGHTS

The Texas program is, overall, a well-managed oil and gas environmental regulatory program. The Review team noted several aspects of the Texas RRC and its operations that merit special recognition, and that may offer ideas for other state regulatory programs.

Data Management

The RRC is at the forefront of data management and processing capabilities with its ECAP program for permitting well drilling, recompletion, and reentry via on-line filing. This involves permitting and tracking authorized facilities. Electronic filing, permitting, imaging, geographic information systems and internet data transfer and access are all part of this system-wide development. The RRC allows both electronic submittals and electronic review of permit applications. This reduces the creation of paper copies. Introduced in May 2000, the RRC has processed 700 to 800 drilling permits filed in this manner. The RRC is re-engineering its work processes and then will re-engineer the data management system to support its processes, rather than allowing data management to dictate work processes.

Mapping Capabilities

Since the last review, the RRC and Texas' mapping capabilities have increased dramatically. In 1997, the OGD created a new Information Management Services (IMS) section, consisting of Well Mapping, GIS Projects, and Central Records, to facilitate electronic distribution of generations of valuable technical information on oil and gas fields and wells. IMS maintains multiple data layers in the GIS systems, such as surveys, highways, and rivers. New GIS layers may be created, or through a state cooperative effort, new GIS data layers may be imported from other governmental entities. The RRC participates in the Texas Statewide Geographic Information Systems program, the purpose of which is to build a carefully crafted organizational and technological infrastructure and to enhance Texas agency investments in GIS to support quality decision-making throughout the state. More information can be found on the Texas Geographic Information Council web site (http://www.tgic.state.tx.us), including the latest statewide plan. GPS devices have been purchased for each District Office and most inspectors have these devices.

Waste Minimization

The RRC has an excellent waste minimization program that gives practical information to operators to assist them in handling wastes by means other than disposal. The RRC has the authority to regulate recycling and it is currently looking into developing incentives for this program.

The RRC Waste Minimization in the Oil Field Manual articulates the RRC program for recycling, product substitution, and source reduction, and reportedly has become the standard for development of waste minimization programs. RRC outreach for the program includes a brochure that will be included with all notices of violation that are issued. The Manual, in PDF format, and additional information on technical practices are available to the public on the RRC website. RRC staff developed a waste minimization training program that has been presented through workshops across the country. A video of the training program has been produced by the IOGCC and is available for purchase. The RRC does an Oil and Gas Regulatory Expo every year and waste minimization has been on the agenda. This information is available to other agencies and other states.

Voluntary Cleanup Program

Texas Senate Bill 310 (2001) authorized the Commission to establish a Voluntary Cleanup Program (VCP) to provide an incentive to remediate a site by removing liability to the state for lenders, developers, owners, and operators who did not cause or contribute to contamination released at the site but want to clean it up with Commission oversight. The Commission anticipates that developers and other persons interested in putting contaminated former oil field property to productive use will enter the program and reduce the number of sites that would otherwise have to be remediated using money from the Oil Field Clean Up Fund. Participants are expected to pay for the clean up and for Commission oversight costs. The Commission has adopted new 16 TAC Chapter 4, Subchapter D to implement this legislation. The RRC is to be commended for initiating and following through on this legislation.

Orphaned Site Cleanup Program

Texas' orphaned well and site abandonment program is aggressively funded and professionally administered. The program reflects well on both the Railroad Commission of Texas and its oil and gas industry supporters.

GENERAL CRITERIA
(2000 Guidelines Section 3)

The RRC proposed to repeal current Rule 8 and replace it with more comprehensive rules governing oil and gas exploration and production waste management. The new rules would have been codified as 16 TAC Sections 4.101 through 4.196, also known as Subchapter B. The new rules were published in the Texas Register on May 17, 2002, and the review team interviewed RRC staff in June 2002 concerning this proposal. The proposal was officially withdrawn by the RRC on November 19, 2002.

SUPPLEMENTAL FINDING 3.1

The proposed Subchapter B rules would have strengthened the waste management program administered by the RRC.

Except for oil spills in non-sensitive areas, Texas currently uses published guidelines to direct operator actions in the event of an unauthorized release. An exception is spill remediation in "sensitive areas" which are handled on a case-by-case basis. Rule 91 defines “sensitive areas” as areas that “include the presence of shallow groundwater or pathways for communication with deeper groundwater; proximity to surface water, including lakes, rivers, streams, dry or flowing creeks, irrigation canals, stock tanks, and wetlands; proximity to natural refuges or parks; or proximity to commercial or residential areas.” Proposed Subchapter B would have prohibited the siting of commercial facilities within a sensitive area. The definition of "sensitive area" is therefore very important for both siting of facilities and remediation of releases.

SUPPLEMENTAL FINDING 3.2

Although Rule 91 contains a very general description of factors that characterize sensitive areas, the regulations provide no operational definition of "sensitive area" by which it can be objectively determined whether or not a particular location is sensitive.

SUPPLEMENTAL RECOMMENDATION 3.2

The RRC should adopt an unambiguous, operational definition of sensitive area. (2000 Guideline 3.1 c.)

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ADMINISTRATIVE CRITERIA
(2000 Guidelines Section 4)

4.1.1 Permitting

The RRC has a regulatory mechanism in place to manage waste generated during E&P operations in an environmentally responsible manner. The RRC's regulatory mechanism relies on the issuance of individual permits, issue of permits by rule, registration of certain facilities, and notice of certain activities undertaken pursuant to rules. The program uses a combination of individual permits for commercial and centralized facilities and some "minor" waste disposal practices and rule authorized operations.

Individual permits are issued for commercial and centralized pit facilities where waste from more than one E&P operation may be stored and/or disposed. The RRC also issues permits to maintain or use pits for storage or disposal of oil field brines, geothermal resource waters, or other mineralized water. These would include saltwater disposal pits, emergency saltwater disposal pits, drilling fluid disposal pits, washout pits, gas plant evaporation/retention pits, collecting pits, skimming pits, landfarming pits, and discharge to surface waters.

The RRC continues to require that permit applications for all commercial and centralized facilities contain a construction plan, closure plan, and operating plan. There are no siting restrictions for the placement of these facilities specified in Rule 8. However, the proposed Subchapter B included Siting Standards for Permitted Pits and Landfarms. These siting standards would have included 100-year floodplains; residences or commercial business establishments not owned or operated by the permittee,;nearest public water supply well or domestic water well or irrigation water well or other well that supplies water for drilling; workover operations (landfarms only); thickness of tillable soil (landfarms only); depth to seasonal high water table; and distance to property lines.

The RRC staff continues to review topographic and geologic conditions during the permit review.—The proposed Subchapter B would have been more specific in its requirements for authorized pits to be lined where pollution is likely to occur if the authorized pit is not lined. The proposed rule outlined general construction standards and liner design, construction, and installation criteria. Currently, Rule 8 lists no specific topographic or geologic restrictions. Synthetic and natural pit liner materials, along with recommended pit bed preparation procedures, are discussed in the Water Protection Manual.

The RRC would have specified additional siting, construction, operation, and closure requirements for authorized facilities under the proposed Subchapter B. The RRC considered adoption of specific geologic, topographic, hydrologic, and other siting restrictions for authorized facilities in 1984. At that time, the RRC determined that the vast diversity of these conditions in Texas prohibited specific siting restrictions. The RRC relies instead on the knowledge, experience, and expertise of staff to impose site-specific restrictions. Since no specific notice of construction and use of authorized facilities is required, the RRC relies on surprise inspections and continual monitoring in the field as its chief enforcement mechanism. The RRC stated that all of its inspectors are familiar with the types of waste and materials that authorized pits and landfarms may contain.

1993 REVIEW FINDING II.1

RRC staff reviews permit applications and, as a matter of policy, considers the hydrology, geology, and climate at the site.

1993 REVIEW RECOMMENDATION II.1

The review team encourages RRC to continue considering site-specific conditions in the issuance of permits, and to continue requiring liners and other design features, when necessary, to prevent pollution and protect the environment and/or human health. (IOGCC 5.3.4.e.)

FOLLOW-UP FINDING II.1

The recommendation has been met.

1993 REVIEW FINDING II.3

As a matter of policy, RRC requires a conceptual design and an operating plan from an applicant as part of the application process. RRC requires closure plans for certain types of pits and landfarming applications.

1993 REVIEW RECOMMENDATION II.3

The review team encourages RRC to continue to require that permit applications for all commercial and centralized facilities contain a construction plan, closure plan, and operating plan. In addition, the review team recommends that RRC require a siting plan for these facilities. (IOGCC 5.7.2.2.a.)

FOLLOW-UP FINDING II.3

The recommendation has been partially met, but neither the RRC rules nor the Water Protection Manual require all of the siting information specified in the 1992 Guidelines. Supplemental Findings and Recommendations to address necessary changes in siting requirements are included in Technical Criteria.

The Texas legislature in 1999 adopted Section 2001.039 of the Texas Government Code, which requires that all rules and regulations be taken through a review and rule-making process every four years. If agency rules are no longer needed then they can be removed and if agency rules need to be re-adopted and/or revised, the agency can proceed to promulgate the rules again. This requirement provides the RRC the opportunity to evaluate rule authorized practices every four years.

1993 REVIEW FINDING II.7

RRC rules authorize reserve pits, mud circulation pits, completion/workover pits, basic sediment pits, flare pits, fresh makeup water pits, and water condensate pits.

1993 REVIEW RECOMMENDATION II.7

The review team recommends that RRC periodically evaluate the rule-authorized waste management practices in Rule 8 to determine whether a minor or individual permit should be required for certain practices. (IOGCC 5.3.2.)

FOLLOW-UP FINDING II.7

The recommendation has been met. The evaluation was done in the rulemaking process and is subject to agency evaluation every four years.

The RRC evaluated rule-authorized management practices when the Subchapter B proposal was developed. Proposed Subchapter B would have specified some minimum siting prohibitions and also would have required a person to line an authorized pit that is not specifically required to be lined if the RRC determines that oil and gas wastes or oil field fluids are likely to escape from the pit. The proposal contained additional requirements for one-time, on-site, rule-authorized landfarming of low chloride drilling fluids and cuttings.

1993 REVIEW FINDING II.8

The rules do not contain conditions related to the geologic, topographic, hydrologic, or other conditions of the site. Rule 8(d)(4).

1993 REVIEW RECOMMENDATION II.8

The review team recommends that RRC revise Rule 8 to include requirements applicable to authorized pits that are based upon specific geologic, topographic, hydrologic, or other conditions. (IOGCC 5.3.2.b.)

FOLLOW-UP FINDING II.8

The recommendation has not been met. A recommendation for more specificity in the rules with regard to geologic, topographic, hydrologic, and other conditions, such as proximity to schools, residences, and hospitals, is included in the Technical Criteria section.

Rule 8 does not impose any term limits for these facilities but does allow staff the discretion to impose such in the terms and conditions of the issued permit. The RRC's District Office personnel inspect commercial facilities on a frequent basis for any recurring violation that would cause the permit to be modified, suspended, or terminated. The Commission proposed term limits [no greater than five years] by rule on commercial/centralized disposal facilities and permitted surface water discharges under Subchapter B. However, the Subchapter B proposal did not impose term limits on permits for collecting pits or other non-disposal pits at commercial UIC disposal well facilities. Under the proposal, these would have continued to be valid for the life of the disposal well. RRC has determined that due to limited staff and other resources, that its efforts to prevent pollution would be more effective if it relies on its field inspection staff to verify compliance with the existing permit conditions rather than spend resources on paperwork.

Term limits for authorized pit facilities vary. Reserve pits and mud circulation pits containing fluid with a chloride concentration of 6,100 mg/liter or less and all fresh water makeup pits are to be closed within one year of cessation of drilling operations. When the chloride concentration is greater than 6,100 mg/liter, the authorized pit(s) must be dewatered within 30 days and closed within one year. Completion and workover pits are required to be dewatered within 30 days and closed within 120 days of the cessation of completion or workover operations. All other rule-authorized pits must be closed within 120 days of final cessation of use.

1993 REVIEW FINDING II.4

Pit permits, other than for commercial pits, normally do not have expiration dates.

1993 REVIEW RECOMMENDATION II.4

The review team recommends that RRC impose a fixed term limit on all of the individual pit permits it issues. The review team further recommends that RRC review the permits for all commercial and centralized disposal facilities no less frequently than every five years. (IOGCC 4.1.1.)

1993 REVIEW FINDING VI.15:

Except for disposal wells and associated pits, all offsite commercial and centralized disposal facilities' permits specify a finite term limit. The agency uses data and information consistent with the IOGCC technical criteria to approve or deny applications, to ensure compliance with permit conditions, and to order corrective actions.

1993 REVIEW RECOMMENDATION VI.15:

The review team recommends that RRC impose term limits in permits for all pits associated with commercial and centralized facilities and at municipal waste landfills. (IOGCC 4.1.1.)

FOLLOW-UP FINDING II.4/VI.15

The recommendation has partially been met, in that term limits are imposed as a term and condition of the issued permit for commercial and centralized Rule 8 facilities, other than those associated with UIC (Rule 9) facilities.

FOLLOW-UP RECOMMENDATION 4.1

The RRC should establish term limits for all individual pit permits it issues. (2000 Guidelines 4.1.1)

At the time of the 1993 review, processing time for permitted facilities was two to four months. Since that time the RRC developed guidelines for permit turnaround. The average processing time has been reduced to about one month. The average processing time will depend on several variables such as the completeness of the application when filed by the applicant and the number of permits to be reviewed. The RRC instituted new policies and procedures to streamline paperwork requirements to free up time for permit application review. For example, RRC instituted a policy of allowing automatic transfer of non-commercial pit permits, rather than requiring a new operator to get a new permit, in order to free up staff time for processing of new permit and commercial permit applications. The use of aerial photographs and better mapping tools has enhanced this process.

1993 REVIEW FINDING II.2

According to RRC personnel, the average processing time for pit and landfarming permit applications is two to four months. RRC has assigned only three staff persons to process pit and landfarming permit applications.

1993 REVIEW RECOMMENDATION II.2

The review team recommends that RRC employ additional personnel for permit application review to ensure that applications are processed promptly. (IOGCC 4.1.1.)

FOLLOW-UP FINDING II.2

The intent of this recommendation has been met. The RRC has not added additional personnel for permit application review. However, the RRC has amended several internal processes and supplied better tools for staff use. These changes have allowed the RRC to reduce the process review time and essentially meet the intent of the recommendation of the initial review team by reducing the process review time to a more acceptable level.

1993 REVIEW FINDING I.5

The review team finds that development of a NPDES and RCRA Subtitle C program will aid RRC in meeting its mandate to regulate E&P wastes.

1993 REVIEW RECOMMENDATION I.5

Although not required by the IOGCC Guidance, the review team encourages this effort.

FOLLOW-UP FINDING I.5

The RRC does not have delegated Subtitle C authority.

FOLLOW-UP RECOMMENDATION 4.2

Although not required by the 2000 STRONGER Guidelines, the review team recommends that RRC continue its efforts to obtain delegation of Subtitle C authority.

4.1.2. Compliance Evaluation

The RRC has a comprehensive compliance evaluation and enforcement program for permitted facilities. The RRC conducts comprehensive investigations of facilities and activities subject to regulation in order to identify failures to comply, and staff routinely inspects these facilities at a frequency commensurate to the risk to the environment and to health and human safety. These inspections are unannounced and may include waste sampling, facility monitoring and compliance investigations. The public is encouraged to report alleged violations. When the RRC identifies an enforceable violation, it does have all the necessary tools available to require compliance with permit terms and general rules. These include immediate shut down of operations, implementation of emergency measures to protect the environment, the issue of administrative orders to correct conditions or impose fines, and the revocation or suspension of the permit.

The Texas State Legislature passed House Bill 1407, 1995, which amended Section 91.114 of the Texas Natural Resource Code. The amendment expanded the RRC's authority to deny and or revoke permits to operators having unresolved violations under order. The violations include all those issued by the RRC under Chapter 85 or 91 of the Texas Natural Resources Code or Chapters 26, 27, or 29 of the Water Code. The RRC does not accept the filing of any drilling permit applications from operators having unresolved violations. The RRC also does not accept other types of permit applications nor issue any certificates of compliance for those entities. The expanded authority also permits the RRC to revoke any previously issued permit, certificate of compliance, or organization report under certain limited circumstances. The law requires the RRC to review the person's compliance history, the seriousness of the violation, the health and safety aspects of the violation(s), and any demonstration of good faith before revoking any permit, certificate, or organization report. The RRC will flag an operator's P-5 (Organization Report, required of all persons conducting business under RRC jurisdiction) when the operator fails to comply with its orders. Prior to issuing any permit, the RRC will check the operator's P-5. The RRC will also check the operator's compliance history. Permits requested and facilities operated by persons with poor compliance histories are scrutinized more thoroughly. Subchapter B would have specified conditions under which permits may by revoked.

A company must list on its P-5 all officers who possess 25% or more ownership in the company. Although there is no mechanism to prevent a person from submitting more than one P-5 or simply changing from one entity's P-5 to another when compliance history prevents or limits the person from operating facilities, the RRC can track an individual's compliance history through the P-5 process. The RRC maintains two separate databases for compliance history. One is maintained by the central office and is available for review by the district office personnel. Separate databases are maintained by individual district offices. The data of a particular district are available only to personnel of that district. Minor permits are for short-term, one-time disposal of E&P wastes. Field personnel have personal knowledge of the compliance history of applicants for minor permits in their respective districts.

1993 REVIEW FINDING II.6

RRC has the capability to do a limited compliance history review before issuance of minor permits.

1993 REVIEW RECOMMENDATION II.6

The review team recommends that RRC expand its capability to evaluate an applicant's compliance history before issuing a minor permit. The compliance history review should determine whether the operator has any outstanding violations or unpaid penalties, or a history of past violations. (IOGCC 4.1.1.)

FOLLOW-UP FINDING II.6

This recommendation has been met.

There is no required separate notification of authorized pit construction and use. However, the RRC receives some prior notice when the Form W-1 (drilling permit) and Form W-3A (Notice of intent to plug) are filed. The permit to drill, deepen, reenter, or plug back is valid for two years from the date of issue and no further notice of operation is required from the operator. Once issued an operator has authority to construct and use any type of rule-authorized pit in conjunction with drilling, completion, and workover operations without further notice. The RRC places no restrictions on the placement of reserve pits relative to drilling operations so there may be some few instances in which these pits are not located within 200 feet of the wellbore. The Commission has no way to know, other than through inspections, when rule-authorized pits not directly associated with drilling, reentry, or recompletion operations are constructed and used, or when fresh water drilling mud is landfarmed on the lease away from the well site.

Operators are required to provide the RRC with 5-day notice of intent to plug a well and also provide at least a 4-hour telephone notice prior to commencing such operation. This notice allows the RRC to witness plugging operations and, while at the site, identify all facilities that require closure. The RRC feels that it is aware of (or reasonably able to determine) the location and construction of authorized pit facilities.

1993 REVIEW FINDING II.9

RRC does not inspect all reserve pit or other authorized pit disposal sites. Operators are not required to notify RRC of the construction or use of pits authorized by rule. RRC depends on its record of drilling activity to predict the existence and location of authorized pits.

1993 REVIEW RECOMMENDATION II.9

The review team recommends that RRC require that it receive prior notification of the construction and use of authorized pits in order to ensure that proper construction, operation, and closure methods are used to protect human health and the environment. (IOGCC 5.3.2.d.)

FOLLOW-UP FINDING II.9

The RRC has not changed its process from the initial review. This recommendation has not been met. The RRC does, however, receive implied notice of reserve pits, mud circulation pits, makeup water pits, and some completion/workover pits when it issues drilling permits (Form W-1). The RRC relies on the knowledge of the field staff for information on the location, construction, operation, and closure of all other authorized facilities. The RRC does not receive notice of rule authorized landfarming operations. The RRC does not believe notification would benefit the agency.

FOLLOW-UP RECOMMENDATION 4.3

The RRC should enact suitable requirements for prior notification of the construction and use of rule-authorized pits and landfarms in order to ensure that proper construction, operation, and closure methods are used to protect human health and the environment. (2000 Guidelines 5.5.2.d.).

4.1.3. Enforcement

Any violation of RRC's rules may subject an operator to an enforcement action. Field inspectors have many options for use to ensure compliance with the RRC's rules. Usually staff will attempt to resolve most violations in the field without having to seek formal enforcement actions against an operator. Field inspectors have a variety of enforcement options available to them. With some minor violations, they may simply contact, either verbally or in writing, the operator and request that the violation be corrected within a prescribed time. On other violations, the inspectors may immediately seek formal enforcement actions. These may include severance or seal of the facility and/or issuance of an administrative order levying a financial penalty and ordering correction of the violation and any subsequent remediation necessary.

The field inspection staff recommends enforcement actions through the District Director to the central office. Attorneys in the central office will review the documentation associated with the referral and confer with the appropriate staff concerning the precise violations to be filed. At the time of the initial review, RRC indicated a broad reliance on Rule 8(b) for enforcement actions. The RRC reports that 67% of all penalties assessed for violations are uncollectible by the RRC. During Fiscal Years 2001 and 2002, the RRC assessed $5,183,832 in penalties and collected $1,728,595. The RRC does refer all unpaid obligations to the Attorney General for collection. The Attorney General collected another $1,271,024 during those two fiscal years (includes assessments issued prior to FY01). Penalties are most often uncollectible because the company has gone out of business and has no assets.

4.2.1 Contingency Planning and Clean-up Requirements

Rule 20 requires the reporting of any spill of oil into water and any spill of oil or associated products on land greater than five barrels. The RRC does not specifically require the reporting of releases of produced water. It considers that spills must be cleaned up under current Rule 8(b) and proposed Subchapter B. Rule 98, Management of Hazardous Oil and Gas Waste, includes reporting requirements for hazardous wastes or materials that would result in hazardous wastes. The RRC does require a permit for cleanup operations and receives notice of spills through this process. Any unauthorized release of oil, associated products, hazardous substance, or deleterious substance is considered a violation. If the operator fails to properly remediate the release, enforcement actions can be brought against the operator, whether or not the release is causing pollution. Most of the RRC's enforcement actions with regard to spills involve the failure of an operator to clean up unauthorized releases.

Since the RRC receives no notice by operators having unauthorized releases of saltwater, the RRC relies on its inspection staff to find and cause such releases to be remediated where it is determined that the spills constitute a threat of pollution of surface or subsurface water. The RRC requires that all spills of crude oil in sensitive areas, condensate, or other contaminants under RRC jurisdiction be remediated to background unless otherwise approved through their spill cleanup permitting process under Rule 91(b). Thus, any operator causing pollution may be subject to a fine. The RRC contends that their current process works well in that only the people currently reporting would report under any rule developed to require reporting of saltwater spills. The recalcitrant operators not reporting now would also not report under any rule requiring such. The RRC believes that a saltwater release reporting rule would only result in a paper shuffle that would not benefit the industry or the RRC.

The RRC does have the ability to respond immediately to any spill that may cause a threat to human safety or the environment using the State Oilfield Cleanup Fund, and they have the authority or authorization to seek reimbursement of these expended funds.

1993 REVIEW FINDING V.2

Except for oil spills greater than 5 barrels and oil spilled to water, E&P waste spills are not required to be reported to RRC.

1993 REVIEW RECOMMENDATION V.2

The review team recommends that RRC amend its rules to require appropriate reporting of spills of E&P waste. (IOGCC 4.2.1.)

FOLLOW-UP FINDING V.2

This recommendation has not been met.

FOLLOW-UP RECOMMENDATION 4.4

The RRC should establish, by rule, a notification process for the appropriate reporting of releases of produced water and other E&P wastes not currently covered by the rules. (2000 Guidelines 4.2.1.)

4.2.2. Public Participation

RRC proposed rules are published in the Texas Register and are posted on their website. The RRC does not otherwise provide specific notice to the landowner or adjacent landowners of the issue of minor permits for waste disposal or of rule-authorized activities, other than the notice of the issue of a drilling permit. The RRC responds to all timely comments. Surface owners receive personal notice of the application for all permitted facilities. Adjacent landowners receive personal notice of applications for certain facilities. The public receives notice of applications for commercial facilities through newspaper publications. The RRC has expanded its list of stakeholders receiving notice of such activities.

The notice period for comment on most applications is 15 days. The notice period for rulemakings is generally 30 to 90 days, although notice of an emergency rulemaking can be as little as 15 days. The RRC believes that the notice period is adequate yet misunderstood. Any person desiring to protest or comment on a permit application is free to do so until that permit is officially issued. That period generally runs 20 to 40 days. Also, a person wanting to protest or comment does not have to present evidence or "be ready for court." The staff will accept any comment or protest at any point prior to issuing the final permit. If a protest is received, the application is placed on hold until the issue is resolved or until the application is presented at an administrative hearing and finally determined at open conference by the Commissioners. According to the RRC staff, a phone call is sufficient to stop the process. The RRC is also liberal in their interpretation of affected party in accepting comments and protests.

1993 REVIEW FINDING IV.4

RRC provides for at least 15-day public notice before issuing individual and one-time annular disposal permits for E&P waste management activities.

1993 REVIEW RECOMMENDATION IV.4

The review team recommends RRC evaluate whether the minimum 15-day notice period provides an adequate opportunity for citizen participation in permitting decisions. (IOGCC 4.2.2.1.)

FOLLOW-UP FINDING IV.4

The RRC has met this recommendation. The RRC evaluated the sufficiency of the 15-day notice and determined that the notice period was sufficient.

Rule 8(d)6(G) and the proposed Subchapter B allow the Director to determine whether notice of an application for a minor permit is or should be required. The RRC does, in practice, require notice and allow an opportunity for comment for certain minor permits, such as roadspreading and off-lease landfarming. However, most minor permits are short-term permits with no notice requirements. Under current Rule 8(d)6(G) a minor permit is valid for 30 days. In August of 1998, the RRC extended the term limit for minor permits from 30 days to 60 days to eliminate the need for an operator to get an extension when 30 days is not adequate. Proposed Subchapter B would have maintained this extension of the term limit for a minor permit at 60 days. Both rules allow minor permits issued without notice to be modified, suspended, or terminated at any time without notice or hearing. The RRC allows the District Directors the latitude to make a determination whether notice should be provided for some minor permit applications. Generally, notice for a minor permit, when given, is given to the affected landowner. Notice is not provided to adjacent landowners. Minor permit applications are put into a report to the head office and are available electronically to the RRC staff. The District Director will also determine whether the waste stream is "minor" based on volumes and characteristic. If the waste can be appropriately handled in 30-60 days, it is considered minor. The Districts handle all applications for minor permits with a record (log) sent monthly to the central office.

1993 REVIEW FINDING IV.5

Because there is no public notice requirement for minor permit applications, the public's opportunity to participate in RRC decisions on the issuance of minor permits is limited.

1993 REVIEW RECOMMENDATION IV.5

The review team recommends that RRC evaluate whether an opportunity to comment should be required for certain minor permit applications prior to issuance. (IOGCC 4.2.2.1.)

FOLLOW-UP FINDING IV.5

The RRC has evaluated whether opportunities exist for comments concerning minor permit applications. The RRC has met this recommendation.

Rule 8(d)6(C) requires notice of permit applications to the surface owner of the land in which the pit or disposal facility is to be located. If such land is within the limits of an incorporated city, town, or village, notice is also provided to the city clerk. The RRC proposed in Subchapter B to expand the notice requirements for commercial facilities to include mailed notice to landowners within ½ mile radius of the proposed facility and publication notice for commercial facilities. Section 91.116 also requires publication notice of any application for a "commercial surface disposal facility" and allows a public information hearing on an application for commercial surface disposal if it is determined to be in the public interest. If a protest is received prior to application approval, the application cannot be issued administratively until the protest is resolved. The applicant may withdraw the application, negotiate resolution with the protesting entity, or schedule a hearing. The RRC considers any protest a valid protest, and any party, whether receiving notice or not, may protest.

Although not specifically required by Rule, the Commission reports that written notice to adjacent landowners is required for permitting of facilities that would be characterized as large "centralized facilities" under the STRONGER Guidelines.

1993 REVIEW FINDING IV.6

RRC regulations do not require that adjacent landowners be given written notice of all applications for commercial or centralized E&P waste management facilities.

1993 REVIEW RECOMMENDATION IV.6

The review team recommends that RRC amend its rules to require that applicants provide written notification to adjacent landowners of permit applications for commercial and centralized facilities. (IOGCC 4.2.2.1.)

FOLLOW-UP FINDING IV.6

The RRC has not met this recommendation.

FOLLOW-UP RECOMMENDATION 4.5

The RRC should adopt rules to require that applicants provide written notification to adjacent landowners of permit applications for commercial and centralized facilities. (2000 Guidelines 4.2.2.1)

The RRC is very active in the area of disseminating program information to the regulated industry and the public. It provides several guidance documents concerning water protection and waste management practices, both on-line and hardcopy versions. The RRC provides educational seminars throughout the state to the regulated community and the public. The public has opportunities to participate in many of the various proceedings before the RRC including, but not limited to, rulemakings, permit application proceedings, and enforcement proceedings. The public also has access to the agency's staff and its records.

In the public outreach area, the RRC developed an Internet web site that became effective in December 1996. All of the RRC's current and proposed Rules are available at this web site. The RRC accepts comments on proposed rules through the web site as well. Additionally, guidance documents and manuals are also available for download. The RRC also expanded its list of persons to whom copies of the proposed rules are circulated. The list includes public advisory and environmental groups. In addition, the RRC holds numerous workshops to discuss proposed rulemakings and distributes informational summaries which include answers to frequently asked questions.

1993 REVIEW FINDING IV.3

Apart from the original rulemaking proceeding, there is no opportunity for public participation with regard to rule-authorized waste management activities.

1993 REVIEW RECOMMENDATION IV.3

<u>Although beyond the scope of the Guidelines</u>, the review team recommends that RRC consider whether it is appropriate to provide public notice of any rule-authorized activities.

FOLLOW-UP FINDING IV.3

This recommendation has been met. Notice is given of all well drilling permits in conjunction with which rule authorized pits may be constructed. Public participation occurs when the rule authorization is established.

Senate Bill 310, 2001, amended Chapter 91 by adding Section 91.1135, Oil Field Cleanup Fund Advisory Committee. The advisory committee has 10 members: the presiding officer of the senate committee with primary jurisdiction over matters affecting natural resources; the presiding officer of the house committee with primary jurisdiction over matters affecting energy resources; one public member appointed by the governor; one member appointed by the lieutenant governor from the academic field of geology or economics; one member appointed by the speaker of the house of representatives from the academic field of geology or economics; and the executive officer, or a person designated by the executive officer, of each of several industry and royalty owner associations. The task of the committee is to review the RRC's Oil Field Cleanup program and make recommendations to the RRC and the Legislature regarding the program.

The Guidelines recommend that the states should use advisory groups of industry, government, and public representatives to obtain input and feedback on the effectiveness of its program. Except for the Oil Field Cleanup Fund Advisory Committee, The Commission relies primarily on ad hoc workgroups for specific projects. The RRC attempts to balance workgroup membership by inviting all potentially affected stakeholders.

1993 REVIEW FINDING IV.12

RRC's information exchange with, and outreach to, the public falls short of meeting the IOGCC criteria.

1993 REVIEW RECOMMENDATION IV.12

RRC should consider establishing advisory groups with industry, government, and members of the public to obtain input and feedback on the effectiveness of aspects of RRC's E&P waste management program. (IOGCC 4.2.2.3.)

FOLLOW-UP FINDING IV.12

With the establishment of the Oil Field Cleanup Fund Advisory Committee and its ad hoc workgroups, the RRC has partially met this recommendation. The RRC staff believes that the Commission is prohibited from forming official standing advisory groups without specific legislative authorization.

FOLLOW-UP RECOMMENDATION 4.6

The review team encourages the RRC to establish volunteer, standing waste management advisory committees comprised of industry, government, and public representatives to obtain input and feedback on the effectiveness of aspects of RRC's E&P waste management program. (2000 Guidelines 4.2.2.3.)

4.2.4 Financial Assurance

The RRC, through recent legislation, will enact a new, more stringent financial assurance mechanism in 2004. Currently, operators have four options for complying with the financial assurance requirements. These are:

1) Option 1 – Bond in the amount of $2 per foot of depth of the well (only available for operators with wells).
2) Option 2 – Bond in a varying amount based on the number of wells operated
   a) 0 to 10 wells – $25,000
   b) 11 to 100 wells – $50,000
   c) 100 plus wells – $250,000
3) Option 3 – A $1,000.00 payment to the State's Oilfield Cleanup Fund, an acceptable record of compliance for the previous 48 months, and an administrative hearing to determine that options 1 and 2 are not available at a reasonable cost.

4) Option 4 – A 12.5% premium of the required bond amount under option 1 or two 2, whichever is less, paid to the State's Oilfield Cleanup Fund.

Options 3 and 4 also require the operator to file a W-1X (Temporary deferral of plugging requirement) with a $300.00 per year inactivity fee to the State's Oilfield Cleanup Fund for each well temporarily abandoned.

The RRC recognized that changes were necessary to the types of financial assurance mechanisms allowed. Texas' Orphan Well program has grown to about 17,000 wells and there are about 5,500 additional inactive wells operated by entities not in compliance with RRC well plugging rules. The average cost of plugging a well using the State's Oilfield Cleanup Fund is $4,500.00. Thus, Texas has a current plugging liability of $76.5 million and an additional potential liability of $24.75 million.

The RRC deliberated with all its stakeholders for more than a year to solve this problem. The proposed solution was the transition to universal bonding for all operators. The Texas Legislature, through Senate Bill 310 (2001), enacted this recommendation effective September 1, 2004. The RRC amended its financial assurance provisions under Statewide Rules 78 and 14 effective January 9, 2002. The Commission is considering Rule amendments to increase the bond amount for bay and offshore wells to cover the higher cost of plugging these wells. The RRC has authority to assess penalties for violations of its rules, including failure to properly plug a well or clean up a site. In fiscal year 2000, the RRC legal enforcement section processed 538 enforcement dockets

For the last ten years, most of the operators in the state have been eligible to provide an annual payment of $100 as financial assurance for their operations, plus a $100 annual fee for each inactive well. Virtually all of the wells that have been orphaned since this alternative to bonding was provided by the legislature have come from un-bonded operators using this form of "financial assurance." Beginning September 1, 2004, options 3 and 4 and the W-1X program will be eliminated in their entirety. This change will require 100% of the entities legally operating wells in Texas to be under a bond. The change will result in a reduction in number of current operators since not all operators will be able to afford and/or qualify for a bond. The RRC has begun its implementation of these changes as wells can now only be transferred to operators under Financial Assurance Options 1 or 2. There are now 2,000 more bonded operators than last year at this time. This is resulting in more marginal wells being plugged by larger operators and a reduction in the revenue stream available to the State's Oilfield Cleanup Fund.

During this transition period to full bonding, all operators have the option of filing a non-refundable annual fee equal to 12½% of the otherwise required bond amount. If the Commission determines that bonds are not available at reasonable prices, operators with an acceptable record of regulatory compliance for the preceding 48 months have the additional option, during the transition period, of filing a nonrefundable annual fee of $1000. A small number of operators have complained that this transition is creating a hardship for them and have proposed that the transition be relaxed; the Commission feels however that the transition is progressing as expected.

The RRC also requires commercial facilities to be bonded under Rule 78(r) (16 TAC3.78(r) relating to financial security for commercial facilities). This rule requires financial security in the form of a bond or letter of credit for commercial facilities and reclamation plants.

1993 REVIEW FINDING II.11

RRC has the statutory authority for, and is currently developing, a bonding program to ensure the proper operation and closure of reclamation plants and commercial E&P waste disposal facilities.

1993 REVIEW RECOMMENDATION II.11

The review team recommends that RRC develop bonding programs for closure of reclamation plants and commercial E&P waste disposal facilities. (IOGCC 4.2.3.)

FOLLOW-UP FINDING II.11

The recommendation has been met.

1993 REVIEW FINDING II.12

Roughly 60 percent of Texas operators take advantage of the $100 fee option. This fee option is being utilized primarily by smaller operators, some of whom may not have the financial resources to properly plug their wells and reclaim their disposal sites.

1993 REVIEW RECOMMENDATION II.12

The review team recommends that RRC review its rules to determine whether the program contains adequate incentives to ensure that operators properly plug their wells, reclaim their lease sites, and properly manage E&P waste sites. (IOGCC 4.2.3.)

FOLLOW-UP FINDING II.12

This recommendation has been met.

4.2.5. Waste Hauler Certification

The RRC requires all waste haulers to be permitted. Part of this permitting system is the establishment of facilities that any specific waste hauler may use. The waste hauler is only permitted or authorized to take waste to the specifically authorized facility. Rule 8(f)(2) and the proposed Subchapter B require that each oil and gas waste hauler maintain certain records showing daily oil and gas waste hauling operations under the permitted authority. The daily records must be dated and signed by the vehicle driver and shall show generally the same information that would be required on a manifest. The record must be available for inspection by the Commission and must be kept on file for at least three years from the date of the operation and recordation.

4.2.6. Waste Tracking

Rule 8(f)(2)(A) requires wastes haulers to maintain daily records showing the identity of the property from which the waste is hauled and to which the waste is delivered. The daily records shall include the type and volume of the waste transported and delivered. Rule 8(g)(1) requires the waste generator to identify the waste hauler transporting waste from each operated facility and the disposal system to which the waste was transported. The waste generator must also record the type and volume of the hauled waste. Both the waste hauler and generator must maintain these records for three years and make them available to the RRC upon request. There are no Rule 8 requirements for commercial waste disposal facilities permitted by the RRC to maintain records on types, quantities, and sources of disposed oilfield wastes, but the RRC does impose record maintenance and reporting requirements as a condition of the permit. The RRC can use this information, along with the information received from the generator and the hauler to develop a discrepancy report. EPA- and TCEQ-permitted waste disposal facilities to which some oilfield wastes are sent do have record keeping and discrepancy reporting requirements (e.g., 30 TAC §355.15, Recordkeeping and Reporting Requirements Applicable to Owners or Operators of Storage, Processing, or Disposal Facilities) and 30 TAC §335.117, Recordkeeping and Reporting.

Proposed Subchapter B would have maintained the current specified that when oil and gas waste is hauled by vehicle from the lease, unit, or other oil or gas property where it is generated to an off-lease treatment, handling, recycling, disposal or injection facility permitted by the RRC, each load shall be accompanied by a manifest, run ticket, or shipping paper. The person generating the waste, the hauler, and the treatment, handling, recycling, disposal, or injection facility would have been required to keep, for a period of three years from the date the waste is hauled copies of all such manifests, run tickets, or shipping papers. The manifests, run tickets, or shipping papers would have had to contain generally the same information that would be required on a manifest. Proposed subchapter B would have required discrepancy reporting upon discovery of any significant discrepancy in waste descriptions, volumes, place of origin, disposal locations or destinations, or other information based on personal observation or information contained in the manifest, run ticket, or shipping paper. The treatment, handling, recycling, disposal, or injection facility operator must submit a letter describing the discrepancy, and a copy of the manifest, run ticket, or shipping paper to the RRC and to the generator and hauler of the waste.

Many waste generators and haulers have developed their own manifest systems to comply with these requirements. The RRC did have many discussions with the waste generating and hauling industries and reviewed their processes and its requirements. The RRC determined that a 3-part form with one copy being submitted to the RRC was not beneficial enough to enact. The RRC believes that its efforts are better targeted at inspection and enforcement rather than this type of record keeping. Should the RRC enact such a requirement, it would be faced with an enormous task of reviewing and maintaining thousands of documents daily.

1993 REVIEW FINDING VII.2

While RRC does not have a three-part form, it does have a waste tracking system to document the movement of wastes from the site of origin to final disposition.

1993 REVIEW RECOMMENDATION VII.2

The review team recommends RRC finalize development of a three-part form to track E&P waste and require retention of the form by the operator for three years. (IOGCC 5.7.2.3.a. and b.)

FOLLOW-UP FINDING VII.2

The Guidelines have changed and no longer require the 3-part manifest system. The RRC is in substantial compliance with the 2000 Guidelines.

The RCC does not require waste haulers to attest on each individual manifest that there was no illegal dumping. As the RRC declined to adopt a three-part waste tracking form, any attestation cannot be a part of that form. The RRC waste hauling permit, includes a requirement that the operators follow the law and the permit also requires the waste hauler to properly train and educate its drivers as to the Rules of the Commission.

1993 REVIEW FINDING VII.3

RRC currently has no requirement for the disposal facility operator and hauler to "attest to no illegal dumping."

1993 REVIEW RECOMMENDATION VII.3

The review team recommends that the "attest to no illegal dumping" be made part of the three-part form being developed. (IOGCC 5.7.2.3.c.)

FOLLOW-UP FINDING VII.3

This recommendation has not been met. The RRC does not require an attestation of "no illegal dumping" on any documents required by the RRC. The waste hauler currently signs a permit application that states the hauler will follow the law.

FOLLOW-UP RECOMMENDATION 4.7

The RRC should require that waste haulers certify in writing on a manifest, run ticket, or shipping paper that no unauthorized wastes were dumped illegally or at a location or facility not designated by the generator and that no unauthorized wastes were mixed with the exempt waste during transport. (2000 Guidelines 5.10.2.3.c.)

1993 REVIEW FINDING VII.4

RRC does not require the reporting of discrepancies from the operator of a disposal facility receiving E&P waste.

1993 REVIEW RECOMMENDATION VII.4

The review team recommends that RRC develop a discrepancy reporting requirement. (IOGCC 5.7.2.3.d.)

FOLLOW-UP FINDING VII.4

The RRC has not met this recommendation.

FOLLOW-UP RECOMMENDATION 4.8

The RRC should adopt rules requiring the operator of a disposal facility to report waste management discrepancies. (2000 Guidelines 5.10.2.3 d)

4.2.7. Location of Closed Disposal Sites

The initial review team felt that the RRC should establish some mechanism to track authorized facilities. Since authorized facilities are closely associated with the wellbore, generally within 200 feet, the RRC only tracks the locations of the wells. The RRC does record wellbore locations, as well as locations of permitted pits and this information is available to the public. The only authorized pits that might not be located within 200 feet of a wellbore are some flare pits, some water condensate pits, and some small sumps. These are specialized pits that generally are used for short periods at a time during equipment malfunction, generally must be lined, and must be emptied and properly closed. The RRC believes that, as long as operators comply with the restrictions, the risk of pollution from this type of pit is not great enough to warrant the additional paperwork and data entry that would be required to maintain these pit locations.

1993 REVIEW FINDING IV.10

RRC does not have record for all rule-authorized pit locations that are located more than 200 feet away from the wellhead; hence, there is very limited public access to pit location information for those pits.

1993 REVIEW RECOMMENDATION IV.10

The review team recommends that RRC keep records of all pit locations and make them available to the public. (IOGCC 5.3.6.f.)

FOLLOW-UP FINDING IV.10

The RRC has not met this recommendation.

FOLLOW-UP RECOMMENDATION 4.9

The RRC should expand its record maintenance system to include data capture of location and type of authorized pits greater than 200 feet from a well. (2000 Guidelines 4.2.7., 5.5.5.f)

The initial review team recommended that the RRC develop a mechanism to track and record all minor permits issued for waste storage and disposal issued by the district or regional offices. The RRC did develop such a mechanism and the central office is now informed of all such permits.

1993 REVIEW FINDING II.5

RRC district offices are not required to notify the central office of the issuance of minor permits. Consequently, RRC has no central records for a large number of disposal practices.

1993 REVIEW RECOMMENDATION II.5

Although beyond the scope of the IOGCC Guidelines, the review team suggests that RRC require the district offices to notify the central office of the issuance of minor permits. The review team also suggests the RRC record minor permits in a central computer system.

FOLLOW-UP FINDING II.5

The RRC has met this recommendation.

4.2.8 Data Management

An effective data management program should include information about permitting, operation, and monitoring of E&P waste management facilities. The program should be able to determine if the facilities maintain effective waste disposal practices and include the ability to share information concerning facility operations. The RRC has made great strides in its data management capabilities. It has developed comprehensive data management program for well permitting, well location and construction information, complaint tracking, and enforcement actions. The RRC has also developed a very informative web site that contains all its current and proposed rules, guidance documents, and stakeholder comments.

The RRC is at the forefront of data management and processing capabilities with its ECAP program for permitting well drilling, recompletion, and reentry via on-line filing. This involves permitting and tracking authorized facilities. Electronic filing, permitting, imaging, geographic information systems and Internet data transfer and assess are all part of this system-wide development. The RRC decided to pilot with the drilling permit process. The RRC allows both electronic submittals and electronic review of permit applications. This reduces the creation of paper copies. Introduced in May 2000, the RRC has processed 700 to 800 drilling permits filed in this manner. The RRC is re-engineering its work processes and then will re-engineer the data management system to support that, rather than the other way around.

The RRC has developed and continues to modify programming capabilities to effectively and efficiently use the data that are available for statewide dissemination. Interested citizens can track permit applications on-line once filed. The requirement for public notification remains. Whereas, the waste disposal volumes and quantitative analysis are not on-line, the information concerning the facility permit is available. The system is also being expanded to include permitting for other activities, including UIC applications, workovers, and other types of permits and applications and will also be used for electronic filing of required reports. The RRC receives more than 2 million paper copy reports per year.

Enforcement information is available to staff making determinations concerning permit application through the docket database (IDOC) and the P-5 computer system. Field enforcement information is available to permitters through copies of notice of violation letters and inspection reports. This information is available to the district office personnel through the wide-area network. This information will be even more accessible after conversion of the RRC's Rbase databases to Oracle.

SUPPLEMENTAL REVIEW FINDING 4.10

The commission has recognized the longstanding deficiency in its information tracking capabilities, and has diligently pursued, through the legislative appropriations process, an effort to migrate its oil and gas information systems to an updated platform. When this happens, information will be more easily and systematically shared between field personnel and management.

SUPPLEMENTAL REVIEW RECOMMENDATION 4.10

The review team encourages RRC to diligently pursue efforts to upgrade its information technology to allow the district offices to routinely share information with management and the public. (2000 Guidelines 4.2.8.3, 8.2)

Texas reviews and approves proposed data access fees, and charges of copies, maps, and other reproduction services based on actual costs of production. Price schedules are posted on the website. Any data posted on the website for review and downloading is free of charge. The RRC has several standardized maps available on-line for downloading but the public cannot yet build maps on request. If the RRC receives a public request for other data that are not available on the web site or that requires additional programming, the RRC cannot specifically allocate resources for filling these requests. If the requests can be filled with minimum programming, the RRC will supply the information at its cost, including programming and replication costs. The RRC feels that the work it is completing on its new oracle system will make this process more efficient.

The RRC does back up its networked data on tape each night and stores these tapes in a vault. These data are restorable should a catastrophic event occur that damages the system or data. This backup system works well and would allow for only minimum loss of networked information. The data stored on individual personal computers are not backed-up by the RRC's data processing personnel. The RRC does have a formal retention schedule to which it adheres.

Since the last review, the RRC and Texas' mapping capabilities have increased dramatically. In 1997, the OGD created a new Information Management Services (IMS) section, consisting of Well Mapping, GIS Projects, and Central Records, to facilitate electronic distribution of generations of valuable technical information on oil and gas fields and wells. IMS maintains multiple data layers in the GIS systems, such as surveys, highways, and rivers. New GIS layers may be created, or through a state cooperative effort, new GIS data layers may be imported from other governmental entities. The RRC participates in the Texas Statewide Geographic Information Systems program, the purpose of which is to build a carefully crafted organizational and technological infrastructure and to enhance Texas agency investments in GIS to support quality decision-making throughout the state. More information can be found on the Texas Geographic Information Council web site (http://www.tgic.state.tx.us), including the latest statewide plan. GPS devices (136 units) have been purchased for each District Office and all field inspectors, as well as personnel in Site Remediation, plugging and other areas, have these devices.

1993 REVIEW FINDING VIII.1

RRC has both mainframe and PC data management capabilities for tracking E&P waste and is expanding use of that capability.

1993 REVIEW RECOMMENDATION VIII.1

The review team recognizes that RRC has developed an exceptional data management system and encourages RRC to continue to expand its use in E&P waste management by:

- Tracing enforcement information on-line, therefore, making operators' compliance history available to E&P waste permitters; and
- Increasing the availability and use of other state and federal resources of information such as information on groundwater, fish, wildlife habitats, and the location of other ecologically sensitive areas. (IOGCC 4.2.7.)

<u>Although beyond the scope of this review</u>, the team recommends outfitting RRC technicians with Global Positioning Devices, so that when inspecting various activities, technicians can acquire accurate information.

FOLLOW-UP FINDING VIII.1

The RRC should receive special commendation on their efforts regarding this recommendation. The RRC has met this recommendation.

FOLLOW-UP RECOMMENDATION 4.11

The Review Team encourages the Commission to continue to request the necessary funding for development of its GIS capabilities, migration of its records to its ORACLE database in integrated formats, online permitting capabilities, and improvement of public access to its records. The Team specifically encourages the inclusion of web-based data access to permitting, well location, production, and waste management (including spill and remediation) information.

The majority of the RRC's data management services are related to reservoir management-type applications, i.e., identification of surface location of wellbores, wellbore construction, production volumes, production tests, drilling permits, and inspection reports. There are sufficient data and data layers available to allow the RRC to create a comprehensive environmental management data system using Geographic Information Systems (GIS) integrated with global positioning information. Such a system would facilitate the issue of all environmental permits and environmental inspection performed by staff.

SUPPLEMENTAL FINDING 4.12

There are many databases available through various Texas State agencies and several data management system available that the RRC could acquire and use to develop a comprehensive environmental data management system to facilitate its permitting and inspection processes.

SUPPLEMENTAL RECOMMENDATION 4.12

The RRC should continue to acquire available databases from other Texas State environmental agencies and data management systems such as GIS programs and develop an integrated comprehensive environmental data management system.(2000 Guidelines 4.2.8.1.)

4.3. Personnel and Funding

4.3.1. Personnel

The RRC has a qualified and experienced staff. It has 12 districts operated through nine district or field offices. Each office has a Director, Assistant Director, engineers, geologists, field inspectors, pluggers, cleanup coordinators, H_2S coordinators, technicians, and administrative assistants. Its field inspectors live throughout the State and are assigned to work designated areas. The RRC has 81.5 FTE positions in its field inspection program available for general E&P inspection, investigation, and witnessing duties. It has an additional 33 FTE positions dedicated to the state's Oilfield Cleanup Program managing state and operator cleanups and site remediation programs. Texas has more than 350,000 sites, averaging about 5,000 sites per inspector. The goal of the RRC is to witness 75% of all operator plugging procedures and 100% of all Oilfield Cleanup Program plugging procedures.

To better use its limited resources, the RRC allows its field inspectors to work out of their homes. This lets them become very acquainted with the natural resources, oil and gas facilities and operators working in these areas. These "outriders" as the RRC terms them, communicate with their respective District Offices daily through the use of computer e-mail, phone, and mail and attend monthly district-wide meetings. The RRC evaluated its use of staff in late 1999 and early 2000 and reduced some paper duties to free up inspection time. This evaluation also resulted in a shifting of some inspectors to other districts to meet the critical needs.

Like most states, Texas is experiencing an inability to attract and retain qualified, experienced field personnel. The State is most affected when younger workers leave for better industry jobs when activity increases, and the long-term issue is the training of younger workers to assume senior management positions. This becomes more critical as current management staff reaches retirement age resulting in a loss of institutional knowledge. Texas is beginning to experience this problem and, in an effort to retain critical employees, the 77th Texas Legislature (2001) allowed agencies to offer retention bonuses to enhance the retention of classified employees. The bonus is not an increase in salary but a one-time payment of up to $3,000 to an individual employed in a classified position deemed as necessary to the operations of a state agency. The employee must remain with that agency in a classified position for 12 months after the date of the execution of a bonus contract. The need to retain the necessary classified employee must be adequately documented. More than 100 bonuses were offered to field inspectors.

The RRC is commended for its attempts to improve staff salaries and for its use of outriders to increase operational efficiency.

The RRC does not have a hydrologist in each field office, but relies on dissemination of technical expertise from its Austin office. Permitted landfarms are required to submit periodic reports as well as a closure report that is reviewed thoroughly by technical staff who may determine that additional field investigation is necessary. At closure of a facility such as a landfarm, an inspector ordinarily examines operator records (which are different from period reports and closure reports) only if there is a complaint or other indication of a problem from outside the program. By its own admission, the program often operates in a reactive mode. The state has approximately 5,000 open wells per inspector, and four staff persons to supervise approximately 650 operator cleanups. Additional technical and field staff are needed for adequate inspection, supervision, and enforcement. The RRC expects that senior, experienced staff will be departing during the next ten years. It will be difficult for replacements to mature on the job because much of the staff is transient, joining the RRC during times of low petroleum prices when the industry releases workers, and leaving the RRC when the industry hires personnel at higher wages than the RRC can pay.

1993 REVIEW FINDING I.6

The OGD [Oil and Gas Division of the RRC] has a highly-qualified, competent work force. The staff has efficiently managed increasing responsibilities with fewer people and fewer dollars. At this time, OGD needs additional funding and staff to more effectively administer and accomplish the goals and objectives of the E&P waste management program.

1993 REVIEW RECOMMENDATION I.6

The review team agreed that the State of Texas should continue to explore ways to supplement funding of OGD. The team supports the efforts of the RRC to increase staff positions and funding of OGD. In particular, the team supports the RRC's efforts to restore the ten planning positions lost by OGD, to place a hydrologist in each district office, to increase the laboratory facilities available to the district offices, and to increase the number of field inspection staff. The state should also seek to make salaries of its staff more competitive with non-governmental employers (IOGCC 4.3.1 and 4.3.2)

FOLLOW-UP FINDING I.6

This recommendation has not been met. Staff salaries are still not sufficiently competitive to assure retention and professional development of employees. In addition, the increasing reliance of the program upon rule-authorized activities rather than permits requires that the program have more staff to inspect situations and judge conditions. The RRC is commended for its attempts to improve staff salaries and for its use of outriders to increase operational efficiency.

FOLLOW-UP RECOMMENDATION 4.13

The State should make the salaries of its staff more competitive with industry, so that good employees are retained to become experienced senior professionals. The RRC should increase the number of staff available to advise operators, to inspect facilities, and to evaluate the wide variety of situations existing in the field. (2000 Guidelines 4.3.1)

SUPPLEMENTAL REVIEW FINDING 4.14

Funds have not been available for RRC staff training and travel. The RRC has used in-house training to bring the agency together for an exchange of information and education. However, as the RRC works to develop and keep skilled, motivated professionals, the opportunity for the staff to attend professional seminars, workshops, and meetings, some of which will inevitably be located out of state, will be essential.

SUPPLEMENTAL REVIEW RECOMMENDATION 4.14

The RRC should provide an on-going training program for RRC staff, particularly technical training for the field staff. The training program should include an in-house education component to take advantage of the expertise that exists within the agency.

The RRC employs 17 people for site remediation in its State Oilfield Cleanup Program. Eight of these are technical people with two managers, three administrators, one hydrologist, one toxicologist, and one geologist. This program is currently responsible for more than 1,600 abandoned sites. Also, the RRC witnesses more than 600 operator cleanups and directing more than 200 state-funded cleanups involving soil and groundwater pollution. The RRC indicated the need of at least four more additional technical people to assist with this program.

The initial review team recommended the RRC continued its development of the Field Operations Manual for its field inspection staff. The first printing of the "RRC's Field Operations Manual" was in early 1995. This manual was published in three ring binder form to allow for updating as required; the manual is currently in need of updating. The manual is available to the regulated community for their use as well.

1993 REVIEW FINDING IX.2

Memoranda, instructions, and procedures relating to inspections already available in the district files have been compiled into a draft field inspection manual that is now being reviewed by the districts.

1993 REVIEW RECOMMENDATION IX.2

The review team supports the development of this manual. (IOGCC 4.3.1.4.)

FOLLOW-UP FINDING IX.2

This recommendation has been met.

4.3.2. Funding

RRC oil and gas pollution prevention activities are funded through a variety of sources. It has three basic funds available for use: state general funds provided through appropriations, federal funds provided for various federal programs and grants, and the State Oilfield Cleanup Program fund. For its oil and gas waste management activities, the RRC receives annual funding of approximately $9 million from state general revenues, $1 million for the federal government, and $20 million from the State Oilfield Cleanup Fund. The State Oilfield Cleanup Fund is discussed in detail in Section 6.4 under Abandoned Sites.

The review team recognizes the statewide budgetary shortfalls being experienced by the State of Texas. These shortfalls have the potential of adversely affecting many vital programs across the State of Texas including, but not limited to, the various regulatory and environmental programs administered by the RRC. Like most State agencies, the RRC is expected to incur a 5 to 10 percent reduction in their upcoming fiscal year. The environmental waste management protection programs administered by the RRC are important programs governing one of the State's most important industries. Many problems currently being experienced are historic problems dating back to times when the RRC's waste management program elements were less comprehensive.

SUPPLEMENTAL REVIEW FINDING 4.15

The State of Texas is experiencing budgetary shortfalls and the RRC expects reduced funding through its general fund appropriations in the coming fiscal year.

SUPPLEMENTAL RECOMMENDATION 4.15

The State of Texas should ensure that the elements of its E&P waste management programs (permitting, compliance and enforcement) are sufficiently funded to maintain their effectiveness. (2000 Guidelines 4.3.2.)

4.4. Coordination Among Agencies

The RRC participates in numerous committees and councils. Representatives of public advisory and environmental groups are members of many of these committees or councils or often participate in the committee/council activities. These groups often provide input and feedback on the effectiveness of RRC's programs. Examples include the Texas Groundwater Protection Committee, Toxic Substances Coordinating Committee, the Texas Radiation Advisory Board, Coastal Coordination Council, Interagency Council on Coastal Spills, Oil Spill Oversight Council, Clean Rivers Act Steering Committee, Galveston Bay National Estuary Program and Corpus Christi Bay National Estuary Program. RRC staff also participated in the Strategic Texas Environmental Priorities Project, which was a comparative risk project.

The RRC interacts with other Texas State Agencies that have some jurisdiction concerning air and water quality, protection of wildlife, and naturally occurring radioactivity. The initial review team recommended that memoranda of understanding be developed with each of the various state agencies interacting with the RRC.

The RRC adopted an updated MOU with the Texas Natural Resource Conservation Commission (TNRCC) as Rule 30, effective May 31, 1998. Coordination between the two agencies concerning the issue of disposal of oil and gas wastes at municipal landfills was addressed in the revised MOU and in a guidance document (revised on January 1, 1994), which reflects additional requirements and restrictions for this type of waste disposal.

The public had an opportunity to comment on the MOU during the rulemaking processes of both agencies. Furthermore, each Texas State Agency is required under Texas Government Code Section 2001.039 (as added by Acts 1999, 76th Legislature, chapter 1499, Section 1.11(a)), to review its regulations once every four years. The public also has an opportunity to participate in this process.

The RRC has no formal MOU with Texas Parks and Wildlife Department (TPWD) or the Texas Department of Health. However, RRC reports that frequent informal contact with other state jurisdictional agencies, including TPWD and TDH at the working level is sufficient to provide the needed coordination. The regulatory functions (migratory birds, fish/wildlife toxicology, etc.) of these two Departments do not really cross into the regulatory jurisdiction of the RRC and the RRC sees little need to establish MOUs with either. The RRC receives information on biota studies conducted by TPWD, and can enforce its own Rule 22 for protection of birds without action by TPWD. The Team understands that an MOU between the RRC and the TDH is in discussion.

1993 REVIEW FINDING I.4

RRC participates in coordinating committees with the other state agencies that have responsibilities for waste management. RRC has finalized one MOU with TWC, has MOUs under development with TACB and GLO, and has developed a working document with TWC regarding disposal of E&P waste in municipal landfills. (Texas Water Commission (TWC), Texas Air Control Board (TACB), General Land Office (GLO))

1993 RECOMMENDATION I.4

The review team recommends that RRC develop MOUs with TACB, GLO, TPWD, and any other agency(ies) with which RRC must coordinate E&P waste management. All MOUs should contain a procedure for periodic review and revision of MOU. The pending revision of the TWC/TDH/RRC MOU should be finalized. The working document for waste disposal in municipal landfills should be finalized as an MOU. (IOGCC 3.1., 4.4.)

FOLLOW-UP FINDING I.4

The RRC has partially met this recommendation by establishing an MOU with the TNRCC (Now the TCEQ).

FOLLOW-UP RECOMMENDATION 4.16

The RRC should develop formal coordination procedures with Parks and Wildlife and the Department of Health through MOUs or other appropriate methods. (2000 Guidelines 3.1 e.)

1993 REVIEW FINDING IV.2

RRC has no formal mechanism for public participation in the development of MOUs with other agencies.

1993 REVIEW RECOMMENDATION IV.2

Although beyond the scope of the IOGCC guidance, one team member believes it necessary to make the following recommendation: RRC should explore methods by which the public could provide formal input into the process of developing MOUs.

FOLLOW-UP FINDING IV.2

Although this recommendation is beyond the scope of the guidelines, the RRC did develop the MOU with TNRCC (now the TCEQ). The TNRCC/RRC general MOU has been adopted by each agency as a rule. The public has an opportunity to comment on the proposed rules, as they are published in the Texas Register.

TECHNICAL CRITERIA
(2000 Guidelines Section 5)

5.1 General

The RRC's reliance on Rule 8, guidelines, and the expertise of the staff gives the RRC and operators considerable flexibility in siting, constructing, operating, and closing exploration and production sites. In the 1993 Texas review, the team expressed its concern with these general standards and recommended the adoption of specific technical standards for pits, landfarms, non-commercial, and commercial facilities. Although some flexibility in a program can be of benefit to the regulated industry and the state, additional information in regulations as to technical requirements for permits can facilitate the routine implementation of these practices by industry. The program will be more efficient as the state and operators know what is expected while site-specific conditions can continue to be accommodated.

Texas proposed new standards for disposal of water condensate; disposal of inert wastes; landfarming of low chloride water base drilling fluids; burial of water base drilling fluid, drill cuttings, sands, and silts; burial of completion/workover wastes; and disposal of sewage, storm water, and hydrostatic test water from new pipelines in Subchapter B. This revision would have set out new standards for rule-authorized pits, including siting standards, general construction standards, operating standards, and closure standards. Current Rule 8 prohibits, as would the proposed Subchapter B revision, pits used for the storage of oil or oil products (production pits), except in emergency situations. The RRC has continued to rely on Rule 8(b) in most enforcement actions. RRC staff has stated that this prohibition of pollution will continue to an important tool for enforcement, although other regulations will often be cited as a basis for enforcement action.

1993 REVIEW FINDING III.1

RRC relies on a very liberal application of Rule 8(b) prohibiting pollution of surface and subsurface water for site restrictions or prohibitions. This provided RRC with a broad tool for pollution prevention as long as it is enforced by a well-trained, well-qualified staff.

1993 REVIEW RECOMMENDATION III.1

The review team recommends that RRC continue its broad enforcement and liberal application of Rule 8(b), until specific site restrictions and prohibitions can be developed and implemented. (IOGCC 5.3.3.)

FOLLOW-UP FINDING III.1

This recommendation has been met.

The RRC does not have specific requirements for waste management facilities. Although the RRC proposed some siting, construction and closure standards for permitted pits, landfarms, and non-commercial facilities in Subchapter B, written standards to guide decisions on site suitability for minor permit applications do not exist. Operators are responsible for compliance with local regulations. When evaluating whether an area is sensitive, the RRC may review local land use regulations, but Rule 8, the guidelines, and proposed Subchapter B fail to specifically address land use regulations. Although the RRC staff considers site suitability for permit and minor permit applications, no written standards to guide these decisions exist.

1993 REVIEW FINDING III.3

In practice, RRC implements siting restrictions for permitted E&P waste facilities. The permit review process includes and addresses such issues as fluid makeup; depth to, and quality and quantity of, groundwater; wetlands; flood prone areas; surface contour; proximity to drinking water supplies and wells, surface water, residential and commercial buildings and schools; geological hazards; and other environmentally sensitive area.

1993 REVIEW RECOMMENDATION III.3

The review team recommends that RRC develop rules specifying site restrictions for the various types of permitted E&P waste management facilities. (IOGCC 5.3.3.)

FOLLOW-UP FINDING III.3

These recommendations have not been met.

1993 REVIEW FINDING III.4:

Some minor permit applications for waste disposal or storage may not be reviewed for site suitability.

1993 REVIEW RECOMMENDATION III.4

The review team recommends that RRC consider site suitability for all minor permit applications requesting authorization for waste disposal or storage at sites which are not already permitted for this activity. (IOGCC 5.3.3.)

FOLLOW-UP FINDING III.4

The recommendation has been met. All minor permit applications are reviewed, either by staff in Austin or in the District Offices, to determine site suitability.

FOLLOW-UP RECOMMENDATION 5.1

The RRC should develop siting rules that incorporate all the siting concerns addressed in 2000 Guidelines 5.1.e.

5.2 - Waste Characterization

Most waste management within the program requires waste characterization through process knowledge or testing of the waste. All permits - rule-authorized, general and minor - currently require characterization of the wastes to be managed under the permits. There are additional testing and characterization requirements for spill cleanup and site remediation, some of which are included in current oil and condensate spill guidance on the RRC website. Site remediation staff works with the permit staff to ensure that contaminated media is properly characterized, and that the remediation staff knows what to expect in the event of a cleanup or remediation action. RRC staff collects samples, using standard sampling protocols detailed in internal RRC guidance, and certified laboratories are hired to run the samples.

Proposed Subchapter B would have added more specificity as to waste characterization requirements and final cleanup standards. The standards proposed in Subchapter B would have set threshold standards for wastes handled by rule-authorized facilities and would have required complete testing and characterization for all general, or full, permits. Although not currently spelled out in Rule 8, RRC staff reports that testing and characterization are always required as permit conditions on full permits.

Testing requirements, including test methods, for air emissions from certain E&P facilities are found in the TCEQ regulations relating to air quality and human health. H_2S emissions are regulated also by the RRC, for protection of public safety, and require monitoring to make sure that safe limits are not exceeded.

SUPPLEMENTAL REVIEW FINDING 5.2

The Guideline standards have been met.

5.3 – Waste Management Hierarchy

The RRC Waste Minimization in the Oil Field manual articulates the RRC program for recycling, product substitution, and source reduction. A waste hierarchy has been established. RRC outreach includes a brochure that will be included with all notices of violation that are issued. The Manual is in PDF format on the RRC website and a download of technical practices is available to the public. RRC staff developed a waste minimization training program that has been presented through workshops across the country. A video of the training program has been produced by the IOGCC and is available for purchase. The RRC does an Oil and Gas Regulatory Expo every year and waste minimization has been on the agenda. This information is available to other agencies and other states.

The RRC has an excellent waste minimization program that gives practical information to operators to assist them in handling wastes by means other than disposal. The RRC has the authority to regulate recycling and it is currently looking into developing incentives for this program.

SUPPLEMENTAL REVIEW FINDING 5.3

The Guideline standards have been met.

1993 REVIEW FINDING VI.5

Low volume E&P wastes may be disposed of in those municipal solid waste landfills whose permits allow that disposal. Disposal of drilling fluids is allowed only at those municipal landfills specifically designed to handle such wastes.

1993 REVIEW RECOMMENDATION VI.5

The review team recommends that RRC issue permits for disposal of drilling fluids in municipal landfills only if a better option is not available. (IOGCC 5.1.)

FOLLOW-UP FINDING VI.5

This recommendation has been met. RCRA Subtitle D requirements for municipal landfills prohibit the disposal of fluids. Since this requirement has been in effect, disposal of drilling fluids in municipal landfills has become a moot issue. Disposal of other E&P wastes, such as drill cuttings, are allowed as long as no fluids are included. The TCEQ regulates municipal landfills and an MOU between the RRC and the TCEQ has coordinated the guidance on disposal of E&P waste in these landfills. This guidance also reminds operators that state law mandates a recycling rate of 40% and state policy considers landfill disposal as the least desirable method of disposal.

5.5 Technical Criteria for Pits

1993 REVIEW FINDING II.10

RRC allows the use of unlined basic sediment pits.

1993 REVIEW RECOMMENDATION II.10

The review team recommends that RRC prohibit the use of unlined basic sediment pits for the disposal of oily wastes. (IOGCC 5.3.5.1.)

FOLLOW-UP FINDING II.10

This recommendation has not been met. However, rules imposing a liner requirement and use and closure requirements for basic sediment pits were contained in the Subchapter B proposal.

FOLLOW-UP RECOMMENDATION 5.4

The RRC should adopt rules, including lining, use, and closure requirements for basic sediment pits. (2000 Guidelines 5.5.4. l)

Proposed Subchapter B included site restrictions, prohibitions, and construction requirements for authorized pits. The RRC currently receives implied notice of reserve pits, mud circulation pits, makeup water pits, and some completion/workover pits when it issues drilling permits (Form W-1) and when an operator files a Form W-3A (notice of intent to plug a well). The RRC relies on the knowledge of the field staff for information on the location, construction, operation, and closure of all other authorized facilities. The RRC does not believe notification would benefit the agency.

1993 REVIEW FINDING III.5

RRC does not consider site suitability for authorized facilities associated with drilling, completion, and production operations prior to the facility's construction and use. No notice from the operator to RRC is required prior to the construction and use of authorized facilities.

1993 REVIEW RECOMMENDATION III.5

The review team recommends that RRC develop rules specifying site restrictions, prohibitions, and construction notice requirements for the various types of authorized pits. (IOGCC 5.3.3.)

1993 REVIEW FINDING VI.7

General Standards for construction of pits are communicated to facility operators through RRC rules (Rules 8 and 22), the Water Protection Manual, and annual seminars held at several locations across the state. Other requirements may be included in facility permits.

1993 REVIEW RECOMMENDATION VI.7

The review team recommends that the regulatory standards for permit issuance in Rule 8 be amended to specify that:

- Pit size should be sufficient to ensure adequate storage until closure, taking into account historical precipitation patterns;
- Pit depth should be such that the bottom does not penetrate groundwater, or such that the pit contents do not adversely impact groundwater or surface water; and
- Berm height, slope, and material should be such that the pit is structurally sound, and that pit integrity is not compromised by terrain or breached by heavy rains, winds, seepage or other natural forces. (IOGCC 5.3.4.)

1993 REVIEW FINDING VI.8

Rule 8(d)(4) does not adequately define construction standards for rule-authorized pits. Criteria that are not addressed for all types of rule-authorized pits include size, configuration, liner requirements, siting considerations, etc. RRC staff has received permission from the Commissioners to develop Rule 8 amendments to more thoroughly define its technical criteria for rule-authorized pits.

1993 REVIEW RECOMMENDATION VI.8

The review team agrees that Rule 8 needs to be amended to define minimum construction standards for all rule-authorized pits. (IOGCC 5.3.4.)

FOLLOW-UP FINDING III.5/VI.7/VI.8

These recommendations have not been met.

FOLLOW-UP RECOMMENDATION 5.5

The RRC should adopt requirements specifying site restrictions, prohibitions, and construction, use and notice requirements for the various types of rule-authorized pits to protect human health and the environment. (2000 Guidelines 5.5.2.d.).

1993 REVIEW FINDING III.6:

RRC published a Water Protection Manual that provides some guidance as to what operators should consider in the construction and use of authorized and permitted facilities.

1993 REVIEW RECOMMENDATION III.6:

The review team recommends that RRC continues publishing and distributing the Water Protection Manual. (IOGCC 4.2.2.2.)

1993 REVIEW FINDING VI.4

RRC staff reviewing permit application use in-house guidelines ("rules of thumb") and their professional judgment to determine suitable and consistent technical requirements for facility construction, operation, and closure.

1993 REVIEW RECOMMENDATION VI.4

The review team recommends that RRC allow staff to periodically compile, publish, and update its in-house technical criteria "rules-of-thumb". (IOGCC 5.21 and 5.2.)

FOLLOW-UP FINDING III.6/VI.4:

These recommendations have been met. The RRC does compile, publish, and update the technical criteria in its various guidance documents, including the Water Protection Manual. Many guidance documents are now available through the RCC website and many of the "rules of thumb" were proposed for incorporation in the Subchapter B rules.

1993 REVIEW FINDING VI.9

RRC uses the individual permit process to impose the operating requirements suggested by the IOGCC Guidance. Some operating conditions for rule-authorized pits are contained in Rule 8(d)(3) and (4), but the rule does not contain all of the IOGCC-recommended provisions.

1993 REVIEW RECOMMENDATION VI.9

The review team recommends that general operating standards for permitted and rule-authorized pits be added to Rule 8. (IOGCC 5.3.5.)

FOLLOW-UP FINDING VI.9

This recommendation has not been met. While operating standards for permitted and rule authorized pits would have been included in Subchapter B, the proposed standards did not include all operational recommendations set out in the Guidelines.

FOLLOW-UP RECOMMENDATION 5.6

The RRC should adopt pit operation standards that address all the Guidelines standards. (2000 Guidelines 5.5.4b, c, d.)

1993 REVIEW FINDING VI.10

Pit closure requirements for rule-authorized pits meet some, but not all, of the IOGCC-recommended requirements.

1993 REVIEW RECOMMENDATION VI.10

The review team recommends that general pit closure standards for permitted and rule-authorized pits be added to Rule 8. (IOGCC 5.3.6.)

FOLLOW-UP FINDING VI.10

This recommendation has not been met.

FOLLOW-UP RECOMMENDATION 5.7

The RRC should adopt rules that meet the 2000 Guidelines. (2000 Guidelines 5.5.4m)

5.6 Technical Criteria for Landspreading

Rule 8 allows landspreading of low-chloride drilling fluids, drill cuttings and wash water as rule-authorized. Under Rule 91, rule-authorized landfarming of crude oil spills in non-sensitive areas is subject to immediate mixing to less than 5% tph and reduction to less than 1% tph within twelve months. Landfarming of other E&P wastes is permitted by the RRC on a case-by-case basis, in which information on the specific wastes and appropriate loading rates are considered. The RRC believes this limitation eliminates the need for testing of the waste and the receiving soils to determine appropriate loading rates. The authorization specifies removal of hydrocarbons, minimum proximity to surface water, maximum slope, and spreading in a manner that prevents pooling, ponding, or runoff of the waste, and requires disking into the soil as necessary to distribute solids present in the waste within the soil. There are specifications for pH, EC, and TPH for the final waste/soil mixture.

Rule 8 does not contain specific standards for landspreading. The proposed Subchapter B rules did not set loading rates, and testing prior to landspreading would not have been required. Operators would have been required to test the “final mix” to determine if the waste, when worked into the soil, would meet the standards. Operators are not required to test prior to landspreading unless there is a concern the background level of contaminants is higher than the standard. Rather than establishing loading rates, the RRC relies on the operator to develop a plan for loading that will result in a mixture that meets state standards Records of the sampling must be kept for 3 years and the results are not sent to the RRC. If a problem arises at the site of the landspreading, the RRC will review the records, conduct an inspection, and require remedial action.

1993 REVIEW FINDING VI.11

RRC has not adopted regulations or published standards specifically for land treatment of E&P wastes.

1993 REVIEW RECOMMENDATION VI.11

The review team recommends that RRC publish a guideline document for land treatment, including its current "rules-of-thumb" standards, and consider amending Rule 8 to include minimum operational requirements for land treatment. (IOGCC 5.4.3.)

FOLLOW-UP FINDING VI.11

The recommendation has been partially met. The absence of a loading rate is inconsistent with Guidelines requirements.

FOLLOW-UP RECOMMENDATION 5.8

The RRC should require testing of the E&P waste prior to landtreatment and the RRC should develop a standard loading rate. (2000 Guidelines 5.6.3.d and 5.6.3.i.)

5.7 Technical Criteria for Burial and Landfilling

E&P wastes are buried on-site only in closed pits; therefore, the standards are the same as for pit closure. Burial is rule-authorized for water-based drilling fluid; drill cuttings, sands, and silts obtained while using oil-base drilling fluids or water-based drilling fluids; and completion/workover pit wastes.

1993 REVIEW FINDING VI.12:

Factors considered by RRC in its review of an application for disposal of an E&P waste by burial are consistent with recommended regulatory requirements in the IOGCC Guidelines. There is no published guidance to operators on technical or performance standards other than the Rule 8(b) "no pollution" standard. The rule-authorized disposal of E&P wastes by burial (Rule 8(d)(3) and (4)) is generally consistent with the operational requirements in the IOGCC Guidance. The only significant exception is the absence of a requirement for rule-authorized burial pits to be lined, if the average salt or hydrocarbon content of the mixture being buried exceeds state-determined criteria unless the waste is solidified, fixed, or encapsulated.

1993 REVIEW RECOMMENDATION VI.12

The review team recommends that RRC publish a guideline document for burial of E&P wastes including its current "rules of thumb" on technical criteria, and consider amending Rule 8 to include the minimum operational requirements for E&P waste burial. IOGCC Guidance section 5.5.3.

FOLLOW-UP FINDING VI.12

This recommendation has not been met. Although the RRC, through proposed Subchapter B pit rules, wrote standards for waste burial, those proposed standards did not require maintenance of liner integrity when pits containing wastes are closed by burial.

FOLLOW-UP RECOMMENDATION 5.9

The RRC should provide operational standards, including maintenance of liner integrity, for burial of E&P waste. (2000 Guideline 5.7.3).

5.8 Technical Criteria for Roadspreading

Roadspreading is generally managed under a minor permit issued for spreading waste on lease roads. Roadspreading is limited to oily wastes, such as tank bottoms, wastes from reclamation plants, and some gas plant wastes. Although not required by rule, RRC practice is to require that the surface owner be notified of a permit application on a lease road. County commissioners must give written permission for roadspreading on a county road.

Guidance for roadspreading of reclamation plant waste and waste from gas plants has been developed in a memorandum that is available to the public. The memorandum provides the application requirements and analysis of chloride concentration and oil content that are required as part of the application. More extensive analysis may be required depending on the nature of the waste

1993 REVIEW FINDING VI.13

In practice, RRC appears to be applying technical criteria for roadspreading that are consistent with the IOGCC Guidelines. These criteria are not published in the Commission's regulations, Water Protection Manual, or other guidelines.

1993 REVIEW RECOMMENDATION VI.13

The review team recommends that RRC adopt minimum regulatory requirements for roadspreading, and that it publish its guidelines for roadspreading permit applications. (IOGCC 5.6.3.)

FOLLOW-UP FINDING VI.13

This recommendation has not been met.

FOLLOW-UP RECOMMENDATION 5.10

The RRC should adopt minimum regulatory requirements for roadspreading. (2000 Guidelines 5.8.2., 5.8.3.)

5.9 - Technical Criteria for Tanks

The RRC has jurisdiction over all tanks at E&P facilities, except hazardous waste tanks at gas plants. RRC does not have specific rules governing installation, maintenance or removal of waste tanks, except for fire prevention and public safety. The locations and sizes of tanks are gathered and maintained by TCEQ under air quality regulations and by TDH under SARA Title III regulations, but not in an electronic format. All storage tanks, including waste tanks at lease operations, are subject to the Rule 8(b) general prohibition against pollution and the Rule 8(d) prohibition on unauthorized disposal, including discharges and spills. In practice, the RRC also attaches special permit conditions for tanks located at centralized/commercial facilities. The permit requirements for tanks at commercial disposal well facilities address catch basins, allowable fabrication materials, maintenance, dikes, gauges, and alarms. Tanks must be maintained in a leak-free condition and must be emptied and repaired if necessary.

Corrosion protection is required only for hydrogen sulfide tanks under Rule 36. Rule 22 requires operators to screen, net, cover or otherwise render tanks harmless to birds. Rule 14(d)(12) requires tanks, vessels, and related piping and flow lines be emptied within 120 days of plugging a well, and all subsurface equipment less than 3 feet below the surface must be removed.

SUPPLEMENTAL REVIEW FINDING 5.11

The RRC partially meets the Guidelines requirements because some requirements are imposed through permitting.

SUPPLEMENTAL REVIEW RECOMMENDATION 5.11

The RRC should adopt rules relating to siting, construction, operation, removal and closure of E&P waste tanks. (2000 Guidelines 5.9.)

5.10 Technical Criteria for Commercial and Centralized Disposal Facilities

The RRC maintains that it is necessary to maintain flexibility to develop commercial and centralized facility permits on a case-by-case basis. Current requirements for construction, maintenance, operation, and closure are specific to the facility permits. These permits and the supporting information are available to the public. General guidance has been developed but the guidance has not been published. The guidelines that are used consist of permits that have already been issued. This case-by-case permitting process may be vulnerable to charges of inconsistency, and the public may not know what to expect in terms of commercial and centralized facility regulation.

Proposed Subchapter B would have required that applications for centralized and commercial disposal facilities must contain a description of the soil, the precipitation and evaporation rates, the depth to and quality of groundwater, and information regarding the proposed facility. Subchapter B would not have required that the application contain information on the permeability of the vadose zone, the direction of groundwater movement, baseline data on the quality of soils, and the baseline data on the quality of nearby surface waters, as required by 2000 Guidelines 5.10.2.2.b.v.

1993 REVIEW FINDING VI.19

All permits are reviewed and issued on a case-by-case basis with no restrictions or requirements established by rule.

1993 REVIEW RECOMMENDATION VI.19

The review team recommends RRC specify, by rule, construction, maintenance, operation, and closure requirements for commercial and centralized facilities. (IOGCC 5.7.2.2.(c)(d) and (e))

FOLLOW-UP FINDING VI.19

This recommendation has not been met.

FOLLOW-UP RECOMMENDATION 5.12

The RRC should adopt rules for construction, maintenance, operation, and closure for commercial and centralized facilities, including the plans enumerated in the Guidelines. (2000 Guidelines 5.10.)

Texas employs an air emissions permitting program, administered by TCEQ, to require facilities to control and minimize air emissions. TCEQ has established permits by rule at 30 TAC Chapter 106, Subchapter O for small salt water disposal facilities, oil and gas production facilities, sour gas treating facilities, and pipeline metering/purging/maintenance operations. Subchapter X has a permit by rule authorization for soil and water remediation projects. Larger oil and gas production and gas processing/treating facilities may install or modify facilities using the standard TCEQ permit located in Subchapter F of 30 TAC Chapter 116 if they meet the standard permit conditions.

All other oil and gas facilities (including most commercial and centralized facilities other than simple salt water disposal facilities) are required to be permitted under the TCEQ's normal New Source Review Permitting program. This permitting process considers such factors as the volatile organic compound emissions, particulate matter carried by the wind, chemical reactions (e.g., production of hydrogen sulfide from sulfur-bearing wastes), and health effects on people who might be exposed to the emissions. These same factors were considered in the development of the permits by rule and standard permits used in oil and gas operations.

RRC does not require operators to demonstrate that the facility has the required approvals from the TCEQ (which has the statutory authority to regulate air emissions). The RRC permits for commercial and centralized facilities do not include plans for preventing or minimizing air emissions other than of hydrogen sulfide, which is regulated by the RRC to protect the public from immediately hazardous releases of H_2S. Public safety concerns relative to air emissions are addressed by the RRC. Commercial and centralized facility permits are available to the public, and protests to issuance of a permit because of air quality concerns are normally filed with the TCEQ.

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ABANDONED SITES

(2000 Guidelines Section 6)

6.1 - Introduction

Statutory authority for the Commission to plug orphaned wells and clean up orphaned sites is found in Chapters 89 and 91 of the Texas Natural Resources Code (TNRC). The Texas Legislature in 1983 created a dedicated Well Plugging Fund with about $3 million in annual industry fees, increased the penalties for violations of environmental protection statutes, and gave the Commission the authority to act immediately to plug leaking wells.

By 1990, it was apparent that the Well Plugging Fund was not adequate for a growing number of orphaned wells and that there was a need for funding to cleanup orphaned oil and gas surface sites. Texas Senate Bill 1103 in 1991 rolled remaining monies in the Well Plugging Fund into a new $10 million/year Oil Field Cleanup Fund (OFCF), with expanded scope and industry fees. (See TNRC §§91.111-91.113) The fund is a dedicated account and receives revenue from the oil and gas industry in the form of fees for permits, oil and gas production regulatory fees, financial assurance collections, sales of salvageable equipment, reimbursement for plugging and remediation costs, administrative penalties, and civil penalties; a full list of the revenue sources is found in TNRC §91.111(c).

The same legislation required operator bonding, with the alternative of financial assurance fees paid into the OFCF. The Commission amended 16 TAC §3.14 (Rule 14) and 16 TAC 3.78 (Rule 78) to implement these changes. From Fiscal Year 1992 through Fiscal Year 2002, the Commission has used nearly $85 million from the OFCF to plug 15,306 orphaned wells and clean up 2,062 orphaned sites.

Some of the steps taken by the Texas Legislature and the Commission since 1991 to remediate abandoned sites and prevent additional wells and sites from being orphaned include:

1992: 16 TAC §3.5 (Rule 5) was amended to deny a drilling permit to an organization/officer with an outstanding final order for a safety or pollution violation.

1992: Rule 14 was amended to limit the number of time extensions an operator can receive before plugging a well without filing a bond.

1992: Rule 14 was amended to require testing of wells at least 25 years old and that have been inactive for more than a year to determine whether the well poses a potential threat to surface or subsurface waters.

1993: The Commission established a formal priority system - including additional environmental, wildlife, and human health factors - for plugging orphaned wells.

1993: 16 TAC §3.91 (Rule 91) was adopted to establish regulatory standards and procedures for cleanup of most crude oil spills.

1993: 16 TAC §3.83 (Rule 83) was adopted to implement new legislation providing a severance tax exemption for wells that had been inactive for at least three years and were returned to production. The statute (and Rule 83) was subsequently amended to provide this tax exemption to production from wells that had been inactive for two years. About 11,000 inactive wells have been returned to production under this program.

1997: The Commission expanded delegations of the Oil and Gas Division Director's approval and emergency response authority to provide more prompt response when a problem was identified.

1998: The Commission began bidding multiple well plugging/site remediation operations under one contract to expedite the work and reduce costs.

1998: The Commission amended Rule 78 and 16 TAC §3.57 (Rule 57) to require the owners and operators of reclamation plants and commercial disposal facilities to file financial security in an amount to ensure proper closure of the facility when operations cease.

2000: The Commission amended 16 TAC 3.1 (Rule 1) and 16 TAC §3.58 (Rule 58) to disqualify an operator from getting an organization report because of outstanding violations. (See TNRC §91.114.) An organization report is required to do any business regulated by the RRC.

2000: The Commission amended Rule 14 and Rule 78 to require an un-bonded operator to obtain a well plugging bond for any well inactive over 36 months and to prohibit transfer of any inactive well without a bond for the well or the new operator. Mechanical integrity tests were required for all plugging extensions by un-bonded operators.

2001: Texas Senate Bill 310 (Railroad Commission Sunset Review Legislation) increased the amounts of several fees dedicated to the OFCF to a projected $20 million per year, established "universal bonding" requirements for all facilities and inactive wells effective September 1, 2004, and made existing "interim" financial assurance alternatives for un-bonded inactive wells more costly and difficult to achieve. The Commission has amended Rules 14 and 78 to implement these legislative changes.

2001: Texas Senate Bill 310 authorized the Commission to establish a Voluntary Cleanup Program to provide an incentive to remediate a site by removing liability to the state for lenders, developers, owners, and operators who did not cause or contribute to contamination released at the site but want to clean it up with Commission oversight. The Commission anticipates that developers and other persons interested in putting contaminated former oil field property to productive use will enter the program and reduce the number of sites that would otherwise have to be remediated using money from the Oil Field Clean Up Fund. Participants are expected to pay for the clean up and for Commission oversight costs. The Commission has adopted new 16 TAC Chapter 4, Subchapter D to implement this legislation.

2002: The Commission has published a regulatory proposal to institute new bonding requirements for bay and offshore wells. Commission staff has considered public comments and is preparing an alternative proposal, which it will propose to the Commission for publication.

SUPPLEMENTAL REVIEW FINDING 6.1

Texas has been extremely proactive in addressing the issues relating to existing orphaned wells and sites, as well as in taking action to stem the growth of this problem.

SUPPLEMENTAL REVIEW FINDING 6.2

The Commission is to be commended for recommending legislation and developing a regulatory program for a voluntary cleanup program - with appropriate Commission oversight - for use by persons who are not otherwise responsible for orphaned well and site abandonment.

6.3. Identification of Abandoned Sites

In most cases, a well is identified as "orphaned" when it is not plugged within the time prescribed by the Commission, the operator fails to provide the required financial assurance for the well or wells, and (in subsequent enforcement action) the Commission determines that the operator either cannot be found, has no assets with which to plug the well, or refuses to plug the well. At the present time there are more than 17,000 wells in the state that are inactive and the last operator of record is delinquent in renewing its organization report.

Abandoned sites are identified through various sources, including lease inspections, complaints, state-funded plugging activity, and personnel from other state and/or federal agencies. All identified sites are collected in an inventory that is maintained in the Austin office of Site Remediation and is accessible to field personnel. There are 1,629 abandoned sites currently eligible for state-funded remediation.

6.4. Funding for Abandoned Site Remediation

Funding for the State Oilfield Cleanup Program is generated through a variety of fees, penalties, and taxes assessed on the oil and gas exploration and production industries. Expenditures from this fund are not subject to legislative appropriation. The Commission is charged with management of the fund. Senate Bill 310, 2001, increased permitting and oil and gas production regulatory fees to increase annual revenues from approximately $12 million to about $20 million. These include fees for drilling permits (variable scale based on depth of proposed well) and other applications (disposal and injection applications, NPDES discharge applications, certificate of compliance, waste hauling permits, hazardous waste generation fees, etc.), the P5 Organization Filing Fees, a percentage tax on oil and gas production, the sale of abandoned oilfield equipment associated with state-funded cleanup sites, penalties assessed for noncompliance with RRC rules, and other various forms of assessments. The statutory changes made in Senate Bill 310 were enacted to address the problem of a growing number of oil and gas wells and sites that have been abandoned by insolvent operators and that must be plugged with OFCF monies.

The Agency Strategic Plan for Fiscal Years 2003-2007 points out that most of these categories of revenue are dependent on the health of the industry. During periods of low prices and rig counts, revenue from permitting fees and production drops. Yet, at the same time, demands on the OFCF increase as poor economic conditions tend to result in more orphaned wells and neglected sites. For a variety of reasons, including Commission delays in implementing the fee increases authorized by the legislature, actual collections for Fiscal Year 2002 were only $16.84 million. The RRC budgeted $20.5 million. This, coupled with a higher than initially projected rate of expenditures, could lead to a declining fund balance, thereby restricting the ability of the Commission to undertake more projects.

Paradoxically, funding for this program may be adversely affected by the new requirement for operator bonding. Operators who are unable to obtain the required bond at a reasonable cost and who have an acceptable compliance record for the previous 48 months may pay $1,000.00 annually into the Fund. Other operators who can neither obtain a bond nor demonstrate an acceptable compliance record may satisfy the financial assurance requirement by paying into the fund 12.5% of the required bond amount (based on the number of wells operated). In either case, the operator also has to pay an annual fee of $300 per inactive well. This revenue stream (approximately $2,000,000.00 annually) will be eliminated as the strict bonding requirement is enacted by Fiscal Year 2005. One of the charges to the Oilfield Cleanup Fund Advisory Committee is to monitor the revenue and expenses for the Fund and make any necessary recommendations to the Legislature for adjustment to the funding levels.

On the surface, the State Oilfield Cleanup Fund appears to be financially well funded. The Fund directly employs 15.5 coordinating and technical positions and indirectly funds 36 field inspector positions. The RRC spends approximately 50% of the available funds on well plugging and the other 50% on state-funded site cleanup operations. The RRC has roughly $75 million in known well plugging liability alone with a potential for that to grow to $100 million if well operated by non compliant operators become orphaned. In addition to the orphaned wells, the State Oilfield Cleanup Fund remediates abandoned surface sites and surface and ground water contaminated areas left by operators who are no longer in business. The RRC has recorded more than 1,600 abandoned sites that would qualify under this cleanup program and projects that about 200 abandoned sites will be closed each year. Based on the projected expenditure listed below and the estimated number of sites to be closed, the RRC will spend about $29,000 per site closure. If this is the anticipated average, the RRC has approximately $46.6 million in site remediation liability.

FY 2002 expenditures by the RRC from the Oilfield Cleanup fund were $18.38 million - $5.23 million on remediation, $11.29 million on well plugging, and $1.86 million on well testing and other programs. From Fiscal Year 1992 through FY 2002, the RRC has spent $85 million from the Oilfield Cleanup Fund to plug 15,306 orphaned wells and remediated or restore 2,062 orphaned sites. The RRC is trying to equalize the spending between each program. In addition to the well plugging and site remediation projections listed above, the RRC projects direct salaries of $4.63 million, indirect salaries and operations of $3.18 million, and an additional $500,000 for well testing and direct salaries associated with such. With $8.31 million in direct and indirect personnel and operating expenses, the RRC has only between $8 million and $12 million per year to spend on well plugging and site remediation. The RRC also anticipates a reduction in revenue ($2 million annually) occurring from the changes to the financial assurance mechanism process. With all considered, the RRC has about 20 years worth of projects already identified ($150 million in potential liability and $8 million annual revenue for well plugging and site remediation).

Senate Bill 310 also created the Oilfield Cleanup Fund Advisory Committee (TNRC §91.1135). The Committee consists of representatives from the legislature, industry, and the public and meets regularly with the Commission to monitor the effectiveness of the OFCF, comment to the Commission regarding proposed rules relating to the OFCF, and make recommendations to the governor, lieutenant governor, and speaker of the house of representatives for any legislation needed to address problems identified with the administration of the fund or otherwise needed to further the purposes of the fund. This will include any necessary adjustments to revenue sources (or expenditures) based on actual program experience with the recent legislative and regulatory changes.

SUPPLEMENTAL REVIEW FINDING 6.3

Texas has established a self-funded model program dedicated to protecting the environment through the plugging of orphaned wells and the closure/remediation of abandoned sites.

SUPPLEMENTAL REVIEW FINDING 6.4

The State Oil Field Cleanup Fund will lose about 10% of its annual revenue stream as the current operator financial assurance programs are phased out for the new bonding requirements.

SUPPLEMENTAL REVIEW RECOMMENDATION 6.4

The Review Team recommends that the RRC and the Oil Field Cleanup Fund Advisory Committee thoroughly review its funding options for any needed replacement of lost or declining revenue. (2000 Guidelines 6.4.)

The RRC has taken advantage of the Oil Spill Contingency Liability Trust Fund for removal of imminent threats to the environment from leaking oil wells and facilities by obtaining close to $700,000 to remediate five abandoned and contaminated sites. The Oil Spill Contingency Liability Trust Fund is a federally managed program enacted through the Oil Pollution Act of 1990 (OPA 90). This program has about $1 billion in reserves for the remediation of oil spills to the Waters of the U.S. or the removal of imminent threats of oil spills to the Waters of the U.S. The U.S. Environmental Protection Agency authorizes the removal or remediation program either by directly handling the cleanup/removal or through a Pollution Removal Funding Agreement with the State or other entities. The EPA may spend only $50 million per year on direct cleanups/removals. The remaining $950 million is dedicated to reimbursement to the other entities cleaning up spills or removing threats. The EPA is the only federal source of money for removal of such threats. The Commission is currently limited on the amount of money the agency can obtain from EPA under OPA 90 and, in fact, has been told not to send any more applications at this time.

The Commission also received $6 million for remediation of contamination from pipeline spills as part of a civil lawsuit settlement with a Texas pipeline operator, $1.2 million in Surface Damage Account funds from GLO for plugging Texas bay wells, and a grant from TCEQ for evaluating the source of salt water seeps in East Texas. The RRC has also received a TCEQ grant to plug 226 wells in the Upper Colorado River Basin, Red River Basin, and Canadian River Basins. Additionally, the TCEQ has tentatively agreed to fund the plugging of an additional 361 wells in these Basins and one other in South Texas.

SUPPLEMENTAL REVIEW FINDING 6.5

The RRC is proactive and aggressive in seeking revenue to protect the environment and works with other state and federal agencies to identify and obtain the revenue necessary to prevent pollution. The Oilfield Cleanup Program is professionally administered and reflects well on both the RRC and the oil and gas industry that actively supports it.

6.5. Criteria for Prioritizing Remediation

TNRC §89.043 provides the Commission with authority to re-plug a well that has not been effectively plugged when neither the operator nor another working interest owner in the well can be found or when neither have assets with which to properly plug the well. These determinations must be made from information developed at a Commission hearing. The Commission may act immediately – without the normal formal notice and hearing requirements - if a well is leaking (or is likely to leak), the leakage will cause (or is likely to cause) a serious threat of pollution or injury to the public health, and the operator fails to take appropriate remedial action. In such a case, the Commission is entitled to be reimbursed by the operator for the costs incurred by the Commission in plugging the well.

NRC §91.113 provides the Commission with the statutory authority to enter the land of another for the purpose of conducting a site investigation or environmental assessment or controlling or cleaning up substances or materials. The Commission is entitled to recover all costs that it has incurred from any person who is a “responsible person” with regard to that site. If a Commission order does not result in the recovery of the costs, the Commission may request the attorney general to file suit against the person to recover those costs. Costs that are recovered are deposited to the oil-field cleanup fund.

If oil or gas wastes (or other substances or materials) from oil and gas operations and regulated by the Commission are causing or are likely to cause the pollution of surface or subsurface water, TNRC §91.113 provides that the Commission may use OFCF money to conduct a site investigation or environmental assessment or control or clean up the wastes, provided that:

(1) the responsible person has failed or refused to control or clean up the substances after notice and opportunity for hearing;

(2) the responsible person is unknown, cannot be found, or has no assets with which to control or clean up the substances; or

(3) the substances are causing the pollution of surface or subsurface water.

Commission staff are trained to respond to situations that require immediate action to prevent or control pollution. The Commission has contractors for placement of booms, major dirt work, etc., but RRC field personnel have shovels and know how to turn off valves. All field people have safety training relating to the types of situations they might reasonably be expected to encounter. The Commission's emergency protocols require that an effort be made to contact operator - by telephone, in person, or otherwise. If all else fails, the Commission will send a certified letter as concurrently with action that is being taken by field personnel as is reasonably possible.

The Commission's Well Plugging Priority System, which was last updated in April, 2002, is designed to ensure that wells that pose the greatest threat of pollution and safety concern are plugged first. The priority system considers 20 factors relating to protection of human health, the environment, and wildlife. Each factor has been assigned a weight dependent on its potential to affect human health, the environment, and wildlife. The sum of the weighted factors determines the priority a well receives. Wells receive a priority between 1 and 4, where 1 is the highest priority. The Commission retains the flexibility to give appropriate weight to unique concerns.

Leaking wells (other than those with minor, easily repaired leaks such as from the stuffing box) are still Priority One, followed by Priority Two wells (which have high fluid levels), and Priority Three and Four wells (all others), ranked according to the risked weighting system described above. Fluid levels for orphaned wells are determined by Commission field personnel, who are trying to "sound" one-sixth of the wells each year (focusing first on those areas where reservoir conditions are known to be conducive to high fluid levels).

The Commission currently has about 100 Priority One wells in its inventory. Not all of these are leaking; if one well on a lease is leaking, all the orphaned wells on that lease are listed as Priority One to make the best use of plugging rigs and Commission personnel. Every priority one well will be plugged this year. If necessary, the Commission will take necessary measures in the interim to contain the leaks.

The vast majority of orphaned wells plugged by the Commission are Priorities Two and Three. In Fiscal Year 2002, the Commission had plugged 1,124 orphaned wells (P1 – 94; P2 – 350; P3 – 679; and P4 – 1) by the end of May and is budgeted for 1,510 orphan well pluggings by the end of August.

SUPPLEMENTAL REVIEW FINDING 6.6

The Commission is required by statute, passed in 2001, to adopt rules for identifying abandoned wells that pose a high risk of contaminating surface water or groundwater, periodically testing high-risk wells by conducting a fluid level test (or, if necessary, a pressure test), and giving priority to plugging high-risk wells with compromised casings. Such rules will make public an internal process that the Commission already practices in determining which abandoned wells should be plugged first.

SUPPLEMENTAL REVIEW RECOMMENDATION 6.6

Although the guidelines do not require rules, the Commission should proceed with the required rule adoption. (2000 Guidelines 6.5)

Priority rankings for surface sites are Priority A (high), Priority B (medium), and Priority C (low). Priority A sites are those where an emergency cleanup is needed because of active or imminent pollution; a threat to public health, safety, or sensitive areas; or anticipated significant increase in cleanup costs if action is delayed. In determining priority rankings for other sites, the Commission considers such factors as the contaminant type, media contaminated, number of potentially affected people, potential for releases or leaks or seeps, need for repeated inspections, distance to surface water, distance to nearest municipal or domestic use water well, proximity to known aquifers, annual precipitation, and native soil type.

When large and complex sites require specialized investigations, the Commission will use contractors to conduct its site assessments, propose cost-effective cleanup techniques, and conduct cleanup activities in the field. In addition to private contractors, the Commission has contracted on occasion with the Texas Bureau of Economic Geology (the University of Texas at Austin) to investigate such complex sites.

The Commission tries, but is not bound under its risk-based priority ranking systems, to handle both any well plugging and surface contamination at an orphaned site at the same time. The priority ranking systems are independent. For instance, if an orphaned site that is a high priority for surface contamination remediation also has a low priority orphaned well, it is not a necessity that the well be plugged at the same time as the surface site is remediated. The Well Plugging Priority System and the similar system for prioritizing remediation of surface sites are published in the Oil Field Cleanup Program Annual Report.

6.5.1. Goal for Remediation

The impact of the OFCF and the Commission's efforts to obtain additional funding from other sources for orphan well and site abandonment is clearly demonstrated by the increase in the number of wells plugged and sites remediated from fiscal year 1992 to the present. In 2001 the Commission plugged its 18,000th well, and has consistently stepped up the number, complexity, and expenditures on sites remediated with 229 completed cleanups, investigations, or assessments in 2001 with contract services expended of more than $6.5 million.

The Commission has stated its orphan well and site abandonment goals in the Agency Strategic Plan for Fiscal Years 2003-2007. The strategic objective is to "Identify and correct existing environmental threats through voluntary operator actions or with use of state funds." Desired outcomes are couched – as shown below - in terms of percentages of non-compliant wells (known as of 2002) plugged with state funds, and total identified sites (known as of 2002) investigated, assessed, or cleaned up, with state funds. These outcomes reflect the Commission's current OFCF revenue projections.

Outcome	**2003**	**2004**	**2005**	**2006**	**2007**
Percentage of known orphaned wells plugged with the use of state funds.	6.0%	4.5%	3.0%	2.3%	2.3%
Percentage of identified sites investigated, assessed, or cleaned up with state funds.	10.0%	10.0%	7.0%	8.0%	8.0%

In addition to the above projected outcomes, the Commission measures progress in orphaned well plugging and site remediation by keeping track of such performance parameters as

- Number of complex, operator-initiated cleanups monitored and evaluated
- Number of wells plugged with the use of state funds
- Number of pollution sites investigated, assessed, or cleaned up with the use of state funds
- Total aggregate plugging depth of wells plugged with the use of state funds
- Average number of days to complete state-funded well plugging
- Average number of days to complete state-funded site clean-up
- Number of orphaned wells approved for plugging
- Number of known inactive wells in non-compliance with the Commission plugging rule
- Number of wells plugged, by operators, without the use of state funds
- Number of identified abandoned pollution sites that are candidates for state funded cleanup

6.5.2. Liability for Remediation

TNRC §89.011 charges the operator of a well with the responsibility for plugging that well. TNRC §89.002(a)(2) and Commission Rule 14(c) specifically designate the person with responsibility for plugging a well as the person specifically identified on the most recent operator designation form filed by that person and approved by the Commission. The statutes provide that an unplugged inactive well may be transferred only if the well is in compliance with commission rules relating to safety or the prevention or control of pollution at the time of the conveyance. They further require that the new operator have a Commission-approved organization report, specifically list the well as one for which the person assumes plugging responsibility, and have a commission-approved bond or other form of financial security covering the well.

For site cleanups, the Commission does not rely on the above statute, nor is there a Commission rule that defines who is responsible for cleaning up an abandoned site. Rather, the Commission interprets the term "responsible person" in the context of TNRC §91.113, meaning "any operator or other person required by law, rules adopted by the Commission, or a valid order of the Commission to control or cleanup the oil and gas wastes or other substances or materials."

The Commission makes this determination based on its current prohibitions in Rule 8 on improper waste disposal and pollution of surface or subsurface water – the person who caused the problem should clean it up. The Commission looks first to the operator of record, but in the final analysis the agency attempts to determine who (current or past) caused the pollution and enforce against that operator. In making this determination, the Commission is not concerned with any contractual releases of liability the current operator may have provided to the previous operator(s); that is a civil matter and outside the jurisdiction of the Commission to adjudicate. Procedures for making a final determination as to how the responsibility for the site cleanup is to be apportioned include notice to all affected parties and opportunity for hearing.

TNRC §89.012 provides each working interest owner in a well is responsible for his proportionate share of the cost of the proper plugging of the well if the well operator fails to plug it as required by statute. More often than not such an effort is not cost effective. To do so, it is necessary to identify the other working interest owners from division orders, find out if they have assets to pay for the work, and work through the hearing process to collect the money. The Commission's legal staff looks for other working interest owners in high-dollar state-funded well pluggings and cleanups, but typically does not do so unless the cleanup is more than $50,000.

In some instances, a person who did not cause the pollution may be required to control or cleanup oil and gas wastes. For instance, a surface property developer who begins to manage or move around oil and gas wastes on a property could fall under Commission jurisdiction by virtue of trying to manage those wastes.

6.6. Standards for Remediation

In plugging orphaned wells and cleaning up orphaned sites, the Commission complies with its own regulations and guidelines in the same manner as operators under its jurisdiction are required to do.

To coordinate orphaned site cleanup activities, the Commission has assigned specially trained cleanup coordinators in each of the nine district offices, supported by technical and administrative staff in Austin. Technical staff in Austin includes geologists, engineers, and a toxicologist. Progress of the sites is monitored on a computer program.

Cleanup standards are determined on a case-by-case basis, depending on site-specifics, including land ownership and current and anticipated future use. At abandoned sites on formerly producing property that are located on land where the surface owner is different from the mineral owner, the Commission keeps the landowner appraised of the agency's cleanup activity. The Commission also keeps in mind, when determining cleanup levels, that the land use could change in the future.

To lessen the costs associated with state-funded cleanup and/or site remediation, the RRC considers the type and level of contamination and current and anticipated land use when determining and appropriate level of remediation. Other than Rule 91, Cleanup of Soil Contamination by a Crude Oil Spill in non-sensitive areas, RRC guidance documents for crude oil and condensate spill cleanup, and Rule 94, Disposal of Oil and Gas NORM Waste, however, no Commission-approved standards, guidance or rules are available for risk-based site remediation. The Commission allows operators to propose cleanup levels for sensitive areas and other contaminants using site-specific characteristics and applying risk-based methods developed by such sources as ASTM, TCEQ, or EPA. In the absence of approved RRC standards, staff has to evaluate both the site information and applicability of the risk-based method on a case-by-case basis

Section 91.1131, Risk Assessment Standards, enacted with Senate Bill 310, 2001, does provide the RRC with the necessary authority to establish risk assessment guidance and adopt risk-based cleanup rules. Section 91.1131 states that the RRC may establish risk assessment as the guide for: 1) conducting site investigations and environmental assessments; and 2) controlling and cleaning up oil and gas wastes and other substances and materials. Any rules adopted under this law must provide for: 1) determining whether an actual or potential risk exist at a site; 2) screening contaminants at the site to identify those that pose a risk; 3) developing cleanup standards based on contamination levels that are protective of human health and the environment; and 4) establishing a reporting mechanism for informing RRC regarding specific remediation activities.

The RRC does realize the value of risk-based guidelines and proposed risk assessment standards during an informal comment period. Concerns about the proposal surfaced during the comment period and the Commission voted to discontinue consideration in 2001.

SUPPLEMENTAL REVIEW FINDING 6.7

The RRC currently uses a risk-based site remediation program for cleanup on a case-by-case basis only. The RRC does not have comprehensive Commission-approved, risk-based standards, guidelines, or rules for site remediation.

SUPPLEMENTAL REVIEW RECOMMENDATION 6.7

Although beyond the scope of the guidelines, the RRC should develop and implement written risk-based remediation guidelines or rules for complex pollution situations to lessen its average cleanup costs for both state-funded and industry-funded operations and allow more sites to be worked. (2000 Guidelines 6.6)

Rule 14 requires an operator, in plugging a well, to empty and remove associated tanks, vessels, related piping and flowlines - and to close all associated pits - that will not be actively used in the continuing operation of the lease within 120 days after plugging of a well is completed. The Commission complies with this directive in abandoning orphaned wells and sites. The state has a first lien, in the amount of the abandonment costs, on any responsible person's interest in equipment located at an abandoned well, site, or facility and used by that person in connection with the activity that generated the pollution or is being abandoned.

For well plugging or site remediation, the surface owner and/or tenant(s) are the primary affected parties. Signs at the sites let these persons know that the Commission is the one abandoning an orphan well or site. In addition, the Commission notifies the surface owner of OFCF abandonment activities on his property. The Commission has experienced few problems with landowners in this regard.

Surface owner or affected person input, when offered, is considered by the Commission in determining the appropriate cleanup levels and methods, but the statutory authority of the Commission largely dictates these decisions. The Commission is charged with the prevention of pollution of surface and subsurface water and will re-vegetate the site to the extent necessary to accomplish that objective. The Commission's public health protection responsibilities also bear on site remediation procedures and cleanup levels. The agency is not responsible for restoration of land to its original use or to some other desired used as may be defined by the landowner.

SUPPLEMENTAL REVIEW FINDING 6.8

The RRC generally does not take the initiative to consult with surface owners and surface tenants in determining the appropriate remediation of surface sites. The RRC does consult with other State agencies having relevant expertise in site remediation as appropriate.

SUPPLEMENTAL REVIEW RECOMMENDATION 6.8

The RRC should consult with surface owners, surface tenants and other State agencies such as the University of Texas Bureau of Economic Geology, when and as appropriate, in determining what surface remediation is needed. (2000 Guidelines 6.6.2)

6.6.3. Record of Remediation

All records pertaining to abandonment of orphaned wells and remediation of orphaned surface sites are retained in the Oil and Gas Division, which is required to comply with a retention schedule for such public information. All records are available to the public pursuant to the Texas Open Records Act, Tex. Rev. Civ. Stat. Ann. Art. 6252-17a.

6.7. Public Participation

Any person who might be affected by Commission decisions on appropriate cleanup levels in a site remediation project may file a complaint with the Commission alleging that these decisions are inadequate or inappropriate and ask the agency to consider alternative methods of cleanup levels. The Commission responds to all complaints, makes any necessary site investigations within 24 hours, and keeps complainants appraised of initial findings, progress, and final outcome throughout the complaint resolution process.

6.7.1. Access to Information

The Commission by statute (TNRC §91.112(b)) has to submit to the Texas Legislature and make available to the public an annual report that reviews the performance of the OFCF and the Commission's orphan well and site abandonment program. The report must include, by region of the state:

(1) the number of wells plugged;

(2) the number of wells abandoned;

(3) the number of inactive wells not currently in compliance with commission rules;

(4) the status of enforcement proceedings for all wells in violation of commission rules and the time period during which the wells have been in violation;

(5) the number of surface locations remediated; and

(6) the number of sites successfully remediated under the voluntary cleanup program.

The report also must provide:

(7) a detailed accounting of expenditures of money in the fund, including expenditures for site investigations and environmental assessments, plugging of abandoned wells, remediation of surface locations, and staff salaries and other administrative expenses;

(8) the method by which the commission sets priorities by which it determines the order in which abandoned wells are plugged;

(9) a projection of the amount of money needed for the next biennium for conducting site investigations and environmental assessments, plugging abandoned wells, and remediating surface locations; and

(10) the status of implementation of the statutory requirements relating to possession and sale of equipment to recover plugging costs.

In addition, quarterly financial reports for the OFCF revenue and expenditures are posted on the Commission's website in the Oil and Gas Division section. Also, sites with documented groundwater contamination are listed in the Texas Groundwater Protection Committee's annual Joint Groundwater Monitoring and Contamination Report, which is available on the Internet at www.tgpc.state.tx.us/publications.html.

SUPPLEMENTAL REVIEW FINDING 6.9

The RRC maintains excellent public records on the state's progress in its abandoned sites program. However, the RRC does not make available to the public a similar compilation of the locations of abandoned sites, the extent of contamination, or statements of the required remediation.

SUPPLEMENTAL REVIEW RECOMMENDATION 6.9

The RRC should release to the public, perhaps via its web page, a periodically updated list presenting the location, extent of contamination, and status of remediation of abandoned sites. (2000 Guidelines 6.7.1)

6.7.3. Participation Regarding Priority on the Inventory and Level of Remediation

[See discussion under Public Participation in Administrative Criteria, above]

6.8. Avoid Future Abandoned Site Problems

In addition to cleanup of abandoned sites, the RRC also is responsible for the oversight of cleanups performed and paid for by the responsible operators. It is not uncommon for operators to discover contamination at their sites during routine environmental assessment and to subsequently seek "no further action" letters from the RRC. Operator cleanups can be extremely complex in both assessment and remedial action. The majority of the projects are long-term remediation projects, many involving cleanup of ground water. These projects involve review of assessments and cleanup proposals and monitoring of cleanup actions to ensure a final cleanup that is protective of public health, safety and the environment. At those sites where the responsible operator owns the surface, the RRC will consider institutional controls, such as deed recordation.

In the past year this activity and requests for guidance from industry have escalated significantly, and currently there are over 600 complex pollution sites in the Operator Cleanup Program. Recent industry bankruptcy actions have highlighted the need to devote additional resources to this effort to accelerate the cleanup of such sites, encourage additional voluntary early cleanups by operators, and avoid the potential for such sites to be orphaned at some future date.

SUPPLEMENTAL REVIEW FINDING 6.10

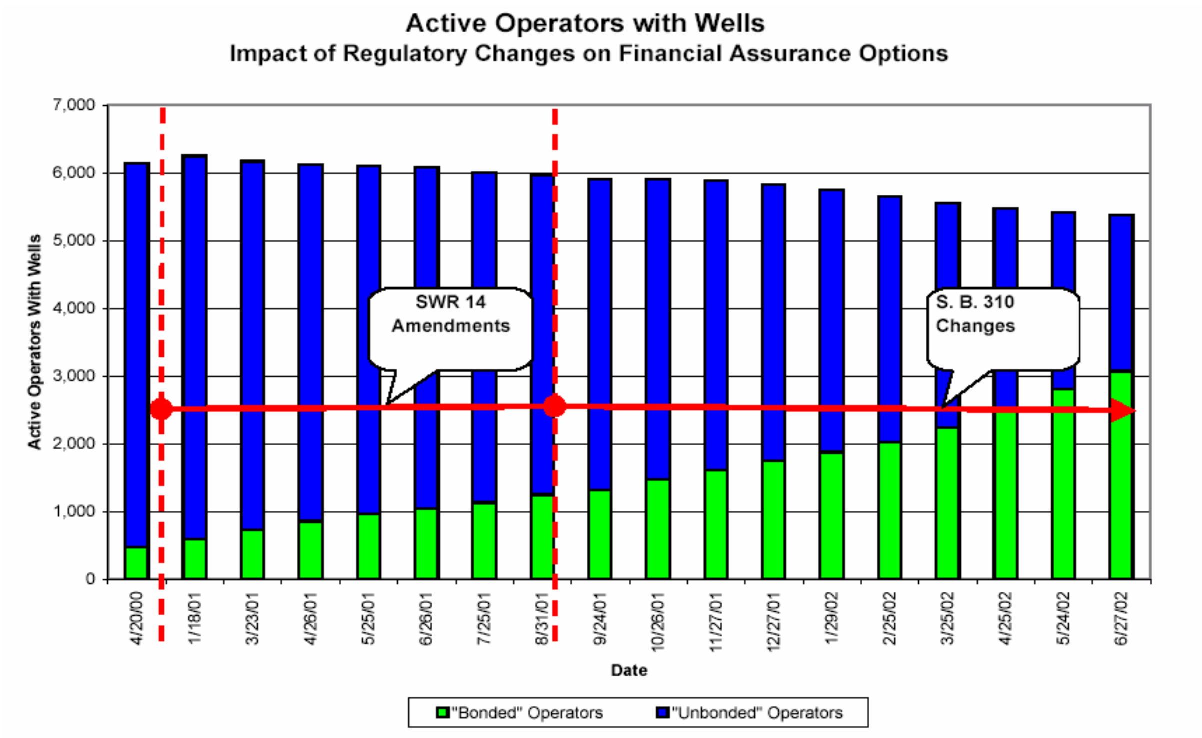
In preventing the orphaning of sites, the RRC is limited by inadequate manpower, restraints on expenditures for training, and lack of historical data regarding oil and gas sites.

SUPPLEMENTAL REVIEW RECOMMENDATION 6.10

The Commission is encouraged to review its overall resource needs with regard to compliance assistance and enforcement, and make appropriate recommendations to the Texas Legislature. (2000 Guideline Section 6.8)

Statutory changes produced by Senate Bill 310 amendments also address the recurring scenario in which a well near the end of its producing life is transferred from a solvent operator to an under-capitalized operator who lacks the resources to plug the well when it ceases production. The amended provisions prohibit the Commission from approving the transfer of a well unless the acquiring operator has a bond, letter of credit or cash deposit as its organizational financial assurance.

The amendments have already led to a dramatic increase in the number of operators who have significant financial assurance in the form of a bond or letter of credit and, in the long term, will stem the influx of "orphaned" wells that must be plugged with funds from the Oil Field Cleanup Fund. The immediate effect, however, is likely to be an increase in the number of recognized "orphan" wells as marginal operators who are unable to meet the more stringent financial assurance requirements cease operations.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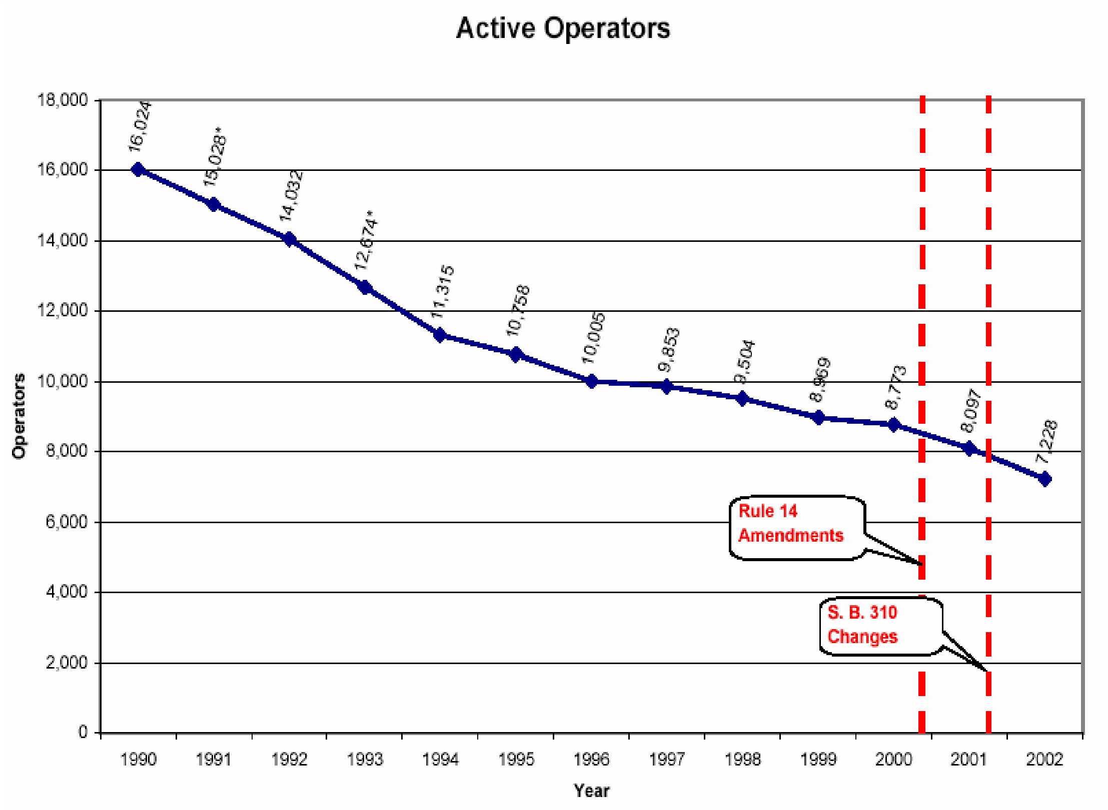
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NATURALLY OCCURRING RADIOACTIVE MATERIALS
(2000 Guidelines Section 7)

Subsequent to the completion of the review but prior to publication, RRC has adopted additional rules which may address some of the recommendations in this section.

Under Texas statutes (Chapter 401, Radioactive Materials and Other Sources of Radiation, Health and Safety Code) the Texas Department of Health (TDH) has jurisdiction over the possession, use, processing, transporting, transferring, and recycling of NORM and the decontamination of equipment and facilities. Under the same statute, the Commission has jurisdiction over disposal of oil and gas NORM waste and the management of NORM waste at oil and gas properties to facilitate disposal at the site. The Commission also recently received statutory authority to require the owner or operator of oil and gas equipment used in exploration, production, or disposal to identify any such equipment which may contain or be contaminated with oil and gas NORM.

TDH regulations establishing risk-based radiation protection standards for the possession, use, transfer, transport, and/or storage of NORM or the recycling of NORM-contaminated materials were originally adopted in 1993. They were subsequently codified in their current form (25 TAC §289.259, Licensing of Naturally Occurring Radioactive Material).

These standards were developed for the protection of workers, the public, and the environment. The regulations exempt possession, storage, use, transportation, and commercial distribution of natural gas and natural gas products and crude oil and crude oil products containing NORM and exempt possession of produced water containing NORM. They provide for general licensing of persons who possess oil-field NORM in concentrations or at exposure rates that exceed the state-adopted action levels should be generally licensed or permitted. Specific licenses are required for commercial storage, removal, decontamination, remediation, treatment or disposal of oil-field NORM.

In 1994, the Commission promulgated 16 TAC §3.94, Disposal of Oil and Gas NORM Waste (also known as Rule 94) to regulate management of oil and gas NORM waste. A rulemaking currently in progress would require identification and marking of oil and gas equipment that contains or is contaminated with oil and gas NORM above a risk-based 50 microR/hr (μR/hr) action level. The current proposal would require such equipment at commercial facilities to be identified within two years and at all other sites within five years.

Rule 94 contains permitting requirements and technical criteria for those disposal methods needing a permit. Any permit issued for disposal of oil and gas NORM contains those requirements deemed necessary by the Commission to protect public health and the environment.

The Commission has issued permits for four (4) commercial oil and gas NORM disposal facilities - one in southeast Texas and three in West Texas. These facilities are authorized to treat and process NORM solids into a slurry prior to disposal in an injection well. Oil and gas NORM wastes that are exempt or are non-hazardous, non-exempt wastes are acceptable for disposal. These facilities do not accept oilfield equipment for disposal, but do dispose of NORM scale that has been removed from equipment.

Rule 94 authorizes - without a specific permit but subject to specific performance standards – disposal of NORM-contaminated solids (such as pipe scale) on the site where they were generated by burial or placement in a well that is being plugged and abandoned. Similarly, contaminated soil may be landspread under certain conditions. Rule 94 also authorizes disposal of oil and gas NORM waste at a licensed facility and injection of NORM treated by a TDH specific licensee provided the operator complies with specific requirements contained in the rule.

Disposal options for NORM-contaminated equipment differ from the options for NORM-contaminated solids. NORM-contaminated equipment that is waste, i.e., equipment that is no longer wanted, may be recycled as scrap metal under TDH regulations or disposed of. The equipment must be decontaminated if it is to be released for unrestricted use (e.g., used for some purpose other than for oil and gas activities). Rule 94 does not allow the burial of NORM-contaminated equipment. Buried flowlines that contain NORM, however, may remain buried contingent on the lease agreement. NORM-contaminated tubulars and other equipment may also be placed in a plugged and abandoned well.

NORM disposal methods prohibited by Rule 94 include discharge of oil and gas NORM waste other than produced water, spreading of oil and gas NORM waste on public or private roads, and any other method that is not specifically provided for by Rule 94.

TDH includes conditions on permits for commercial storage, when appropriate, to limit the volume or duration of storage of oil and gas NORM in excess of state action levels. There are no such limitations on private storage by an oil and gas operator, other than the worker protection exposure standards in the TDH regulations. The RRC has considered requiring disposal of NORM within a particular time period (as suggested by Section 7.3.7 of the Guidelines). Currently, approximately 11,000 barrels of Texas-generated NORM waste is present in the State. The RRC has, for the present, concluded that setting a time limit for NORM disposal is not warranted by the volumes of NORM waste accumulation.

Rule 94 contains a provision reminding oil and gas operators of the need to comply with applicable TDH rules. To help operators better understand the full scope of oil and gas NORM regulation, Commission and TDH staff are preparing to conduct joint seminars for oil and gas operators on oil and gas NORM waste management.

TDH and the Commission have discussed the need to develop a Memorandum of Understanding (MOU) regarding NORM, but such an MOU has not been prepared to date. Texas statutes define the division of responsibilities between the two agencies with respect to oil and gas NORM. In addition, staff of RRC, TDH and the TCEQ (which has statutory authority over disposal of non-oil and gas NORM waste) closely coordinate NORM issues at regular interagency coordination meetings and at the quarterly meetings of the Texas Radiation Advisory Board.

SUPPLEMENTAL REVIEW FINDING 7.1

Between the Commission and TDH, Texas has an oil field NORM regulatory program that addresses, use, possession, transport, storage, transfer, decontamination, and disposal to protect human health and the environment. The Commission has proposed new rules to require operators to identify NORM-contaminated equipment that should meet the requirements of the Guidelines.

SUPPLEMENTAL REVIEW RECOMMENDATION 7.1

The Commission is encouraged to adopt rules that require operators to label NORM-contaminated equipment, so as to adequately advise affected parties that the equipment may be NORM-contaminated. (2000 Guidelines 7.2)

SUPPLEMENTAL REVIEW FINDING 7.2

TDH has regulatory standards for survey instruments, but does not have published guidelines for identifying and documenting equipment, materials, and sites that may contain NORM above the action levels. This deficiency is expected to be remedied and the requirements of the Guidelines met when the joint Commission and TDH oil and gas NORM training program for oil and gas operators is developed and implemented.

SUPPLEMENTAL REVIEW RECOMMENDATION 7.2

The Commission and TDH should continue with development and implementation of the proposed oil and gas NORM training for oil and gas operators. (2000 Guidelines 7.3.3)

SUPPLEMENTAL REVIEW FINDING 7.3

TDH regulations prohibit release, for unrestricted use, of land and equipment containing oil and gas NORM above state action levels. Current Commission rules do not require notification to purchasers of equipment containing or contaminated with NORM above state action levels.

SUPPLEMENTAL REVIEW RECOMMENDATION 7.3

The Commission should adopt rules that require operators to provide for appropriate notification to subsequent owners. (2000 Guidelines 7.3.8 and 7.3.9)

SUPPLEMENTAL REVIEW FINDING 7.4

Although TDH and the Commission are still in the process of finalizing a formal MOU regarding division of jurisdiction over oil and gas NORM, they do have formal coordination procedures - including interagency task groups with periodic meetings between themselves and with the Texas Radiation Advisory Board - that facilitate jurisdictional clarity and regulatory consistency as required by Sections 4.4 and 7.3.11 of the Guidelines.

SUPPLEMENTAL REVIEW RECOMMENDATION 7.4

The State should ensure that the Texas Radiation Advisory Board has general public representation including public interest and environmental representation. (2000 Guidelines 7.3.12, 4.2.2)

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PERFORMANCE MEASURES
(2000 Guidelines Section 8)

The RRC's formal performance measurements are organized to comply with the legislative appropriation process. Goals set in the agency's strategic plan are included in its legislative appropriation request which, when adopted, becomes the resource allocation plan for the biennium. The Commission's Strategic Plan for Fiscal Years 2001-2005 lists Environmental Protection as the primary goal. Other goals include safety, resource development, and technological enhancements.

Strategic Plan Objectives to meet the goal of environmental protection are:

(1) reducing the occurrence of pollution violations, and

(2) identifying and correcting existing threats through voluntary operator actions or through the use of state funds.

The Railroad Commission tracks and reports several parameters (inputs, outputs, and outcomes) to evaluate how effectively it is achieving its environmental protection goals. These parameters are used for budgeting and staffing purposes and are measured using prior years as benchmarks.

Some RRC formal performance parameters for measuring environmental protection include:

- Percentage of oil and gas facility inspections that identify environmental violations;
- Number of inspections performed;
- Number of enforcement referrals;
- Number of permits processed;
- Percentage of known non-compliant wells plugged with state funds;
- Percentage of pollution sites investigated, assessed, or cleaned up with state funds; and
- Number of complex operator cleanups monitored.

Based on budgeting and resource allocation, inactive wells and abandoned sites are the RRC's highest priority performance indicators. The RRC focuses on site remediation and plugging of Priority 1 wells (wells that are leaking or could leak). Recent changes to the oil field cleanup fund will allow the agency to maintain its focus on cleaning up abandoned sites and plugging abandoned wells. Complexity of site cleanup makes it difficult to measure performance by simply counting the number of sites remediated. A statutorily created committee provides oversight and helps set goals for the use of the Oil Field Cleanup Fund. Well plugging and site remediation is benchmarked against prior years and also against neighboring states.

Field personnel, operators, and the public are additional sources of input for central management and decision-makers, providing a mechanism for continuous monitoring and modifications to the program in an ongoing, informal, cyclic process. Data from the District Office field staff are entered into the Field Operations ORACLE database, and analyzed to adjust priorities and resources, and to determine trends or compliance problems. Any of the information on the District Office forms may be manipulated to determine trends or compliance problems. As new issues arise, resources can be reallocated, although the primary focus has remained on the formalized performance measures tailored to the legislative appropriations process. The primary parameters measured at the district office include witnessing operator pluggings, mechanical integrity tests, cleanup of surface spills, and cementing of surface casings.

District offices are responsible for resolving issues in the field. Field staff receive safety training, and may attend periodic agency-wide conferences. Site remediation staff receive some training in risk assessment. In addition, most field staff have prior industry experience that is job related.

The commission, through rulemaking, has the ability to modify its program to respond to environmental threats. For example, in the 1950's, the commission began issuing "No-pit orders" for certain counties, and ultimately passed a statewide rule eliminating salt-water disposal pits in 1969. More recently, in 1991, the commission adopted a rule for the protection of migratory birds, under pressure from the public and US Fish and Wildlife Service. The Commission also adopted NORM regulations in 1994 in response to concerns about public health and safety.

Complaints are another source of information, which the agency can use to determine whether changes are needed to respond to environmental threats. Field staff respond to approximately 100 complaints per month, mostly for environmental concerns which often relate to abandoned sites. RRC central office management is able to track complaint trends in order to decide whether resource reallocation is warranted. Complaint response is the only measure related to the general public or affected parties which is routinely tracked by the agency.

In this review, the RRC agreed to be evaluated under a draft experimental set of proposed new guidelines for Performance Measures (the "Draft Guidelines"). These Draft Guidelines are presented in Appendix B. The Draft Guidelines (8.1 – 8.4) are based on the 2000 Guidelines sections 8.1 – 8.3, although they contain additional detail. References to the Draft Guidelines in this section are to the draft Performance Measures Guidelines in Appendix B.

SUPPLEMENTAL REVIEW FINDING 8.1

NOVs, which are typically documented in District Office inspection reports, make up the vast majority of compliance information available to the commission. Most NOVs are resolved informally at the district office level.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.1

RRC should use inspection reports and NOVs as part of an ongoing cyclic self-evaluation, to determine trends and the need for modifications to the program. (Draft Guidelines 8.3.2)

SUPPLEMENTAL REVIEW FINDING 8.2

RRC field staff report that most rule violations associated with pits are found on rule-authorized, rather than individually permitted~~,~~ pits. Tracking and reporting on trends in complaints and inspection reports could help the agency determine how to ensure that rule-authorized activities are equally protective of the environment as permitted activities.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.2

RRC should track and report complaint and inspection information related to rule-authorized activities, in particular rule-authorized pits. The information should be used by the commission to determine whether it needs to amend its rules or better communicate the standards to operators. (Draft Guidelines 8.1, 8.2)

SUPPLEMENTAL REVIEW FINDING 8.3

Almost all performance measures used by the RRC are administrative, dealing with allocation of resources and tallies of tasks completed. These measures are appropriate for indicating how well the program is functioning administratively. However, in addition to administrative parameters, performance measures should also indicate to what extent the rules and practices of the program bring about environmental protection (Guidelines 8.1). The RRC does not routinely use quantitative environmental impact parameters as performance measures.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.3

The RRC should institute measurements of environmental impacts such as the nature and extent of contamination by E&P waste, environmental impact trends, timeliness in controlling releases, and/or progress of abatement. These measurements should be made available to the staff, the industry, and the public through the RRC's data management capabilities, just as production and permitting information are made available. (Draft Guidelines 8.2)

The RRC's program is structured around a philosophy of minimal regulation. Rather than promulgating numerous detailed regulations, the agency relies on the general prohibition of pollution in Rule 8(b). RRC's promulgated rules and informal guidelines specify only a few cleanup standards or procedures. The agency does not rely on formal requirements for cleanup procedures such as facility investigations, corrective measures studies, and post-abatement monitoring.

SUPPLEMENTAL REVIEW FINDING 8.4

Without attendant performance measures, neither the agency nor the public knows whether or not the philosophy of minimal regulation and increased flexibility promotes compliance and results in better environmental protection.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.4

The RRC should institute quantitative measures, including state-wide nature and extent of contamination, to assess the effectiveness of its case-by-case handling of spills, its procedures for remediation, and its standards for rule-authorized waste treatment. Documentation of the selected parameters and the ability to acquire, assess, and present the data are critical to this assessment. (Draft Guidelines 8.1 and 8.2)

SUPPLEMENTAL REVIEW FINDING 8.5

The RRC relies as little as possible on formal enforcement action and penalties, preferring voluntary action by the responsible party.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.5

The RRC should include a performance measure of enforcement as a measure of the effectiveness of the agency's administrative controls in the prevention and abatement of pollution. This measure should enable evaluation of whether the program's responses to operators encourages or inhibits compliance and timely remediation. (Draft Guidelines 8.2)

SUPPLEMENTAL REVIEW FINDING 8.6

The public and affected parties provide valuable input to RRC. Examples of this input include comments on rules, requests for hearings, involvement in contested permitting or enforcement matters, and complaints. However, complaint tracking is the RRC's only measure of public participation.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.6

RRC should implement tracking of performance measures to determine the effectiveness of public notice and participation, including measures related to public and affected persons' participation in rulemaking, permitting (including minor permits), and enforcement. RRC should track and make available to the public the composition of all advisory committees, working groups, and taskforces, especially those groups that provide input to the staff on rulemaking. RRC should strive to ensure broad representation of all relevant viewpoints on such groups. (Draft Guidelines 8.3.2)

SUPPLEMENTAL REVIEW FINDING 8.7

Field inspectors are the eyes and ears of the agency. They gain first-hand knowledge of compliance issues, usually resolving them informally at the district office level. District office and field personnel make numerous decisions, such as decisions relating to violations, sampling, and public input. RRC utilizes information from field staff in assessing program performance primarily through informal communication, such as periodic meetings between managers and field personnel. Field staff are often the most knowledgeable people with regard to the effectiveness of Commission regulatory and enforcement procedures in achieving the goals of the agency. While valuable, this process results in reliance on institutional memory that is easily lost with personnel changes.

SUPPLEMENTAL REVIEW FINDING 8.8

Performance measurement cases (no-pit orders, migratory bird protection, surface water impairment list) are excellent examples of establishing benchmarks and goals and developing measurement techniques that allow documentation of progress. However, these cases also show that RRC may not have been as proactive as it could have been, modifying its program after a long period of time or in response to outside pressure from the public, the legislature, or other agencies.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.7/8.8

RRC should create a documented process for obtaining input from within the agency, with emphasis on input from field staff, to identify program strengths and weaknesses, and make program changes accordingly. (Draft Guidelines 8.3.2)

SUPPLEMENTAL REVIEW RECOMMENDATION 8.9

RRC should track outreach to the public and affected parties. (Draft Guidelines 8.3.2)

SUPPLEMENTAL REVIEW FINDING 8.10

RRC effectively manages data for tracking and reporting formal (legislative appropriations-driven) performance measurement, but many potential performance indicators are informally tracked and not routinely made a part of a systematic evaluation by regulators.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.10

RRC should implement a data management system that facilitates review and evaluation of district office information. In particular, potential performance data relating to permitting and enforcement matters, currently housed in district offices, should be accessible by central office staff and the public. (Draft Guidelines 8.2)

SUPPLEMENTAL REVIEW FINDING 8.11

RRC is in the process of updating its website to provide the public the same level of information related to spills and violations as for production reports.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.11

The review team encourages the RRC expand the performance measurement information on its website to include spills and enforcement actions. The information should be easily accessible by the general public, and searchable by operator and by county. (Draft Guidelines 8.2)

SUPPLEMENTAL REVIEW FINDING 8.12

While the RRC has done a good job measuring efforts to address cleanup of contaminated sites and plugging of inactive or abandoned wells, opportunities exist to improve performance measures tied to permitting and enforcement, in order to prevent pollution or the threat of pollution before it happens. For example, while tracking the number of permits processed and the average processing time logically relate to the goal of resource development, these output and efficiency measures are inadequate to determine whether permits are sufficiently protective of the environment.

SUPPLEMENTAL REVIEW RECOMMENDATION 8.12

The Railroad Commission should use trend indicators, including the following, to determine whether rule changes are needed:

- ***Variances requested by operators;***
- ***Complaint information;***
- ***Inspection reports/notices of violation; and***
- ***Requests for hearings by affected parties.***

(Draft Guidelines 8.3.2)

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APPENDIX A

GLOSSARY OF ACRONYMS

GLOSSARY OF ACRONYMS

μR/hr	MicroRoentgens per hour
ASTM	American Society for Testing and Materials
E&P	Exploration and Production
EPA	United States Environmental Protection Agency
FTE	Full Time Employees
GIS	Geographical Information System
GLO	General Land Office
GPS	Global Positioning System
H_2S	Hydrogen Sulfide
IDOC	Docket Database
IMS	Information Management Services
IOGCC	Interstate Oil and Gas Compact Commission
MOU	Memorandum of Understanding
NORM	Naturally Occurring Radioactive Materials
NOV	Notice of Violation
NPDES	National Pollutant Discharge and Elimination System
OFCF	Oil Field Cleanup Fund
OGD	Oil and Gas Division
OPA	Oil Pollution Act of 1990
RCRA	Resource Conservation and Recovery Act
RRC	Railroad Commission of Texas
STRONGER	State Review of Oil and Natural Gas Environmental Regulations
TAC	Texas Administrative Code
TACB	Texas Air Control Board
TCEQ	Texas Commission on Environmental Quality
TDH	Texas Department of Health
TNRC	Texas Natural Resource Code
TNRCC	Texas Natural Resource Conservation Commission
TPWD	Texas Parks and Wildlife Department
TWC	Texas Water Commission
VCP	Voluntary Cleanup Program

APPENDIX B

COMPLETED TEXAS QUESTIONNAIRE AND SELECTED ATTACHMENTS

Exhibit 7

In East Texas, a town fights to keep an oilfield waste dump from opening near wetlands and water wells

The Texas Railroad Commission has rejected the proposal twice over water contamination concerns, but locals are dismayed that the commissioners keep giving the developer more chances to alter its application.

BY DYLAN BADDOUR, **INSIDE CLIMATE NEWS** JAN. 30, 2023 5 AM CENTRAL **SHARE**

Sign up for The Brief, The Texas Tribune's daily newsletter that keeps readers up to speed on the most essential Texas news.

PAXTON — Deep in the Piney Woods of East Texas, a landfill developer wants to build an oil sector dump site some 500 yards from this small town's wells.

In Paxton, water lies just a few feet below ground. Ponds and wetlands dot the boggy forests. The town, population 850, has plenty to drink. But residents fear it could all be at stake with Texas regulators poised to permit plans to permanently bury hundreds of millions of tons of oilfield waste here.

"It's just common sense. You don't go dumping that kind of stuff right next to a local water supply," said Eric Garrett, president of the nonprofit Paxton Water Supply Corporation and pastor of a local Pentecostal church. "That's not even up for discussion."

This discussion, however, doesn't seem to end. The community has spent four years and a small fortune fighting the proposal. No matter what they do, residents say, they can't convince Texas regulators that this is a bad idea.

"As hard as they have fought, as protracted a battle they've put up, there must be quite some stack of money involved," said Garrett, 61 with slicked-back hair, wearing a suit and tie in his church.

In Texas, the nation's top petroleum producer, regulation of the oil and gas business falls to the Texas Railroad Commission. Headed by three elected commissioners, all Republicans, the commission issues permits for every oil well and dump site in Texas.

Permit applications are typically approved unless challenged by a third party, such as the residents of Paxton, who have found that threats to public health must reach a high bar to compete against economic interests for the commission's sympathies.

When the commission met last December, its technical permitting division rejected the Paxton project's permit for the second time in four years over concerns about groundwater contamination. But Commissioner Jim Wright, a former rodeo cowboy and landfill developer, wasn't ready to let the project die.

"I myself have constructed safe landfills in similar conditions," Wright told the meeting in the Texas Capitol. "It can be done."

Instead of issuing a final rejection, Wright suggested the commission provide the developer, McBride Operating LLC, with a list of edits and additions to the application and invite them to resubmit. The commission had already asked the firm to amend its application at least four times since 2019.

"The cost for oil and gas waste disposal in East Texas is high, and I don't want to negatively affect production in the area," Wright said.

Dumping in East Texas

Several industrial dumps have cropped up in Deep East Texas to serve the fracking boom in the Haynesville Shale, which straddles the Texas-Louisiana border.

According to Geoffrey Reeder, a former environmental manager with Union Pacific Railroad who lives in East Texas, Texas has fewer rules for oilfield waste dumps than Louisiana, making it economically attractive to landfill developers.

Louisiana requires lab tests to verify the contents of all oilfield waste brought to landfills. Texas doesn't.

"Texas has nothing more than the good ol' boy system," said Reeder, a certified geoscientist in both states. "You could send radioactive waste over there and nobody would know."

Louisiana also limits how close waste dumps can sit to water wells and schools, while Texas doesn't, said Reeder, who previously fought against plans for another oilfield waste near his home in San Augustine County, which was canceled last year.

Solid wastes from oil production include mud used for drilling that is laced with chemicals, other substances that settle at the bottoms of oil tanks and any hydrocarbon-bearing soils from the well site. All of them are considered "non-hazardous" in Texas because federal law exempts most oil and gas waste from regulation. Still, oilfield waste may include benzene, arsenic, cadmium, chromium, lead, mercury and selenium.

"Trying to protect our water"

McBride, the Paxton project developer, rejected allegations that the facility may threaten groundwater quality. In a statement, McBride said it has hired the environmental consulting firm Wood PLC to review the site, finding that "the surface of the property consists predominantly of low permeability clays which act to safeguard the deeper groundwater."

"The prospect of groundwater contamination has been exaggerated by certain owners and their agents who specialize in such exaggeration to generate fear without regard to the actual facts," a statement provided by McBride's lawyer said. "This facility is designed with multiple redundant synthetic and natural barrier systems to prevent groundwater contamination and will be able to contain rainwater that comes into contact with the waste for proper offsite disposal."

The proposed location in Paxton has two ponds and a wetland. A creek originates there and then meanders into the Sabine River.

That creek, Cypress Creek, runs along the land that Linda Wheeler, a 54-year-old retired nurse, shares with six other households and four generations of her family. These 200 acres, which Wheeler's grandfather once split between his children, are full of ponds, swamps and natural springs. The families drink from three private wells.

"Why are we still fighting this? It's disheartening that they're giving them another chance," she said. "It's already been denied."

The first denial was in December 2019. The Railroad Commission's technical permitting division wrote that the presence of wetlands, shallow groundwater and permeable soil meant "the proposed facility location is not a viable option for the processing and permanent internment of oil and gas waste."

"The design and layout of the facility is not protective of surface waters features or groundwater," the ruling said.

It then listed more than 40 recommended changes for McBride to make to its application and gave the developer 30 days to resubmit. Over the next two years, the commission gave McBride at least three more opportunities to fill in missing information.

In November of 2021, the commission held a two-week hearing in which experts, engineers and lawyers for McBride argued their case before an administrative judge. Residents of Paxton attended, including Wheeler, as did the head of Paxton's water supply, to argue against the proposed dump. The town raised tens of thousands of dollars to hire experts and lawyers of its own, and to order independent studies of the terrain.

"Money makes the world go round, but there are things more important than money," Wheeler said. "We're just trying to protect our water."

At the hearing, Paxton residents pointed out McBride's record of contamination. The developer's facilities failed Railroad Commission inspections 48 times since 2015 over pollution violations, sometimes with multiple infractions, commission records show.

According to Janet Ritter, who owns a cattle ranch adjacent to the proposed dump site and attended the hearing, the judge ordered the complainants only to focus on the technical merits of the specific permit under review, and had comments about McBride's other facilities stricken from the record.

After a yearlong review, the commission's technical permitting division again recommended denial of the permit at its December 2022 meeting, when Commissioner Wright again moved to offer McBride another chance.

"I think some of us are starting to realize the beast we are dealing with. You can't afford to fight them," said Janet Ritter. "We've spent roughly $50,000, but our neighbor has spent more."

Another opponent, a banker and rancher named Terry Allen, posted a $300,000 deposit to sue McBride in county court. Allen's 93 acres border the proposed dump site, and several creeks run from that tract to his.

The lawsuit alleged the project would pollute local weather supplies, a violation of the Texas Natural Resources Code. A county judge initially agreed and issued a temporary injunction, barring McBride from beginning construction.

But McBride appealed, and a higher judge reversed the decision.

The judge invoked "mandamus," a legal tool which he, in his opinion, called "an extraordinary remedy … appropriate when the trial court abuses its discretion."

The judge acknowledged the Railroad Commission's initial rejection of the permit over water contamination concerns but wrote that legal standard "requires a plaintiff to have concrete injury before bringing a claim."

Because McBride had not yet received a permit to build its waste facility, the judge wrote, "the dispute remains abstract and hypothetical, rendering it unripe for judicial review."

He ordered the trial court to reverse its decision and dismiss the case against McBride.

Allen declined to comment, citing advice from his lawyer, who did not respond to requests for comment.

According to Stacy Cranford, general manager of Paxton Water Supply, the court wants Paxton to wait until it's too late.

"When the damage has been done, it's irreversible," he said, wearing steel-toed boots and a camouflage jacket. "Ten million dollars won't fix our water then."

It's not just Paxton that's at stake, he said. This town overlies the massive Carrizo-Wilcox Aquifer, which arches from Arkansas to Mexico and provides drinking water for millions of people.

"If you contaminate one spot, you contaminate the whole thing," Cranford said. "It doesn't take a rocket scientist to figure out that's a plan for disaster."

Exhibit 8

Caller Times

NEWS

TCEQ investigates Blackhorn Environmental Services in Orange Grove

Robin Bradshaw Alice Echo-News Journal
Published 2:07 p.m. CT Dec. 2, 2020 | **Updated 3:34 p.m. CT Dec. 7, 2020**

Editor's note: This article has been updated to reflect that the company serves Eagle Ford, Texas Gulf Coast Southern Region and users of the Port of Corpus Christi.

ORANGE GROVE -- Orange Grove residents who share property close to Blackhorn Environmental Services, LLC. received a possible validation from the Texas Commission on Environment Quality for complaints that involve poor air quality near County Road 308.

The TCEQ report follows a grievance made by neighboring property owners. Neighbors presented safety and health concerns to the Jim Wells County Commissioners Court this past October involving the Blackhorn Environmental disposal facility.

Blackhorn Environmental Services LLC. is located on 232 acres near County Road 308 and is a disposal facility that services the oil and gas industry. It is permitted and regulated through the Texas Railroad Commission. The disposal facility specializes in the handling of non-hazardous oil and gas waste. The company serves Eagle Ford, Texas Gulf Coast Southern Region and users of the Port of Corpus Christi.

The investigation report issued by TCEQ is an alleged violation associated with an order of enforcement based on multiple citizen complaints, citizen-collected evidence and an investigation conducted by a TCEQ Investigator.

The investigation determined that offensive sour petroleum waste odors from Blackhorn Services Disposal Facility were found in sufficient frequency, intensity, duration and offensiveness to interfere with normal use and enjoyment of property as well as adversely affect human health.

TCEQ has recommended Blackhorn Environmental Services submit an action plan to the TCEQ Corpus Christi regional office to stop any recurrence.

"I have lived here my entire life and I have never seen anything like this before," said Jennifer Green, neighbor to Blackhorn Environmental Services. "The doe are gone, rabbits are gone, butterflies are gone and the land is lifeless. It is not the same environment I have known all these years -- especially in regards to wild animal life."

Blackhorn Environmental Service, LLC. submitted the following statement:

"Blackhorn has not discharged any air contaminants in such concentrations and of such duration that could be injurious to human health or that would reasonably interfere with the normal use and enjoyment of animal life, vegetation, or property. No employees have reported health or safety issues while working in close proximity to waste materials in this facility. Neighbors, active in pending litigation against Blackhorn, have filed numerous complaints over the past 14 months with the TCEQ citing 'unpleasant petroleum odors.' Time and time again, Blackhorn has been exonerated of the alleged violation. ... Blackhorn is confident that this alleged violation will also be cleared."

Exhibit 9

PHW
PUBLIC HEALTH WATCH

ENVIRONMENT

For Texans, Fighting State-Regulated Oilfield Waste Dumps Can Be a Costly, Do-It-Yourself Effort

Some Texans who challenge oil-and-gas waste sites must spend significant sums and time on investigating what they say the Texas Railroad Commission should examine. Will new regulations for handling waste increase oversight or just maintain the status quo?

by **Jason Buch**
August 15, 2023

Built on a former caliche mine, the Blackhorn Environmental Services oil and gas waste disposal facility includes pits to separate solid and liquid material and other pits where waste is dried before being dumped in disposal cells. Credit: Google.

This story is being co-pubished by ***The Texas Tribune****.*

Less than a year after an oilfield waste disposal site opened near Tara Jones' home in 2019, she and her family noticed a foul odor.

They lived a half-mile away, amid the mesquite trees and pastures west of Corpus Christi. But the sour smell from the Blackhorn Environmental Services site was potent.

Jones would later learn her neighbors had been complaining for months about Blackhorn's waste pits near the town of Orange Grove, population 1,300. Neighbors later said they sneezed, coughed, got itchy eyes and, on the worst days, felt nauseated.

When the stench reached her house, it became a regular nuisance for Jones, her husband Calvert and their two children — to the degree that she started keeping a written log. She complained to the Railroad Commission of Texas, which regulates the oil, gas and pipeline industries. After one especially bad night, when the odor gave her a headache and made her sick to her stomach, she intensified her efforts. She began filing public records requests with the Railroad Commission and poring over thousands of pages of documents.

The cause of the odor was never determined. But Jones says she discovered that she and her neighbors had to agitate and do their own investigations to convince regulators to act.

In 2021, Blackhorn was found to have violated its permit by receiving industrial waste for which it wasn't authorized at the Orange Grove site; the company was sued over the issue by the Texas Commission on Environmental Quality, or TCEQ. Blackhorn appealed the permit violation, kept operating and wasn't fined by the Railroad Commission.

"They [the Railroad Commission] are an entity in existence for the industry and the industry alone, in my opinion," Jones said.

Tara Jones, who lives half a mile from the Blackhorn Environmental oil and gas waste facility near Orange Grove, Texas, said she spent almost a year learning the state's regulatory rules and investigating the commercial dumping operation. Credit: Jason Buch.

Jones and her neighbors aren't the only Texans frustrated with the Railroad Commission, complaining that its policing of waste disposal is weak and doesn't protect public health. The agency, led by three elected commissioners, has been criticized for years by advocacy groups and some lawmakers who accuse the commission of being too cozy with the industries it regulates.

In the small East Texas town of Paxton, for example, residents raised tens of thousands of dollars to **fight a proposed oilfield disposal facility**, worried it would pollute their drinking water. The Railroad Commission staff last year recommended denying the permit, but commissioners allowed the company to submit a new proposal.

Deep-pocketed businesses can keep pushing permits until protesters run out of resources to fight them, said Virginia Palacios, executive director of Commission Shift, a nonprofit that advocates for the agency's reform.

Amid the criticism, the commission is rewriting regulations for waste-disposal facilities, known as **Statewide Rule 8**, at the request of industry and legislators. That rulemaking can be lengthy and complex. But Rule 8 hasn't been significantly revised in decades — an era that brought major changes to the oil and gas industry, including the fracking revolution. To adapt, the Railroad Commission has adopted operating procedures that aren't part of the formal rules.

Critics say those procedures are too lenient, allowing for lax oversight. Preliminary drafts of the rule obtained by Commission Shift through public records requests show the Railroad Commission is essentially "taking their current operating procedure and just codifying it," Palacios said. She added, "We definitely don't see any of the public protections in this rule that we would want to see."

Critics are also raising red flags because the process is being led by a commissioner, Jim Wright, who has ownership interests in disposal companies.

Aaron Krejci, a spokesperson for Wright, said "it would be premature to discuss" drafts of the proposed regulations and provided a statement from the commissioner. The statement said Statewide Rule 8 is badly in need of an update, and modernizing it was "one of the catalysts" for Wright's candidacy three years ago.

Wright said "it is time to update and strengthen this rule to better reflect the technological advancements and modern practices of the 21st century."

Wright ran for office "to serve the citizens of our state … not for personal gain," Krejci said, adding that his boss's experience in the industry "is an asset to the state of Texas."

"He has seen how the actions of a few can tarnish the reputation of an entire industry and give a competitive advantage over those who follow the rules and requirements," Krejci said.

Railroad Commission's Role

The Railroad Commission is the state's oldest regulatory agency, created in 1891. It hasn't had anything to do with railroads in nearly two decades, instead serving as the primary regulator of the state's oil and gas industry, a top economic driver. It also oversees pipelines and coal and uranium mining.

Headquartered in a high-rise near the State Capitol in Austin, the commission has nearly 1,000 employees and 11 additional offices across the state. Its three commissioners, all Republicans, are elected to six-year terms. A small army of permitting staffers, inspectors, hearing examiners and administrative law judges reviews records and recommends whether to grant a permit or propose a fine, but the commissioners make the final decisions.

Its stated mission, authorized by the legislature, requires a delicate balancing act: The commission is charged with promoting economic development through permitted exploration of oil, natural gas and other resources, yet is also responsible for protecting the environment and public health.

A contentious part of its regulatory landscape is the disposal of oilfield waste, created by drilling operations and related industries. The Railroad Commission issues permits to commercial dumping operations, waste pits and drying pads where oil and gas producers pay to dispose of potentially dangerous drilling byproducts. These include fracking water, sand and storage tanks.

Federal and Railroad Commission regulators do not categorize oil and gas waste as hazardous — something environmentalists and public health advocates have criticized. Producers in Texas have argued that chemicals used in oil and gas production are proprietary, and they're not required to disclose them. Yet as oil and gas production has increased, so has the need for disposal sites, putting them in closer proximity to Texas' growing population.

Critics, including landowners, say not only are the elected commissioners too deferential to industries about permits or compliance, they and staff members often take at face value companies' representations. Proving a company violated its permit is often left up to residents and community leaders, such as in Orange Grove — a potentially costly and time-consuming exercise.

Companies applying for permits to operate waste facilities conduct their own soil testing and give the Railroad Commission information about the location of wetlands, water wells and aquifers. Commission staff generally accept those as fact, leaving nearby landowners to point out any problems, said Melissa Troutman, a climate and energy advocate who in 2021 co-authored a report about oil and gas waste in Texas.

"Depending on who's looking at it at the agency, they might find a problem, or they might rubber-stamp it," Troutman said. "Agencies are required to issue permits pretty quickly."

R.J. DeSilva, the Railroad Commission's communication director, said the agency has added a compliance team to address any issues that occur after facilities are permitted and pursue enforcement if needed.

Commission staff "take all measures to help ensure community and environmental safety," DeSilva wrote in an email.

Laura Capper, a Houston-based energy consultant who has advised waste disposal companies seeking permits from the Railroad Commission, disputed that the agency rubber-stamps permit applications. She said while the commission rarely does on-site inspections for permits, staff members carefully review information from the companies and check it against public records. Commercial disposal facilities receive greater scrutiny than private sites, where operators dispose of their own waste, and must put up large bonds, which can top $1 million, to cover potential remediation costs, Capper said. She said "99%" of companies adhere to regulations, although among regulators "there's kind of an assumption that you're playing by the rules."

Uproar in East Texas

Two wells of the Paxton Water Supply Corporation, shown here in January 2023, sit about 1,000 yards away from a controversial proposed dump site. Credit: Dylan Baddour/Inside Climate News.

The controversy over waste facilities was evident In February, when the commission's chair, Christi Craddick, was testifying before a state Senate committee about the commission's budget. State Sen. Robert Nichols, a Republican from Jacksonville in far East Texas, began asking questions about why his constituents were spending tens of thousands of their own dollars to fight an oil and gas waste facility.

Texas has less restrictive rules on waste disposal sites than Louisiana, Nichols said, making disposal facilities near the state line tempting places for oil companies to dump. The proposed facility near Paxton was of particular concern. The residents had raised $50,000 to fight the facility, Nichols said.

State Sen. Robert Nichols

"Your staff has rejected … this application from an administrative standpoint because it's right next to an aquifer, next to the city water supply, next to wetlands, things like that," he said. "But somehow or another [it] keeps being raised from the dead."

Craddick told Nichols she couldn't comment on a matter pending before the commission beyond saying companies whose permits were rejected "have a right to come file" new applications.

McBride Operating LLC had applied in 2019 to develop the waste facility with a drying pad, truck washout pad and landfill half a mile east of Paxton. Community opposition quickly grew intense. Neighbors hired lawyers and a geoscientist to contest the permit and try to poke holes in McBride's proposal, particularly its assertion that nearby wetlands and the Carrizo-Wilcox Aquifer would be safe from contamination. The fight culminated in a two-week hearing before a Railroad Commission administrative law judge in November 2021. The commission's staff recommended denying the permit.

At a public commission meeting in December 2022, however, Wright proposed giving the project developers another chance.

"East Texas has certain conditions like shallow groundwater, which makes it difficult to permit a location for the permanent disposal of oil and gas waste," he said. "The cost for oil and gas waste disposal in East Texas is high, and I don't want to negatively affect production in the area. However, this need for disposal capacity, dire as it may be, cannot cause the commission to relax its rules and regulations for protection of freshwater."

He made a motion to send the permit application back to the commission's hearings division, giving McBride a chance to fix its permit application.

"I myself have constructed safe landfills in similar conditions that handled not just oil and gas waste, but rather industrial hazardous waste," Wright said. "In other words, it can be done."

All three commissioners approved the motion. The Railroad Commission held a three-day hearing this spring and hasn't made a recommendation.

John Hicks, a lawyer for McBride Operating, blamed the drawn-out process in part on the neighbors protesting the site, using the term "NIMBY", an acronym for "not in my backyard." He said an inexperienced Railroad Commission staffer wrote the 2021 recommendation to deny the permit, which Hicks called "flawed." He applauded Wright's decision to send the application back for another hearing.

McBride "has also had its time and resources burdened in order to disprove the protestants' arguments," Hicks wrote in an email. "McBride is also a landowner and is merely seeking to exercise its property rights within the law."

Linda Wheeler, who lives near Paxton, spent two weeks in Austin at her own expense to protest McBride's permit application at the 2021 hearing. But she couldn't leave Paxton to attend the hearing this year because her elderly mother needed care.

"I can't tell you how many times they've given [McBride Operating] a chance to fix this," she said. "I think they're wanting us to give up."

Critics' Perception of Conflicts

Wright, a South Texas rancher who was elected to the commission in 2020, probably knows the waste disposal business better than other commissioners and most commission staff.

Jim Wright

He says his first job at age 19 was at a hazardous waste facility. In the four decades since — he's 61 — he has gone from employee to owner. According to his public financial disclosures, Wright has ownership in three waste-hauling companies regulated by the Railroad Commission; he's president of one and director of another.

Yet Wright came onto the commission as somewhat of an outsider. He defeated an industry-backed incumbent in the Republican primary. He has taken positions that suggested he would serve independently of influence from the oil, gas and waste disposal industries. Among the stances were **suggesting on the campaign trail** that disposal site permits are too quickly granted and promising to recuse himself on matters involving campaign donors.

But environmental advocates question whether Wright can be an impartial regulator. He once paid fines for **environmental violations** by a company he had owned. He's **softened** his promise on potential conflicts of interest, now saying he'll recuse himself only on matters involving contributors who gave directly before a commission vote.Blackhorn executives and McBride Operating are among the dozens of companies, lobbyists, lawyers and executives with ties to the energy industry that have donated to Wright's campaign.

Wright isn't the only commissioner who critics say has conflicts.

Craddick is the scion of a political family that **made a fortune** in the oil and gas industry and has accepted contributions from people involved in the oil and gas industry, campaign disclosure records show. That includes more than $20,000 from **McBride Operating and its owner**. Commissioner Wayne Christian, a former legislator, has also received campaign donations from oil and gas interests, including a **$100,000 contribution** in 2020 from a company whose disposal site he'd voted to approve against the commission staff's recommendation. Both Craddick and Christian have received donations from Blackhorn executives.A Paxton landowner opposed to the McBride facility gave several hundred dollars to Christian and Wright.

Asked about a report on commissioners' financial ties to industries, Craddick **issued a statement** in 2021 saying Texas Ethics Commission laws ensure transparency and "I take these laws seriously." Christian **said** during his 2022 race that campaigns are

Wayne Christian

expensive to run but he has never allowed a political contribution to influence his decisions.

Critics of the commission say they're skeptical Wright can lead a recrafting of Rule 8 regulations to benefit the public good.

"When it comes to the waste industry, he has a personal financial interest in it," Palacios said. "It's hard to say if he has strong enough environmental values or strong enough concern for public health that it will outweigh his business interests."

Krejci, Wright's spokesperson, said the commissioner owns less than 10% of one of the Railroad Commission-regulated companies listed on his financial disclosures and is not involved in its day-to-day operations. The other two companies also conduct operations regulated by the TCEQ and the federal government, Krejci said.

"As a candidate for office and now as commissioner, I base my decisions on what I believe is best for the state and our citizens," Wright said in a statement.

The Rule 8 regulations last underwent an overhaul in 1984 and saw minor changes in the 1990s. When Railroad Commission staff last tried to rewrite the rule 20 years ago — commissioners didn't adopt the changes — they held workshops in five cities and sought public comments. That hasn't happened this time. Commission Shift has accused Wright of soliciting input only from industry representatives.

Krejci said he expects a draft to be posted on the Railroad Commission's website by late summer or early fall. An informal public comment period will occur before the proposed rules are submitted to the commissioners. After that, the proposed rule will be published in the Texas Register for a formal comment period before the commissioners vote on whether to adopt it. While an industry task force has provided input, Krejci said the final product will be the work of Railroad Commission staff and the commissioners. He accused Commission Shift of trying "to attach false motives to the commissioner's stated goals to provide needed updates to Statewide Rule 8."

"Commissioner Wright anticipates the proposed rule will strengthen protections and provide greater clarity for all parties," Krejci said.

A recent draft of the new rules has some changes Commission Shift supports, like requiring more wells to monitor groundwater near waste facilities.

Virginia Palacios

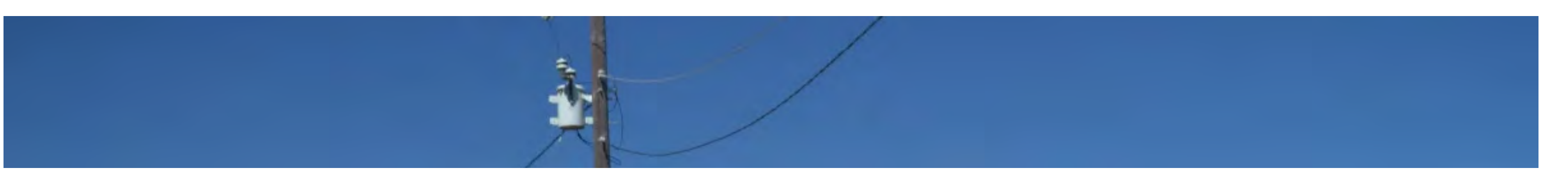
"But what we're not seeing are stronger standards for protecting the public or the environment," Palacios, the watchdog's executive director, said.

For example, a recent draft of the proposed rule would codify the Commission's *laissez– faire* policy toward fining permit violators, Palacios said.

Louisiana, in contrast, makes it easier to protest permit applications and limits the number of times a company can amend its application, she said.

Among the changes Palacios would like to see in the new rule: increasing public outreach, strengthening enforcement provisions, more rigorous testing of oilfield waste and requiring a more intensive review of permit applications.

Residents Challenge Disposal Site



The entrance to the Blackhorn Environmental Services oil and gas waste disposal facility is on a narrow county road southwest of Orange Grove, Texas. Since the facility opened in 2019, neighbors have complained of foul odors and pressed state regulators to take action. Credit: Jason Buch.

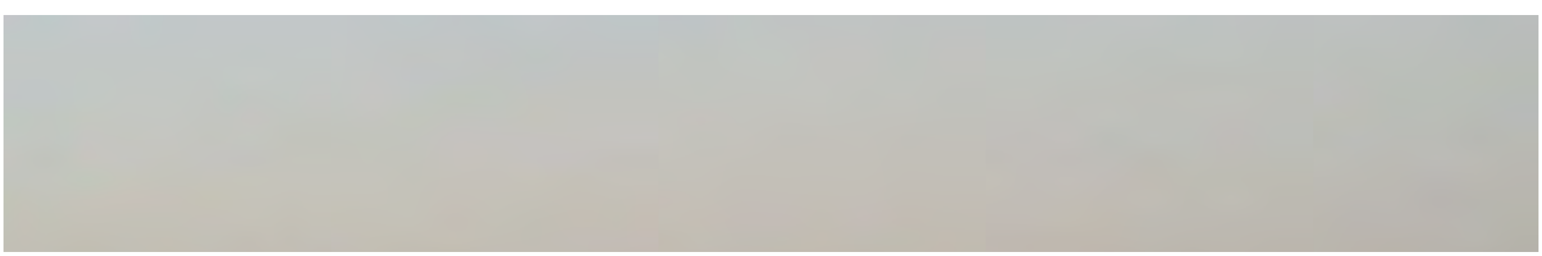
In Orange Grove, the odor from Blackhorn's disposal site caused neighbors to file dozens of complaints with the state in 2019, the year the facility opened.

In late 2019 and early 2020, investigators from the Railroad Commission and the TCEQ paid regular visits to the facility and nearby properties, records from both agencies show. Jones said inspectors told her that air quality was within the TCEQ's jurisdiction, not the commission's. In April 2020, the TCEQ issued a notice of violation to Blackhorn for "unpleasant petroleum odors" that interfered with "normal use and enjoyment of animal life, vegetation, or property," according to a TCEQ environmental investigator's summary. But the TCEQ didn't penalize the company.

In 2020, 11 neighbors, excluding the Jones family, sued Blackhorn in a Jim Wells County district court alleging it had failed to notify the Railroad Commission of nearby drinking water wells. The lawsuit also complained of odors that made it "unbearable to be outside and seep into the house," causing headaches, runny noses and itchy throats, according to affidavits filed in the lawsuit. Even the complainants' dogs had runny noses.

In August 2020, a TCEQ investigator responding to complaints "immediately felt nauseous [from the odor] and had to leave the area promptly," according to court filings.

Tara Jones began keeping detailed odor logs in late 2019 at the TCEQ's request. The following August, she documented 14 hours of rank odors on one day, 18 and a half hours on another.



Months after an oil and gas waste disposal facility opened near Tara Jones and her family's house near Orange Grove, Texas, they started noticing a foul odor that would sometimes make them ill. Jones said it took more than a year of agitating before state regulators took action. Credit: Jason Buch

One night in December 2020 the Jones family again came home to a foul odor. Tara Jones said she rushed her daughters inside, but the stink had permeated the house. She and her family had a metallic taste in their mouths, and she and her husband got headaches, Jones said.

"My headache was so strong, I felt like I was going to throw up," she said.

Jones decided that keeping odor logs and relying on the diligence of regulators was not enough. She familiarized herself with Blackhorn's permit and state rules, then began filing requests with the Railroad Commission and the TCEQ for records of waste delivered to the Blackhorn facility, and the tests performed on that waste.

"At that point I was like, 'If they're not going to do it, I'm going to do it," she said.

In April 2021, commissioners voted to renew Blackhorn's permit, with Wright noting they would keep monitoring the situation.

That same day, Tara Jones emailed a lengthy summary of her findings to the Railroad Commission. She alleged that Blackhorn received waste from unlicensed haulers. Jones also asked why waste, identified as "backwash" and "contaminated bottoms" in the company's reports to the commission, was being shipped to Blackhorn by a facility owned by Valicor Environmental Services in nearby Robstown. And whether that waste was being tested for toxics, as required.

The following month, the Railroad Commission told Blackhorn it **had violated its permit** by taking waste from three companies, which Jones had flagged, that weren't approved oil and gas waste haulers. It also asked for more information about tests conducted on the Valicor waste. In early June, the Railroad Commission notified Blackhorn it had also violated its permit by accepting waste from Valicor, and **the permit would be suspended**, commission records show. DeSilva, the commission's communication director, said the investigation of Blackhorn was prompted by a March 2021 inspection of Valicor's facility.

Since January 2020, the Orange Grove facility had accepted 644 loads of unpermitted waste from Valicor that hadn't been properly tested for toxics, the Railroad Commission said. The TCEQ later said it tracked 3.8 million gallons and 871 cubic yards of waste from Valicor to the Blackhorn facility.

Neighbors on the small cattle ranches near the Blackhorn Environmental waste disposal site said they suffered headaches, runny noses and itchy throats from the noxious odors that wafted through their property. Credit: Jason Buch

Blackhorn appealed, denying it had violated its permit. The companywas allowed to keep operating pending the commission's decision on the permit suspension.

In a statement to Public Health Watch, Patricia Canales Bell, Blackhorn's attorney, wrote that "the Valicor material is non-hazardous and chemically and physically similar to traditional oil and gas waste materials that are managed and processed daily at the Blackhorn facility."

TCEQ is investigating Valicor's role in unauthorized waste sent to the Blackhorn facility, according to agency records. Valicor declined to comment.

Four days after commission staff issued the June violation notice, the commissioners voted to deny the Jones family's appeal of their decision to renew the permit. Wright said Blackhorn would have to provide more information to prove it was in compliance.

"The people of Texas have my word that we will continue to closely monitor this situation," he said.

In November 2021, the Railroad Commission gave Blackhorn **a clean bill of health**, ending the permit suspension without issuing a fine. The company had stopped accepting unpermitted waste and taken steps to prevent future violations, commission staff said.

"The RRC's priority was ensuring the facility was brought into compliance with its permit and that there were no continuing issues," DeSilva, the commission spokesman, wrote in an email.

Canales Bell, Blackhorn's lawyer, wrote in an email to Public Health Watch that the company followed Railroad Commission environmental protection rules. Blackhorn had the waste tested, and the results show "that the Valicor material presents no greater concern or threat to human health or the environment when compared to traditional oil and gas waste generated at the well site," Canales Bell wrote.

"The Railroad Commission has confirmed that all operations of the Blackhorn facility are in full compliance with every aspect of the issued permit under Statewide Rule 8," she added.

In early 2022, a judge in Jim Wells County dismissed most of the claims in the lawsuit filed by Blackhorn's neighbors. A few months later, both sides reached a settlement on the remaining piece of the lawsuit. Neither would share details of the agreement.

Jones and other neighbors were disappointed with the Railroad Commission's decisions. They still didn't know what had been making them sick, and Jones said she thought Blackhorn deserved stiffer penalties.

"There's no incentive to do better," she said. "You don't even get a slap on the wrist."

Palacios, of Commission Shift, said a draft of the proposed Rule 8 would allow commission staff to more easily monitor the specific waste that is dropped at disposal sites by letting companies submit their manifests electronically. But electronic reporting wouldn't be required. If it were and the commission checked the reports, oversight would be more rigorous than the system in place, which relies on private citizens like Jones to review typed or handwritten manifests and reports, Palacios said.

Jones "had to learn how the system functions, then she had to comb through the records line by line when the computer could do this in a split second," Palacios said.

The lights from Blackhorn Environmental's disposal facility are visible from neighboring properties near Orange Grove, Texas. State regulators said the facility accepted unpermitted waste but allowed Blackhorn to keep operating it. A Blackhorn attorney said the materials were similar to traditional oil and gas waste processed at the facility daily. Credit: Jason Buch.

State Goes to Court

As the Railroad Commission took steps to end the case against Blackhorn, the TCEQ pressed ahead with its investigation.

During a June 2021 inspection, TCEQ asked for records about Blackhorn's facility, according to court filings. Blackhorn initially promised to provide the records electronically, but then told inspectors they would have to return to the Orange Grove facility to view them, according to court filings and agency records.

In April 2022, the Texas attorney general **sued Blackhorn** on behalf of the TCEQ, asking a judge to impose civil penalties for Blackhorn's accepting waste from Valicor, which the TCEQ regulated, and refusing to provide the records. Blackhorn has argued in court that the TCEQ doesn't have jurisdiction over the company.

Canales Bell, Blackhorn's attorney, said the TCEQ's request for records was voluminous and "overly burdensome."

The agency never responded to Blackhorn's invitation to inspect records at the Orange Grove facility, she said.

"Instead, it included this groundless records allegation in its original petition and seeks damages against Blackhorn," Canales Bell said.

That case is pending. Last year, the Railroad Commission gave Blackhorn permission to receive waste from a Superfund site, but that plan was derailed after the TCEQ intervened.

Tara Jones said that when her neighbors rallied to oppose Blackhorn's operating permit nearly a decade ago, her family stayed out of it. Her husband works in the oil and gas industry, and they didn't want to bite the hand that feeds them. When other neighbors sued the company over the odors and water wells issue, the Joneses didn't join. But she spent enormous amounts of time trying to figure out what was making her family sick — a testament to how miserable they were, she said.

When she heard about the attorney general's lawsuit, she started crying.

"It was just so much work, and I wasn't getting any traction from the Railroad Commission," she said. "It was almost relief that, hey, somebody really is listening, and hopefully we can get it resolved."

A few months ago, the odor from the waste disposal site returned, although it's milder than before, Jones said. She has started keeping an odor log again.

Correction: The month that Tara Jones and her family suffered health effects from a foul odor at their home again was December 2020, not December 2021.

Jason Buch is a freelance journalist based in Texas.

Exhibit 10

Mark Henkhaus
RE: RRC Proposed Rule Changes - Chapter 4
August 15, 2022 at 3:47 PM EDT
To: Paul Dubois

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On your call I represented PBPA, as their Regulatory Practices Committee chair. We have a full RPC meeting tomorrow, and before I shared any documentation I wanted to clear with you. I'll not share anything now but I'll review from the ***two pages*** of notes I took!

With your OK I would share with the regulatory folks at Diamondback, Apache, Chevron, and a few select others. I've got people that I trust at these companies. I'd probably float it by a water midstream company also, likely H2O Midstream Permian, whom I have a good working relationship with.

I understand Milestone has been involved in this, and the first real early draft I saw from them took things a little too far into their business model. Don't tell them I said that, but I want to make sure that the waste handlers are not using the Commission to further their business, if you know what I mean.

I need to spend some time reviewing your proposals before I get specific.

Thanks Paul!
Mark

From: Paul Dubois <Paul.Dubois@rrc.texas.gov>
Sent: Monday, August 15, 2022 2:41 PM
To: mark@permianregulatory.com
Subject: RE: RRC Proposed Rule Changes - Chapter 4

Hi Mark,

I'm not used to crickets on conference calls! But I understand you all are just getting started. Can I ask, who are you representing?

I am looking for good feedback that helps us move forward. My instructions were to share with the associations, expecting the associations to selectively share with you and other consultants/lobbyists/members. I don't mind other input, but I'd like to keep the feedback at this time limited to the persons chosen by the associations.

Bottomline, I'm looking to know what support there may be, where the tough spots are, and the best way to move forward.

Thanks!

Regards,

Paul Dubois, P.E.
Assistant Director, Technical Permitting | Oil & Gas Division
Railroad Commission of Texas
512-463-6778
Take our Customer Service Survey

From: Mark Henkhaus <mark@permianregulatory.com>
Sent: Monday, August 15, 2022 2:27 PM
To: Paul Dubois <Paul.Dubois@rrc.texas.gov>
Subject: RE: RRC Proposed Rule Changes - Chapter 4

Thanks Paul. I bet we have more questions next time. Do you prefer this (and the revisions you sent recently) to remain within the trades' control, or are you good with providing this to operators who may want to review the proposals early? Wil honor your preference.

Appreciate your willingness to discuss, that means a lot.

Mark

Mark Henkhaus, P.E.
Permian Regulatory Solutions, PLLC
www.permianregulatory.com
432-894-1857

From: Paul Dubois <Paul.Dubois@rrc.texas.gov>
Sent: Monday, August 15, 2022 2:09 PM

Exhibit 11

STRONGER

State Review of Oil & Natural Gas Environmental Regulations

Guidelines for the Review of State Oil and Gas Environmental Regulatory Programs

2022 Edition

STATE REVIEW OF OIL AND NATURAL GAS ENVIRONMENTAL REGULATIONS, INC.
www.strongerinc.org

SECTION 1 | Introduction

1.1 Background

The 1980 amendments to the Resource Conservation and Recovery Act (RCRA) created an exemption to the federal hazardous waste program for oil and gas exploration and production (E&P) wastes pending completion of a study by the U.S. Environmental Protection Agency (EPA). In 1988, EPA completed its study and determined that these wastes should not be regulated as hazardous wastes. EPA's regulatory determination concluded that existing state and federal regulations were generally adequate, but that some regulatory gaps existed, and that enforcement of existing regulations was inconsistent. EPA proposed a three-pronged approach to address these concerns that included working with the states to encourage improvement in state regulations and enforcement programs. Further discussion of the regulatory determination follows in section 1.2.

In 1989, the Interstate Oil and Gas Compact Commission ("IOGCC") responded by offering to assist EPA by creating a state regulatory review process. The IOGCC created the Council on Regulatory Needs, bringing together state, environmental, and industry representatives to develop national guidelines for state oil and gas programs. In early 1990, the Council released a document entitled "EPA/IOCC Study of State Regulation of Oil and Gas Exploration and Production Waste". This document established guidelines that represented recommended criteria for regulatory programs. The Council also proposed to implement a process by which state oil and gas programs were reviewed in comparison with those guidelines.

In 1990, EPA provided a grant to the IOGCC to initiate state regulatory program reviews in comparison with the guidelines. Review teams were comprised of state regulatory officials, environmental representatives, and industry representatives. Representatives of other interested parties, such as federal agencies and tribal governments, were invited to observe the process. State reviews were conducted in states that volunteered for review. Recommendations were offered as blueprints for change to be considered by state legislators and regulators.

The Council recommended that the guidelines be reviewed and updated every three years. In 1994, the Council updated the guidelines and added sections regarding naturally occurring radioactive material (NORM) and abandoned wells.

In 1999 a multi-stakeholder organization was formed by the state review program participants to revitalize and carry the state review program forward. This organization is called State Review of Oil and Natural Gas Environmental Regulations, Inc. ("STRONGER"). STRONGER is a non-profit corporation that has been formed to educate regulators and the public as to the appropriate elements of a state oil and gas exploration and production regulatory program, and to compare various state programs against the guidelines developed by STRONGER and for the protection of public health, safety and the environment.

In 1999, STRONGER established five committees to review and update the 1994 version of the Guidelines. STRONGER incorporated the consensus recommendations of the committees, including a new section on performance measures in the 2000 Guidelines update. STRONGER again initiated revision and updating of the Guidelines in 2004, which resulted in the 2005 Guidelines. The 2005 Guidelines incorporate spill prevention and performance measures into the administrative criteria section and were expanded to include a new section on stormwater management.

In 2009 STRONGER formed a workgroup that developed guidelines for hydraulic fracturing that were finalized in 2010, and updated in 2013. STRONGER adopted guidelines for Air Quality in 2014, and updated the Air Quality Guidelines to address methane emissions in 2019. In 2015 STRONGER adopted guidelines for Reused & Recycled Fluids, as well as making minor updates to the General Criteria, Administration, Technical Criteria, NORM, and Hydraulic Fracturing sections. In 2017 STRONGER developed additional reused and recycled fluids guidance pertaining to pipelines used to transport produced water. In 2019 the STRONGER Board of Directors updated the Administrative and Technical Criteria.

Since 1990, 41 initial, follow-up, and single-topic state reviews have been conducted against the guidelines criteria: 12 under the 1990 edition guidelines, 5 under the 1994 edition guidelines, 11 under the 2000 edition guidelines, 2 under the 2005 edition guidelines, 7 single-topic reviews on hydraulic fracturing, 3 single-topic reviews on air quality, and 1 follow-up review under the 2015 edition guidelines. These states have implemented many of the recommendations from their respective state reviews, as documented in STRONGER's report entitled "A Report and History on the STRONGER State Review Process" (June, 2015).

1.2 EPA's Regulatory Determination for E&P Waste

The 1980 amendments to the RCRA required EPA to conduct a study of the environmental and potential human health impacts associated with E&P wastes and their associated waste management practices. EPA completed its two-year study in 1987. Based on the findings in the Report to Congress, and on oral and written comments received during public hearings in the spring of 1988, on June 30, 1988, EPA decided not to recommend federal regulation of E&P wastes as hazardous wastes under Subtitle C of RCRA (EPA 1988). The Agency gave the following reasons for its determination:

a. "Subtitle C does not provide sufficient flexibility to consider costs and avoid the serious economic impacts that regulation would create for the industry's exploration and production operations;

b. "Existing state and federal regulatory programs are generally adequate for controlling oil, gas, and geothermal wastes. Regulatory gaps in the Clean Water Act and UIC (Underground Injection Control) program are already being addressed, and the remaining gaps in state and federal regulatory programs can be effectively addressed by formulating requirements under Subtitle D of RCRA and by working with the States;

c. "Permitting delays would hinder new facilities, disrupting the search for new oil and gas deposits;

d. "Subtitle C regulation of these wastes could severely strain existing Subtitle C facility capacity;

e. "It is impractical and inefficient to implement Subtitle C for all or some of these wastes because of the disruption and, in some cases, duplication of state authorities that administer programs through organizational structures tailored to the oil and gas industry; and

f. "It is impractical and inefficient to implement Subtitle C for all or some of these wastes because of the permitting burden that the regulatory agencies would incur if even a small percentage of these sites were considered Treatment, Storage, and Disposal Facilities (TSDFs)." (53 FR 25456, July 6, 1988).

In the determination, EPA found that "existing state and federal regulations are generally adequate...Certain regulatory gaps do exist and enforcement of existing regulation in some states is inadequate." To address those concerns, EPA announced a three-pronged approach that consists of:

- "Improving federal programs under existing statutory authorities in RCRA Subtitle D, the Clean Water Act, and the Safe Drinking Water Act;
- "Working with states to encourage improvements in the states' regulations and enforcement of existing programs; and
- "Working with Congress to develop any additional statutory authority that may be required."

1.3 State and Federal Relations

Periodic evaluations of state and federal E&P waste management programs have proven useful in improving the effectiveness of those programs and increasing cooperation between federal and state regulatory agencies. Stakeholder review mechanisms have demonstrated the need for establishment of a performance baseline against which E&P waste management programs can be evaluated. Those mechanisms have led to the identification of strategies that will improve communication and program understanding between the states and the federal government.

1.3.1 Strategies for Maintaining a Successful Relationship Between State and Federal

Agencies

As stated in EPA's regulatory determination for E&P waste, "…existing state and federal regulations are generally adequate to control the management of oil and gas wastes. Certain regulatory gaps do exist, however, and enforcement of existing regulations in some states is inadequate." The key is that overall state programs are adequate, and have improved since 1990 through adoption of recommendations from reviews, information sharing among the states and self-initiated program improvements. To address remaining gaps and build upon the success of the state review program, the focus of future efforts should be to utilize information developed from the reviews already conducted, augmented by new information developed by the stakeholders, to improve the performance of state regulatory programs.

The stakeholders — oil and gas producing states, public interest representatives, and industry representatives — have identified ten related strategies that enhance state and federal relationships.

a. Commitment to Work Cooperatively. The states and federal agencies should maintain a commitment to work cooperatively to improve the design, implementation, and enforcement of state and federal programs for managing E&P wastes. State and federal agencies should take steps to encourage open communications among state and federal agencies, the regulated industry, and other interested parties pertaining to the management and regulation of E&P wastes.

b. Recognition of Different Priorities. States should recognize the interest of federal agencies in achieving national goals and objectives and assuring adherence to federal statutory and regulatory requirements. At the same time, federal agencies should recognize the authorities, responsibilities, and capabilities of states to regulate certain activities within their borders.

c. Recognition of Different Statutory Objectives. Several of the federal statutes governing protection of the environment (*e.g.,* RCRA, Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Clean Air Act (CAA)) provide for state implementation of certain elements with federal oversight. The objectives of and authorities granted by each statute differ. As such, it should be recognized that federal and state authorities and implementation approaches may differ.

d. Recognition of Regional Diversity. As discussed in the Report to Congress and the legislative history of the SDWA, variable approaches to the management of E&P wastes are necessary. These variable approaches are partly a result of the different geologic, hydrologic, or historic conditions in states and areas within a state, the diverse characteristics of oil and gas activities, and differences in state government structures among the producing states. Guidelines or criteria, whether issued by a federal agency such as EPA or as advocated by STRONGER, should be sufficiently flexible to permit states to take into account these varying conditions.

e. Baseline of Performance. The criteria adopted by STRONGER should be used by federal or state agencies that are responsible for any portion of an E&P waste management program. These criteria should serve as a baseline of performance by which the effectiveness of programs can be judged. The criteria provide states flexibility to address unique conditions while accomplishing the goals set forth in Section 3.

f. State Responsibility for Enforcement. Enforcement is a critical component of a state E&P waste management program. Federal government involvement should occur only if the state agency fails to enforce the requirements or requests federal assistance.

g. State Program Review Process. The state program review process should continue to provide states with an independent evaluation of their E&P waste management programs using criteria adopted by the IOGCC and STRONGER.

h. Resolving Conflicts/Building Consensus. Where there are unresolved national issues or concerns regarding E&P waste management, a task force should be created which is similar in makeup and form to that established for the EPA's Office of Drinking Water Mid-Course Evaluation of Class II UIC programs. The creation of this task force would bring knowledgeable federal and state regulators together to discuss issues, to ascertain whether problems associated with these issues are real or perceived, and to decide how best to address the issues. This process should be based on the best available information and could be initiated by either the federal government or the states.

i. Effective Multi-Agency Coordination. Coordination among the state agencies is addressed in more detail in section 4.4. However, each state should recognize that coordination among various agencies is necessary for building and maintaining trust between the state agencies and the federal agency that has oversight responsibilities.

j. Technical and Financial Assistance. The federal government should provide technical and financial assistance to states to improve the design, implementation, and enforcement of state E&P waste management programs. Such assistance may be in the areas of training, enforcement, and data management.

SECTION 2 | Scope of the Criteria

2.1 General

a. These criteria are intended to guide states in assessing and improving their regulatory programs for E&P waste management, abandoned sites, naturally occurring radioactive materials (NORM), storm water management, hydraulic fracturing, air quality, and reused & recycled fluids. This document, therefore, sets out the elements of an effective program using "should" rather than the mandatory "shall", and "are encouraged to" for elements which are desirable, but which are not necessary for an effective program.

b. These criteria address waste management practices that are unique to E&P operations and wastes that were determined by EPA to be exempt from the hazardous waste management requirements of Subtitle C of RCRA. These narrowly defined wastes include drilling muds and cuttings, produced water and other wastes associated with E&P activities. The chemical and radiological characteristics of these wastes and the management practices associated with the storage, treatment, and disposal of these wastes are covered by these criteria. Wastes that are uniformly regulated by RCRA hazardous waste management requirements, as well as general industrial wastes such as solvents, off-specification chemicals, commercial products, household wastes, and office refuse are not addressed by these criteria.

c. These criteria apply to all new and currently operating E&P waste management facilities. In addition, the criteria in Section 6 apply to abandoned sites, the criteria in Section 7 apply to NORM, the criteria in Section 8 apply to storm water management, the criteria in Section 9 apply to hydraulic fracturing, the criteria in Section 10 apply to air quality, and the criteria in Section 11 apply to reused and recycled fluids.

d. These criteria do not address disposal of E&P wastes by injection or surface discharge when those waste management practices are regulated by EPA or by the states under authority of the federal SDWA and federal CWA, respectively. Brief descriptions of the regulatory frameworks authorized by those laws follow in Sections 2.2. and 2.3.

e. In addition to a review of provisions of the SDWA and CWA that are applicable to E&P wastes, this section also contains federal definitions of solid wastes and hazardous wastes and reviews EPA's waste mixture rule; lists examples of exempt and non-exempt E&P wastes; and describes general requirements for the management of non-exempt wastes. States may have different definitions for solid and hazardous wastes.

2.2 Class II Injection Wells

The SDWA is the primary federal statute that governs injection wells. The SDWA required the EPA to promulgate regulations to protect drinking water sources from contamination through underground injection, but directed the Agency not to prescribe requirements that would impede oil and gas production. EPA established five classes of injection wells, categorized by purpose, potential for endangering drinking water, depth of injection, and characteristics of their injectate quality. Class II injection wells are broadly defined as related to oil and gas injection activities. Activities in this class relate to the disposal of fluids associated with oil and gas exploration and production, enhanced recovery operations, and the storage of liquid hydrocarbons.

Enhanced recovery describes all efforts to increase ultimate production of oil and gas from a reservoir, and this terminology will be considered to encompass other nomenclature in common usage such as pressure maintenance, secondary recovery, and tertiary recovery. All enhanced recovery techniques include methods for supplementing natural reservoir forces and energy, or otherwise increasing ultimate recovery. Such techniques include water injection, gas injection, gas cycling, and miscible chemicals and thermal processes.

Class II UIC programs are administered by the States where EPA has approved primary enforcement authority (primacy), or are directly implemented by EPA where the States have not sought or received approval for their UIC program. Amendments to the SDWA in 1980 further allowed a State with an existing regulatory program to obtain primary enforcement authority from EPA as long as the State was able to demonstrate that its program was effective in protecting underground sources of drinking water (USDWs), rather than adopting the complete set of Federal requirements. States with UIC program primacy receive federal funding for program implementation.

In general, EPA determines which fluids may be injected into Class II wells in direct implementation UIC programs. Primacy States follow their EPA-approved primacy agreements in ascertaining whether specific fluids are qualified for injection into their Class II wells.

Among the minimum requirements for Class II wells are:

a. Only approved fluids may be injected,

b. No injection may endanger a USDW,

c. No well may be used for injection without a permit, unless authorized by rule.

d. All injection wells must demonstrate mechanical integrity at least once every 5 years.

2.3 NPDES-Permitted Discharges

All point-source discharges of pollutants to surface waters of the United States must comply with the requirements of permits issued under the National Pollutant Discharge Elimination System (NPDES). The NPDES program is administered by EPA under the authority of the federal CWA or by the states through programs delegated by EPA. NPDES permits establish effluent limitations and monitoring requirements for discharges.

Effluent limits are based upon the more stringent of levels which can be achieved through the use of available technology, and levels necessary to meet EPA-approved state water quality standards.

The CWA requires NPDES permits for E&P waste discharges to surface water. Currently, effluent guidelines prevent most discharge to surface waters except the following categories:

a. Discharges to certain coastal areas;

b. Discharges of low-salinity produced waters which are of beneficial use in arid regions west of the 98th meridian; and

c. Discharges from stripper oil wells in certain areas.

2.4 Federal Definition of Solid Waste

a. In simplest terms, a solid waste is any material that is discarded or intended to be discarded. According to RCRA, solid wastes may be solid, semi-solid, liquid, or contained gaseous material. Commercial products are not solid wastes unless, and until, they are discarded. Commercial products and their releases may also be regulated under other statutes such as the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Toxic Substances Control Act (TSCA), Superfund Amendments and Reauthorization Act (SARA), and the Occupational Safety and Health Act (OSHA).

b. EPA has also determined that produced water injected for enhanced recovery is not a waste for purposes of RCRA Subtitle C or D, since produced water used in enhanced recovery is beneficially recycled and is an integral part of some crude oil and natural gas production processes.

2.5 Hazardous Waste

Under RCRA, a solid waste may be designated as hazardous waste if it is specifically listed as a hazardous waste or if it exhibits one or more of the characteristics of hazardous wastes. (See 40 CFR 261).

2.5.1 Listed Hazardous Waste

a. EPA has listed numerous types or classes of solid wastes as hazardous waste because they typically exhibit one or more of the characteristics of hazardous waste, or have been shown to exceed certain human toxicity criteria, or contain any one of the chemical compounds or substances that are listed as hazardous constituents. (see 40 CFR 261 APP VIII.)

b. EPA's regulations contain four lists of hazardous wastes: 1) hazardous waste from non-specific sources; 2) hazardous waste from specific sources; 3) commercial chemical products that become acutely hazardous waste when disposed; and 4) commercial chemical products that become toxic wastes when disposed.

2.5.2 Characteristically Hazardous Waste

a. EPA considers any solid waste to be a hazardous waste if it exhibits any one of the characteristics of ignitability, corrosivity, reactivity, or toxicity.

b. The toxicity characteristic is determined by the toxicity characteristic leaching procedure (TCLP). The list of constituents includes eight heavy metals and thirty-two organic compounds

2.6 EPA's Identification of Exempt Exploration and Production Wastes

The list below identifies many, but not all, exempt wastes. In general, E&P exempt wastes are generated in "primary field operations" and are unique or intrinsic to exploration and production activities (e.g., drilling for, producing, and purifying crude oil and natural gas), and not as a result of maintenance or transportation activities.

All wastes generated in transportation and refining are non-exempt. EPA's regulatory determination for E&P wastes (see 53 FR 25453, July 6, 1988) found that the following wastes are exempt from RCRA hazardous waste management requirements:

- "Produced water;
- "Drilling fluids;
- "Drill cuttings;
- "Rig wash;
- "Drilling fluids and cuttings from offshore operations disposed of onshore;
- "Well completion, treatment, and stimulation fluids;
- "Basic sediment and water, and other tank bottoms from storage facilities that hold product and exempt waste;
- "Accumulated materials such as hydrocarbons, solids, sand, and emulsion from production separators, fluid treating vessels, and production impoundments;
- "Pit sludges and contaminated bottoms from storage or disposal of exempt wastes;

- "Workover wastes;
- "Gas plant sweetening wastes for sulfur removal, including amine, amine filters, amine filter media, backwash, precipitated amine sludge, iron sponge, and hydrogen sulfide scrubber liquid and sludge;
- "Cooling tower blowdown;
- "Spent filters, filter media, and backwash (assuming the filter itself is not hazardous and the residue in it is from an exempt waste stream);
- "Packing fluids;
- "Produced sand;
- "Pipe scale, hydrocarbon solids, hydrates, and other deposits removed from piping and equipment prior to transportation;
- "Hydrocarbon-bearing soil;
- "Pigging wastes from gathering lines;
- "Wastes from subsurface gas storage and retrieval, except for the listed non-exempt wastes;
- "Constituents removed from produced water before it is injected or otherwise disposed of;
- "Liquid hydrocarbons removed from the production stream but not from oil refining;
- "Gases removed from the production stream, such as hydrogen sulfide and carbon dioxide, and volatilized hydrocarbons;
- "Materials ejected from a producing well during the process known as blowdown;
- "Waste crude oil from primary field operations and production; and
- "Light organics volatilized from exempt wastes in reserve pits or impoundments or production equipment."

On March 22, 1993, EPA provided "clarification" regarding the scope of the E&P waste exemption. (see 58 FR 15284-15287.) EPA clarified the concept of primary field operations for crude oil and natural gas production. To fall under the scope of the exemption, an E&P waste must be generated in primary field operations and be unique or intrinsic to the production process. In addition, EPA stated that certain waste streams generated by oil and gas service companies may be "uniquely associated" with primary field operations and as such are within the scope of the RCRA Subtitle C exemption. EPA further clarified that an exempt waste remains exempt regardless of the waste’s custody transfer, and that the residual waste from the treatment of an exempt waste remains exempt (e.g., residual sediment and water from crude oil reclamation from exempt tank bottoms). EPA's clarification cautioned, however, that exempt crude oil reclamation and service-company wastes may not remain exempt if they are mixed with non-exempt materials or wastes. States should carefully review EPA's clarification along with EPA publication EPA530-K-01-004 (October 2002). (found at http://www.epa.gov/epaoswer/other/oil/oil-gas.pdf). EPA periodically issues interpretive letters regarding the oil and gas exemption. One such letter was issued in November 1993 and is referred to in EPA publication EPA530-K-01-004.

2.7 EPA's Identification of Non-exempt Exploration and Production Wastes

Non-exempt wastes include wastes that are not unique to E&P and wastes generated by transportation (pipeline and trucking) and service activities. While the following wastes are non-exempt, their regulatory status as "hazardous wastes" is dependent upon whether they are listed as hazardous waste or they exhibit a hazardous waste characteristic. Non-exempt wastes should be managed as described under Section 2.8. EPA's 1988 regulatory determination lists the following wastes as non-exempt:

- "Unused fracturing fluids or acids;
- "Gas plant cooling tower cleaning wastes;
- "Painting wastes;
- "Oil and gas service company wastes, such as empty drums, drum rinsate, vacuum truck rinsate, sandblast media, painting wastes, spent solvents, spilled chemicals, and waste acids;
- "Vacuum truck and drum rinsate from trucks and drums transporting or containing non-exempt waste;
- "Refinery wastes;
- "Liquid and solid wastes generated by crude oil and tank bottom reclaimers;
- "Used equipment lubrication oils;
- "Waste compressor oil, filters, and blowdown;
- "Used hydraulic fluids;
- "Waste solvents;

- "Waste in transportation pipeline-related pits;
- "Caustic or acid cleaners;
- "Boiler cleaning wastes;
- "Boiler refractory bricks;
- "Incinerator ash;
- "Laboratory wastes;
- "Sanitary wastes;
- "Pesticide wastes;
- "Radioactive tracer wastes; and Drums, insulation, and miscellaneous solids."

EPA did not specifically address, in its 1988 regulatory determination, the status of hydrocarbon-bearing material that is recycled or reclaimed by re-injection into a crude stream. However, under existing EPA regulations, recycled oil, even if it were otherwise hazardous, could be reintroduced into the crude steam, if it is from normal operations and is to be refined along with normal process streams at a petroleum refinery facility. Regulations addressing an exclusion for used oil are at 40 C.F.R 261.6(a)(4), and regulations addressing an exclusion for recovered oil are at 40 C.F.R. 261.4(a)(12) as revised.

2.8 Requirements for Non-exempt Wastes

a. EPA's hazardous waste regulations require that a hazardous waste determination be made for any non-exempt E&P waste. The determination may find the non-exempt waste either to be listed as a hazardous waste or to exhibit a hazardous waste characteristic. If a non-exempt waste is found not to be listed as a hazardous waste or not to exhibit a hazardous waste characteristic, it is a non-exempt non-hazardous waste.

b. If a non-exempt waste is not a listed hazardous waste, it should be tested whenever there is reason to believe it may exhibit one or more of the hazardous waste characteristics. Alternatively, a hazardous waste determination may be made based on knowledge of the process by which the waste is produced. Although there is no requirement that a non-exempt waste be tested to determine if it is hazardous, civil and criminal penalties may be imposed if the waste is not managed in a safe manner and according to regulations.

c. Depending on the actual hazardous waste quantity generated and accumulated on-site, RCRA hazardous waste management standards for generators may apply.

Additionally, treatment, storage, or disposal activities on-site may be subject to more stringent RCRA Subtitle C requirements, such as permitting and corrective action.

d. Non-exempt waste should also be segregated whenever possible from exempt waste. If the non-exempt waste was a listed hazardous waste, its mixture with an exempt waste could make the entire commingled waste stream subject to stringent RCRA Subtitle C requirements, including the requirement that the waste be disposed at a hazardous waste facility. When segregation is not practical, the non-exempt waste should be examined closely to assure that it is not a hazardous waste. See Section 2.9 for additional discussion of waste mixtures.

e. Some states have adopted hazardous waste regulations and have obtained authority from EPA to administer the federal hazardous waste regulations. Those state programs' regulations may differ from those that EPA has promulgated; however, by law, the states' regulations must be at least as stringent as the federal programs.

2.9 Waste Mixtures

EPA's RCRA regulations provide that the commingling of any listed hazardous waste with a non-hazardous waste generally renders the entire mixture a hazardous waste. The intent of this mixture rule is to prevent avoidance of hazardous waste regulations through dilution. For example, discarding a listed hazardous waste (e.g., a half-empty container of a listed solvent) in a reserve pit could cause the otherwise exempt pit contents to become a hazardous waste and result in the expensive closing of the reserve pit under RCRA hazardous waste regulations. Likewise, the mixing of a characteristic hazardous waste with an exempt waste could render the entire mixture a hazardous waste. Also, in those cases where the mixture is no longer considered a hazardous waste, the process of rendering the hazardous waste non-hazardous could be considered treatment of a hazardous waste and RCRA Subtitle C would apply.

Unused commercial products are not exempt wastes when disposed and, if hazardous (or potentially hazardous), should not be disposed with exempt E&P waste. All reasonable efforts should be made to completely use commercial products, return them to their vendor if they are not fully used, or segregate them from other waste for management and disposal.

SECTION 3 | General Criteria

3.1 General

An effective program for the regulation of E&P activities should include, at a minimum:

a. Statutory authority that adequately details the powers and duties of the regulatory body;

b. Statutory authority to promulgate appropriate rules and regulations;

c. Statutes and implementing regulations which adequately define necessary terminology;

d. Provisions to adequately fund and staff the program;

e. Mechanisms for coordination among the public, government agencies, and regulated industry; and

f. Technical criteria for E&P environmental management practices.

3.2 Goals

An effective state program should contain a clear statement of the program's goals and objectives. Such goals should include, at a minimum, protecting human health and the environment from the mismanagement of E&P activities while recognizing the need for an economically viable oil and gas industry. When establishing regulations and policies for E&P waste management, states should use the waste management hierarchy set forth in Section 5.3 to encourage waste minimization and source reduction.

3.3 State/Regional Variations in Criteria

These criteria are intended to provide guidance to the states in the formulation, development, and evaluation of oil and gas environmental regulatory programs. Fundamental differences exist from state to state, and within regions within a state in terms of climate, meteorological patterns, air quality compliance status, hydrology, geology, economics, and method of operation, which may impact on the manner in which oil and gas exploration, development, and production is performed. State oil and gas programs can and should vary from state to state and within portions of a state. The process by which these criteria are incorporated into state programs is a function of, and within the discretion of, the responsible state agency. It is recognized that state programs must vary in order to accommodate differences in climate, hydrology, geology, economics, and method of operation or to accommodate individual differences in state administrative procedures or law. Furthermore, in some instances, in order to accommodate regional, area-wide, or individual differences within a state, it is appropriate for site-specific waivers or variances to be allowed for good cause shown. All such variations should be consistent with the goals of Section 3.2.

SECTION 4 | Administrative Criteria

4.1 Basic Requirements

Various federal regulations applicable to the delegation to states of federal environmental programs provide a useful framework for the development of criteria for an effective state oil and gas exploration and production (E&P) environmental regulatory program. Such environmental regulatory programs should, at a minimum, include provisions for permitting, compliance evaluation, and enforcement.

4.1.1 Permitting

A state should have a regulatory mechanism to assure that E&P activities are conducted in an environmentally responsible manner. A program to achieve that objective may rely on one or more mechanisms, including issuance of individual permits, issuance of permits by rule, establishment of regulatory requirements by rule, issuance of general permits, registration of facilities, and/or notification of certain activities undertaken pursuant to general regulations. State agencies should have authority to refuse to issue or reissue permits or authorizations if the applicant has outstanding, finally determined violations or unpaid penalties, or if a history of past violations demonstrates the applicant's unwillingness or inability to comply with permit requirements. Where the operator responsible for E&P activities changes, state requirements should address the new operator's financial responsibility and compliance history. An effective state program should provide that a state permit does not relieve the operator of the obligation to comply with federal, local, or other state permits or regulatory requirements.
Individual permits for specific facilities or operations should be issued for fixed terms. In the case of commercial or centralized facilities, permits generally should be reviewed and revised, if necessary, no less frequently than every five years. Where two or more regulatory programs mandate similar requirements, those requirements should be combined where feasible. The process for obtaining permits and other authorizations should also involve prompt consideration and response to applications while preserving the integrity of the permit review process, including appropriate public participation. For the purposes of these guidelines, the terms "license" or "licensing" as used in Section 7 of these guidelines, criteria for the management of E&P NORM, will be synonymous with the terms "permit" or "permitting" as they are used throughout these guidelines.

4.1.2 Compliance Evaluation

State programs should contain the following compliance evaluation capabilities:

a. Procedures for the receipt, evaluation, retention, and investigation for possible enforcement action of all notices and reports required of permittees and other regulated persons. Investigation for possible enforcement action should include determination of failure to submit these notices and reports. Effective data management systems as prescribed in Section 4.2.7. can be used to track compliance.

b. Inspection and surveillance procedures that are independent of information supplied by regulated persons and which allow the state to determine compliance with program requirements, including:

   i. The capability to conduct comprehensive investigations of facilities and activities subject to regulation in order to identify a failure to comply with program requirements by responsible persons;

   ii. The capability to conduct regular inspections of regulated facilities and activities at a frequency that is commensurate with the risk to the environment that is presented by each facility or activity; and

   iii. The authority to investigate information obtained regarding violations of applicable program and permit requirements.

c. Procedures to receive and evaluate information submitted by the public about alleged violations and to encourage the public to report perceived violations. Such procedures should not only involve communications with the public to apprise it of the process to be followed in filing reports or complaints but should also communicate how the state agency will assure an appropriate and timely response.

d. Authority to conduct unannounced inspections of any regulated site or premises where E&P activities are being conducted, including the authority to inspect, sample, monitor, or otherwise investigate compliance with permit conditions and other program requirements.

e. Authority to enter locations where records are kept during reasonable hours for purposes of copying and inspecting such records.

f. Investigatory procedures that will produce a paper trail to support evidence which may be admitted in any enforcement proceeding brought against an alleged violator, including clear inspection and inspection reporting procedures.

4.1.3 Enforcement

4.1.3.1 Enforcement Tools

With respect to violations of the state program, the state agency should have effective enforcement tools, which may include the following actions:

a. Issue a notice of violation with a compliance schedule;

b. Restrain, immediately and effectively, any person by order or by suit in state court from engaging in any impending or continuing unauthorized activity which is causing or may cause damage to public health or the environment;

c. Establish the identity of emergency conditions which pose an imminent and substantial human health or environmental hazard that would warrant entry and immediate corrective action by the state agency after reasonable efforts to notify the operator have failed;

d. Sue or cause suit to be brought in courts of competent jurisdiction to enjoin any impending or continuing violation of any program requirement, including any permit condition, without the necessity of a prior revocation of the permit;

e. Require, by administrative order or suit in state court, that appropriate action be undertaken to correct any harm to public health and the environment that may have resulted from a violation of any program requirement, including, but not limited to, establishment of compliance schedules;

f. Revoke, modify, or suspend any permit upon a determination by the state agency that the permittee has violated the terms and conditions of the permit, failed to pay an assessed penalty, or used false or misleading information or fraud to obtain the permit; or

g. Assess administrative penalties or seek, in court, civil penalties or criminal sanctions including fines and/or imprisonment.

h. Forfeiture of financial assurance instruments.

i. In some states, enforcement remedies include authorities to cause cessation of production or transportation of product, and/or seizure of illegal product.

4.1.3.2 Penalty Guidance

States should develop guidance for calculations of penalties that include factors such as:

1. the economic benefit resulting from the violation,
2. willfulness,
3. harm to the environment and the public,
4. harm to wildlife, fish or aquatic life or their habitat,
5. expenses incurred by the state in removing, correcting, or terminating the effects of the unauthorized activity,
6. conservation of the resource,
7. timeliness of corrective action,
8. notification of appropriate authority,
9. history of violations, and
10. location of the violation relative to disproportionately affected communities.

Benefits of guidance for calculation of penalties include consistency in the assessment of penalties and development of readily defensible assessments. Penalties should be such that an operator does not benefit financially from unlawful conduct and should provide compliance incentive to other operators. When supplemental environmental projects (SEP) are considered, states should ensure that project outcomes benefit the affected community. When considering SEP options, states should consult with residents of the affected community to gain insight about potential projects. States should evaluate their enforcement options and policies to assure that the full range of actions available are effectively used.

4.1.3.3 Right of Appeal

The right to appeal or seek administrative and/or judicial review of agency action should be available to any person having an interest which is or may be adversely affected, or who is aggrieved by any such action.

4.2 Additional Program Requirements

Beyond basic requirements, an effective state program should also include a variety of other administrative requirements as discussed below.

4.2.1 Contingency Planning and Spill Risk Management

4.2.1.1 State Contingency Program

a. The state should develop and adopt a state contingency program for preventing and responding to spills and unauthorized releases to land, water, or air from E&P facilities. The state program need not duplicate applicable federal regulations for contingency planning and spill risk management. The state's contingency program may include a state contingency plan or may consist of a set of regulations or operator contingency plan requirements. The program should define the volume of a spill or release of a petroleum product or waste and the level of risk to various receiving environments that triggers implementation of the spill contingency plan and response requirements.

b. The state contingency program should also contain funding provisions which enable the state agency to undertake immediate response actions for significant spills or releases which constitute a threat to human health or the environment in the event that a responsible operator cannot be located or is unwilling or unable to respond to the spill or release in a timely manner.

4.2.1.2 Reporting Capabilities

The state should provide mechanisms for operators or the public to report spills and unauthorized releases. These mechanisms should include telephone access 24 hours a day, 7 days a week. A single point of contact 1-800 telephone number should be considered. Telephone answering capabilities should include provisions for the prompt notification of appropriate state agency personnel.

4.2.1.3 Interagency Coordination

The state should provide for coordination of actions between appropriate agencies that have jurisdiction for the management of risks from spills and unauthorized releases from E&P facilities. This includes clear designation of onsite spill responsibilities.

4.2.1.4 Operator Prevention of, and Response to, Spills and Releases

The state agency should require an operator to take measures to prevent, and prepare to respond to, spills or unauthorized releases of petroleum products or waste that may occur at an E&P facility. These requirements can be spelled out in regulations or guidance, or they may be included in operator-specific or site-specific plans.

4.2.1.4.1 General

State contingency programs should address the following:

a. E&P facilities, equipment at those facilities, and materials found at E&P sites that may pose a significant threat to human health and/or the environment;

b. The various types of receiving environments, including water (surface and groundwater) and land (environmentally sensitive areas, special soil or geological conditions, urban areas, cultural and special resource areas); and

c. Public and responder safety concerns, including training for response personnel.

The state program should require the operator to identify the following:

d. The operator's incident command structure, including emergency contact information for key personnel;

e. Equipment, manpower, contracted services, and other logistical support necessary for response to spills and unauthorized releases;

f. Opportunities for coordination of joint response actions, manpower or equipment, with nearby well sites or other facilities of the operator or other operators;

g. Procedures for identification of and communication with parties impacted or threatened by spills or unauthorized releases;

h. Acceptable methods of containment of spills and unauthorized releases; and

i. Acceptable disposal methods, such as on-site remediation, approved disposal facilities, and waste haulers, for materials of concern.

4.2.1.4.2 Prevention Measures

Where spills and unauthorized releases pose a significant risk to human health and/or the environment, the State should require prevention measures that may include the following:

a. Secondary containment such as dikes, berms and firewalls, or equivalent measures;

b. Tertiary containment and/or monitoring systems in high-risk areas;

c. Inspection, testing, and maintenance schedules and procedures for facilities and equipment;

d. Site security measures as necessary; and

e. Periodic review of spill histories to identify opportunities to reduce future spills and unauthorized releases.

4.2.1.4.3 Response Measures

A State program should include reporting and notification procedures to be used in the event of a spill or unauthorized release. These should include the following:

a. Agencies and parties to be notified with contact information;

b. The type of reporting (verbal, written) required for various incidents;

c. Reporting time requirements;

d. Reporting thresholds;

e. Operator reporting information, such as the name of the operator and the operator's representative reporting the incident; a description of the incident, including the date and time of the incident and its discovery; the type and volume of material released; the location of the incident; the apparent extent of the release; damage or threat to groundwater, surface water, land, and/or air; and weather conditions; and

f. The state should specify any requirements for final reporting, site monitoring, and necessary agency approvals. Any final report should identify the incident cause and actions taken to prevent or minimize the likelihood of a recurrence.

States should provide guidance for containment, abatement, and remediation, including the following:

g. Cleanup standards;

h. Required sampling and analyses;

i. Where appropriate, approved non-mechanical response actions, such as the use of dispersants and in-situ remediation, including identification of the agencies that must provide approval of these operations; and

4.2.1.5 Follow-Up Actions

The state program should provide for enforcement, as described in Section 4.1.3. of these Guidelines, for the failure of an operator to report or respond to spills and unauthorized releases as required. The state program should also consider provisions for the assessment of damages caused by an incident. A state program should contain provisions allowing the state to pursue a responsible operator for reimbursement of state monies expended in responding to such a spill or release.

4.2.1.6 Database

The state data management program, as described in Section 4.2.7. of these Guidelines, should include information on spills and unauthorized releases. This data should be analyzed periodically as part of a program effectiveness evaluation as described in Section 4.2.3, Program Planning and Evaluation, of these Guidelines.

4.2.2 Public Participation

4.2.2.1 Notice and Records

Affected communities should be provided with adequate notice of the agency's consideration to issue a permit or license for appropriate E&P activities. Such efforts should balance efficient permit processing with meaningful opportunity for input from the affected public. The agency should establish guidance on determining the degree of public input for different types of permits or licenses. In addition, the agency head should have the authority to convene a public hearing when s/he determines it to be in the public interest. Where public input is sought, the agency should utilize communication methods that will most effectively reach affected communities. Effective communication should include creating short, plain-language summaries of proposed actions that are understandable by people with a variety of educational attainment and levels of English proficiency. States should consider factors that may limit meaningful involvement of affected communities in public comment opportunities, such as non-English speaking populations, timing of meetings, and availability of internet access. When translation is required comment periods should be extended to allow adequate time for both translation and outreach to the population. States should interface with community groups in the affected community to inform and plan for translation needs. States should also consider offering interpretation services for any hearings or public meetings about proposed permits or licenses, to make those meetings accessible to non-English speakers.

The agency should consider methods to enhance the responsiveness of its public participation such as responding to comments and sharing how the program considered comments in its decision making. Where possible, notice should be coordinated with the requirements of other concurrently applicable state or federal programs. The agency may also require operators to provide written notice to adjacent landowners of record for such areas and in such manner as may be prescribed by the agency.

Agency records should generally be available for review by the public in accordance with applicable state and federal laws and agency practices. Where information submitted by an operator is of a confidential business nature, an agency should have procedures for segregating that information and protecting it from disclosure. In all cases, spill, violation, and waste disposal and pit location records should be available to the public. Agencies should establish a minimum record keeping period of three years that should be automatically extended while any unresolved enforcement action regarding the regulated activity is pending.

4.2.2.2 Program Information

States should provide for the dissemination of program information to the regulated industry and the public. Such educational materials should include information or guidance on contingency planning, spill response, permitting, operating, monitoring and other requirements. Wherever possible, educational materials should be concise and written in plain language that is easily understood by members of the public with a variety of levels of educational attainment and English proficiencies. Educational materials should be provided in the two most commonly spoken languages[1] within the state (or a smaller geographic unit such as a county where applicable). Such efforts should be part of an ongoing process through which information is exchanged in an open forum. Because E&P environmental requirements are undergoing numerous changes, states have the obligation to inform the regulated industry and the public of changes.

Industry associations, community groups, religious organizations, community centers, and other organizations may provide opportunities for convenient and effective dissemination of information. States should actively make use of seminars, newsletters, special mailings, association committees, incentive programs and other mechanisms.

4.2.2.3 Advisory Groups

States should use advisory groups of industry, government, and public representatives, or other similar mechanisms, to obtain input and feedback on the effectiveness of state programs for the regulation of E&P activities. Provision should be made for education or training as is appropriate to give such advisory groups a sound basis for providing input and feedback. States should seek opportunities to partner with community groups to gather information on unique community needs and input. States should seek to foster positive relationships with such community groups to develop open lines of communication and improve the transparency and availability of data. When community members serve on advisory groups in a purely volunteer capacity (i.e., are not paid by their employer for their participation), states should explore providing stipends or participation incentives (i.e., gift cards) to compensate the community members for their time.

4.2.3 Program Planning and Evaluation

4.2.3.1 Program Planning

States should have a sound regulatory development process which includes both short- term and long-term strategic planning for defining goals and objectives, setting priorities, and evaluating the clarity, efficiency, and effectiveness of the E&P environmental regulatory program. In formulating environmental regulatory programs, states should use the best available scientific and technical information and should consider the environmental, economic and energy impacts of the regulations.

[1] The U.S. Department of Justice makes map of the most commonly spoken non-English languages by county available on its website: https://www.lep.gov/maps

4.2.3.2 Program Evaluation

Beyond the general, technical, and administrative criteria set forth elsewhere in this guidance document, a program for the regulation of E&P activities should evaluate how well the program protects human health and the environment while recognizing the need for an economically viable oil and gas industry. Program evaluation measures may be of a wide variety and include positive indicators (what's working) as well as negative indicators (what's not working). Some administrative aspects of program performance can be evaluated by examining how well the program enables the industry, the public, and the regulators themselves to function. Environmental aspects can be evaluated by assessing some combination of preventive measures, the qualities and characteristics of E&P wastes the severity of impact from a spill or unauthorized release, and the timeliness of remediation. While it is important for the program to have adequate rules, performance evaluation indicates to what extent the implementation of a rule or practice of the program brings about environmental protection.

Although a formal evaluation of program performance might occur at periodic intervals, the monitoring of activities and the modifications to the program form an ongoing, cyclic process. This process has no specific beginning or ending point. Rather, the steps in the process form a continuous progression that should be examined during performance review.

A state should select parameters that are appropriate for use in measuring the effectiveness of its E&P regulatory program. Documentation of the selected parameters and the ability to acquire, assess, and present the relevant data are critically important to evaluation of performance. This requires establishing a definition of the parameters being evaluated and specifying the technical measurements to be made or the technical data to be examined. In addition, it requires installation and use of a data management system that facilitates review and evaluation.

Program performance should be evaluated periodically, using measures that can be applied consistently from one evaluation period to another, although the measures may evolve and improve in time. If a database of releases, regulatory activities, remediation sites, or other information is used for performance evaluation, it should, if possible, extend backward in time so as to enable a measure of progress on historical problems.

4.2.3.3 Qualities of Performance Measures

In evaluating its performance, a program should have data management capabilities to enable assessment of program effectiveness and timeliness. Evaluation measures should do the following:

a. Be quantitative, whenever possible;

b. Allow consistent evaluation across time;

c. Be available to program personnel, the industry, and the public;

d. Document significant trends;

e. Summarize an evaluation of the nature and extent of contamination [Section 5.2], abandoned wastes, and abandoned facilities [Section 6] as they occur across the state; NORM [Section 7], stormwater management [Section 8], hydraulic fracturing [Section 9], air quality [Section 10], and reused & recycled fluids [Section 11].

f. Include identification and priority of outstanding environmental threats, so as to aid the program in targeting its efforts;

g. Enable evaluation of whether the program's responses to violations encourage compliance.

Evaluation of performance may include, as an example:

a. Contamination: the state-wide nature and extent of environmental contamination by E&P wastes;

b. Trends: whether the extent of contamination by E&P wastes is increasing or decreasing, and the reasons why;

c. Prevention: the effectiveness of the program's efforts in preventing releases of E&P wastes to the environment;

d. Timeliness: the timeliness of agency actions in controlling the impacts of E&P wastes released to the environment;

e. Abatement: the effectiveness of agency actions in abating pollution by E&P wastes, or in causing pollution to be abated; and

f. Enforcement: the effectiveness of the agency's administrative controls in the prevention or abatement of pollution by E&P wastes [Section 4.1].

4.2.3.4 Baselines and Follow-Up

A state agency should regularly evaluate its effectiveness in attaining the goals set forth in Section 3.2 in a way that will create a baseline against which to compare the program's performance in the future. A state agency is encouraged to conduct periodic self-assessments in addition to the assessments conducted in the State Review Process. These self-assessments should document successes and should identify areas for improvement. This will allow continual improvement of a state's program while recording its successes.

The utilization of performance evaluations and a continual improvement process will demonstrate the state's efforts to adapt to changes in technology, concerns of the public and regulated community, and to provide both for the documentation of successes and identification of areas requiring improvement.

4.2.3.5 Examples of Program Evaluation

4.2.3.5.1 Assessment of Impacts

A state could identify documented cases that demonstrate reasonably clear links of cause and effect between operational practices and resulting environmental impacts. Such impacts might be human health effects, ecological effects, effects on wildlife or livestock, or effects on natural resources. From examination of documented cases, a state could determine whether those cases were the result of violations of existing program requirements, insufficient programmatic enforcement of the requirements, other causes, or whether the cases suggest that the requirements should be revised.

A case could be documented if impacts are found to exist as part of the findings of a scientific study. Such studies could be formal investigations supporting litigation or a state enforcement action, or they could be the results of technical tests (such as monitoring of wells) if such tests (a) were conducted with state-approved quality control procedures, and (b) revealed contamination levels in excess of an applicable state or federal standard or guideline (such as a drinking water standard or water quality criteria).

Examples of possible impact indicators could include the following:

a. The area or other measure of contaminated or affected ground or surface water, tracked periodically over time.

b. A histogram of the number of releases versus time, amount of produced resource and number of wells in the state. Releases might be grouped by material released, such as crude oil, produced water, etc.

c. A histogram of the number of releases of a given material versus the approved time to completion of remediation.

d. The time elapsed between an agency's receipt of a remediation proposal or related correspondence, and the agency's response to that proposal or correspondence.

e. Analysis of activities and results

f. Activity and results analysis comprise administrative measures of program goals, plans, and operations. These measures focus on prevention of pollution, efficiency of operations, priorities, and the allocation of resources within the program.

The following are examples of activities:

g. The development of a strategic plan with goals, milestones, and establishment of priorities [Sections 3.2, 4.2.3]. The plan should be based on anticipated threats and/or known impacts, as well as budget and administrative factors that may be beyond the control of the agency.

h. The development of a program promoting use of the waste management hierarchy [Section 5.3].

i. A review of the number of stream miles listed as impaired by oil and gas activities in the state biennial Integrated Water Quality Monitoring and Assessment Report required under Sections 305(b) and 303(d) of the federal Clean Water Act.

j. An evaluation of the number of wells abandoned without being properly plugged compared to levels of financial assurance or other program measures to address orphan wells.

k. Evaluation of the results of surveys to determine the satisfaction of permit recipients and other customers with program implementation.

l. The development of a program, including time and activity tracking, to conduct efficiency studies of average time to issue permits, conduct inspections and perform other required activities.

m. A documented process for obtaining input from within the agency, from the public, and/or from an advisory group for identification of program strengths and deficiencies [Section 4.2.2.3].

n. Evaluation of the results of a training, educational, or outreach program [Section 4.2.2].

o. Evaluation of the effectiveness of the agency's enforcement program. [Sections 4.1.2, 4.1.3, 4.2.1.2].

The following are examples of results:

p. The number of inspections by the agency.

q. The number, type and causes of spills, accidents and safety incidents reported to the agency.

r. The number of operations witnessed by the agency.

s. The number, type, frequency and cause of violations detected by inspectors [Section 4.1.2].

t. The number, type, frequency and cause of complaints by the public, and the time required to resolve those complaints [Section 4.2.2.1].

u. The number of violations, the time to resolve those violations, and the number unresolved [Section 4.1.2].

v. The number of actions going to hearing, enforcement, and/or fines [Section 4.1.3].

4.2.4 Financial Assurance

All states should have an adequate financial assurance program to provide resources to the state to close or remediate a site should an operator fail to meet its obligations under the law. The goal of any financial assurance program should be to avoid passing on the responsibility for closure and remediation costs to the state. An adequate financial assurance program should be supported by the following elements: frequent site inspections; strict permit enforcement; and appropriate regulations governing and monitoring “inactive status” of covered facilities.

States should identify activities such as closure and remediation and other relevant activities for which criteria have been set forth in Section 5 that need to be covered by financial assurance. Some states require financial assurance for inactive wells, some for drilling and/or plugging, some for waste disposal facilities, and some for the life of the well.

States should determine the types of financial assurances that will provide reliable monetary resources to the state and will facilitate an operator’s compliance with permit requirements. Types of financial assurance may include the following:

a. Surety bonds;

b. Self-bonding;

c. Letters of credit;

d. Certificates of deposit;

e. Cash,

f. Federal, state, or municipal bonds; and

g. Other forms of collateral.

Some states require performance bonds and some states require penal bonds. Some states accept a nonrefundable fee to be paid into the well plugging fund in lieu of a bond. Some states allow phased payments of collateral into a fund so that small operators can develop a collateral bond over a specified period of time. States should develop financial assurance options that facilitate an operator's compliance with bonding requirements. In addition to single well bonds, many states allow blanket bonds. This allows operators to assure that an established minimum level of financial assurance is provided without the commitment of an unnecessary amount of operating funds.

States should periodically review the amount of assurance required to determine if the amount is adequate to provide incentive for proper plugging of a well and reclamation of a site, and to assure proper management of E&P wastes.

In the case of commercial and centralized facilities as defined in Section 5.10, including those that manage TE/NORM, state financial assurance requirements should be sufficient to cover the costs of appropriate facility decontamination, reclamation, and closure, and should extend through any post-closure care, monitoring, or control period. (see Section 5.10.2.2.4.)

States should develop appropriate procedures to access an operator's financial assurance when the operator does not meet the obligations covered by the financial assurance. These procedures should include provisions for notice, hearings, and forfeiture.

Some states have special funds, such as well-plugging funds, that are available for state use to correct problems where an operator does not comply with state requirements.

Although the availability of such funds may be a consideration in some states when determining bond coverage amounts, special funds should be used to supplement rather than completely take the place of other forms of financial assurance provided by the operator. The use of special funds should be limited to instances where the responsible operator cannot be determined or is unavailable. These special funds can be generated by taxes, fines, forfeitures, or fees.

4.2.5 Waste Hauler Certification

The appropriate state agency should have authority to require the training of drivers of trucks that are involved in the commercial transportation of E&P waste to a commercial or centralized disposal facility. Such training should include, among other things, emphasis on proper record keeping, the need to deliver the waste to the designated facility and emergency response and notification procedures. The appropriate state agency should also have authority to require the registration of all vehicles used to commercially transport the waste and of all commercial waste haulers.

4.2.6 Location of Closed Disposal Sites

A state program should contain authority with respect to disposal site closure, including authority to identify the location of the disposal site and for such information to be permanently maintained by the state agency for public review. Whether the location of a waste disposal site is disclosed in the public land records is a matter that is within the discretion of the state.

4.2.7 Data Management

4.2.7.1 General

Effective data management systems should be maintained due to the amount of information that states compile. Such systems should include permitting, operating, spill, remediation, and monitoring information and should include those data elements that an individual state finds are necessary to make cost-effective, risk-based decisions. Data should be maintained on as detailed a level as is necessary for the agencies to conduct their regulatory reviews. States and the federal government should undertake efforts to facilitate the sharing of data among responsible agencies, the public, and other users. States should develop policies for data access, data dissemination, and the allocation of cost of services to governmental and non-governmental users.

4.2.7.2 Electronic Data Management

Electronic filing, permitting, imaging, geographic information systems and internet data transfer and access are technologies that can contribute to program efficiency and data accessibility. Because of the efficiencies of electronic data management and enhanced accessibility of electronic data to regulators, the industry and the public, agencies are encouraged to develop systems for the electronic submittal, storage and retrieval of agency data. States are encouraged to implement electronic data management systems to improve program efficiency, public data access, and data security to the extent they are appropriate to the State's regulatory program.

Web-based maps available to the public should include appropriate information (i.e. permits, enforcement activities, and information from co-regulators to the extent possible). In developing such maps, state programs should balance publicly available information with contemplation of possible safety and security issues associated with mapped facilities.

4.2.7.3 Retention and Access

An agency's data management program should provide for the capture of data and images as appropriate, and for both protecting the quality of data collected and the long-term protection and backup of captured information through measures such as off-site duplicate storage, archiving, and/or data retention and destruction policies.

Agencies should include public and industry access in their data management systems. Most program data are available to the public under various sunshine rules. Some records may be retained as confidential files for a defined period of time. Certain confidential types of data may also be discoverable. States should develop policies that define data sets to be made available to the public and/or industry.

4.3 Personnel and Funding

4.3.1 Personnel

For a state program to function effectively, sufficient, properly trained personnel to accomplish the goals and objectives of the program are necessary.

In determining its personnel needs, a state agency should consider not only the number of activities that it must regulate and inspect, but also the accessibility of those activities to agency personnel. Accessibility will be heavily influenced by the size of the area to be regulated, the local terrain, and road conditions. In addition, a state agency should evaluate how its personnel needs will be affected by activities occurring in environmentally sensitive areas (e.g., in close proximity to surface water and groundwater).

Generally, personnel needs should be evaluated in each of the categories of administration, legal, technical, and field inspectors. In each case, a state agency should define the areas of responsibility for the position, as well as any prerequisite experience and background. In addition, the state agency should provide for the continuing training of personnel to keep them abreast of changes in regulations, policy and technical issues, and to increase professionalism. This training can be accomplished through such means as seminars and university short courses. The following discussion addresses these issues in each of the major personnel categories:

4.3.1.1 Administration

The elements of the administration of a state program should include traditional administrative functions such as program planning and evaluation, budgeting, and personnel. In addition, administration should be responsible for such programmatic functions as permitting, licensing, financial assurance, and ownership transfer. Public involvement and data collection management are also key elements of program administration. The conduct public hearings, the coordination of enforcement activities, and the referral of cases to legal personnel for follow-up action should also be administrative functions.

4.3.1.2 Legal

Legal support for an E&P environmental regulatory program can be provided by in-house state agency lawyers through the support of the attorney general's office or through independent counsel. In any case, sufficient legal support should be provided to a state agency to assure that the regulatory program has an effective capability to pursue appropriate enforcement actions in a timely manner against violators of program requirements. A critical element of this capability is that the program's legal element be capable of directing the preparation of enforcement cases and providing guidance and direction to field inspectors and others involved in case preparation. The legal element of a program should also be involved in both the procedural and substantive aspects of rulemaking.

4.3.1.3 Technical

All program elements require adequate technical support. In supporting administrative functions, technical personnel should provide geologic and engineering evaluation, and technical specifications on such matters as cementing and casing. Technical support to the legal and field personnel is necessary for the development and implementation of rules and in the preparation of enforcement cases.
In support of field inspectors, technical personnel should be capable of mapping hydrologically sensitive areas and areas containing treatable water and provide support in determining pit construction requirements and guidance in waste handling. Key technical personnel should have a Bachelor of Science degree in geology, engineering, hydrology, earth science, environmental science, or a related field, or possess equivalent experience. Technical personnel should be subject to continuing education in such areas as ongoing development of rules, policies, and technological changes.

4.3.1.4 Field Personnel

Field personnel should be responsible for conducting routine inspections of regulated facilities and activities to assure compliance with program requirements. In addition, field personnel should be among the state agency's on-site representatives to witness critical regulated activities and to observe or supervise clean-up or remedial actions. Field personnel also should be involved in the assembly of evidence for enforcement actions and in the state agency's community relations.

Field personnel generally should be high school graduates or have equivalent experience and should otherwise be knowledgeable about oil and gas field-related work and waste management practices.
The ongoing training of field personnel should emphasize the range of chemical and radiological constituents in E&P wastes and at E&P sites, sampling and investigative procedures associated with enforcement proceedings, and a thorough understanding of current rules and policies of the program, as well as sound environmental practices. Field personnel should be provided with training in TE/NORM identification and management, where appropriate.

In addition, field personnel should be skilled in the handling of hazardous materials and in all aspects of personnel safety. They should also be trained in the identification of abandoned sites and the abandoned site remediation program, storm water management practices and requirements, and hydraulic fracturing processes.

4.3.1.5 Training Requirements

State programs should provide for adequate and effective training of state agency personnel regarding the regulations, policies, and criteria applicable to E&P activities. These programs should include training for agency personnel on such issues as site maintenance, contingency planning and spill response, permitting requirements and standards, compliance requirements and criteria, data management, enforcement procedures, investigative procedures, court preparation, report writing, sampling and analysis, and such other issues relating to proper E&P environmental regulation as may be necessary. Training programs should be incorporated as an on-going activity to encourage consistent enforcement of regulation throughout the state.

4.3.2 Funding

An effective E&P environmental regulatory program should be funded at a level sufficient to allow it to accomplish its environmental protection goals and objectives. While many state agencies are funded through a general appropriation from that state's legislature, each state agency should evaluate other sources of funding such as user fees, special levies on production, the dedication of fees and penalties to special accounts, and grants from various sources.

4.4 Coordination Among Agencies

Many state programs regulating E&P activities have their roots in oil and gas conservation programs that were established during the early part of the last century. In most cases, these programs have evolved to accommodate other state and federal objectives such as protection of human health and the environment.

In most states, multiple agencies are involved in the management of E&P activities. Different agencies are often responsible for the regulation of oil and gas wells, pits and impoundments, disposal wells, surface water discharges, spill prevention and response, and disposal of drill cuttings and muds. Each agency has its own administrative requirements relating to permitting, operational requirements, and financial assurance, and develops its own budget priorities. Each has its own inspection and enforcement authorities. Unless a high level of formal interagency coordination exists, such unilateral program development and implementation can lead to duplication of personnel effort, duplication of regulation with sometimes conflicting standards for the industry, and duplication of funding. Duplication of programs often diminishes the effectiveness of spill response, permitting, inspection, enforcement, training, and other regulatory activities.

Where multiple state agencies have jurisdiction over the management of E&P activities, budget development should be coordinated and the agencies should develop formal coordination procedures, such as the development of interagency Memoranda of Agreement, interagency task forces with periodic meetings, and/or interagency legislative and regulatory review panels to ensure jurisdictional clarity and regulatory consistency. Where state oil and gas environmental regulatory agencies interface with other state agencies on permitting, enforcement, and other activities with a nexus to environmental justice[2] (EJ) issues, they should evaluate the alignment of their EJ definitions to ensure that affected communities are given equal consideration.

Additionally, states should review existing agreements to assure that they are current and effective. Finally, interagency mechanisms should be developed to facilitate the sharing of information among and between involved agencies so that each agency can carry out its program responsibilities.

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[2] The US EPA defines environmental justice (EJ) as, “The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.”2 Definitions of environmental justice may differ from state to state, or from agency to agency within a state, but generally refer to low-income communities or minority communities or communities of color such as would be identified by US EPA’s EJSCREEN mapping tool.

SECTION 5 | Technical Criteria

5.1 General

These technical criteria for E&P waste management practices address waste characterization, waste management hierarchy, pits/impoundments, land applications, tanks, and centralized and commercial facilities. In most cases, these criteria are general in scope. States should establish and implement specific performance standards and design specifications based on site-specific or regional differences in geology, hydrology, climate, and waste characteristics. State E&P waste management programs should include the following general provisions as requirements:

a. Facilities and sites used for the storage or disposal of wastes derived from the exploration and production of oil and natural gas should be operated and managed at all times to prevent contamination of groundwater, surface water, soil, and air with the goal of, protecting public health and safety, the environment, and preventing property damage.

b. Facilities and sites operated specifically for the storage or disposal of exempt E&P wastes should not receive, collect, store, or dispose of any wastes that are listed or defined as hazardous wastes and regulated under Subtitle C of RCRA, except in accordance with state and federal hazardous waste laws and regulations.

c. Disposal of E&P wastes into municipal solid waste landfills may be considered. If such disposal is allowed, it should only be allowed where the landfill is designed to contain such wastes, and the E&P wastes contain no free liquids and are not mixed with non-exempt wastes prior to disposal.

d. Technical criteria for siting, construction, and operation of E&P waste disposal facilities should be flexible enough to address site-specific or regional conditions based on findings by the regulatory agency.

e. Siting Criteria

   i. States should incorporate siting requirements in statewide rules for pits, landspreading, landfilling and burial, and waste reclamation facilities. Area-wide rules or site-specific permits may contain additional siting conditions.

   ii. No E&P waste management facility should be located in within a 100-year flood plain or areas where other surface drainage issues may impact surface impoundment in the event of a significant storm event.

   iii. Where necessary to protect human health, E&P waste management facilities should not be located in close proximity to existing residences, schools, hospitals or commercial buildings. The need for minimum distance criteria from residences or other buildings to the boundary of E&P waste management facilities should be considered.

   iv. Siting requirements should consider factors such as depth to and quality of groundwater; proximity to wetlands, floodplains, water bodies; proximity to drinking water supplies; topography, geology, geologic hazards; and other environmentally sensitive areas as designated by the appropriate governmental authority.

   v. Siting of E&P waste management facilities should be consistent with applicable land- use requirements.

5.2 Waste Characterization

5.2.1 Purposes

Waste characterization should support at least the following functions of a state's E&P waste management program:

a. Ensuring E&P waste management practices are suited to the particular wastes involved and in compliance with applicable program requirements; and

b. Ensuring commercial E&P waste facilities are managing only wastes they are authorized to handle.

5.2.2 Sampling and Analysis

a. Waste characterization requirements should include appropriate testing of E&P wastes prior to disposal. Testing should be appropriate for the type of waste, method of disposal, and the potential for adverse health and/or environmental effects associated with potential exposure. State waste management programs should establish criteria for ongoing testing to detect changes in the chemical composition of wastes as necessary. Waste management practices and regulatory requirements may be improved by obtaining a more complete knowledge through sampling and analysis of the range of hazardous and toxic constituents in E&P wastes. Potential waste characteristics include radionuclides, metals, organic content, pH, salinity, sulfur compounds including hydrogen sulfide content, and other potentially hazardous compounds as required by the state. At a minimum, waste characterization requirements should provide data necessary to meet the purposes of waste characterization described in Section 5.2.1, and to administer and enforce state program requirements effectively.

b. Testing and sampling data conducted as part of waste characterization should be available to the public consistent with the provisions of Section 4.2.2.1.

c. State requirements for the assessment of E&P wastes for TE/NORM should meet the criteria of this section and of sections 7.3.3. and 7.3.9. Such requirements should address all types of radiation expected in E&P wastes.

d. These guidelines do not address all the details of a waste characterization program, such as testing methods, frequencies, or parameters. The details are expected to vary depending upon the waste, the proposed management practice, and other state program requirements.

5.2.3 Quality Control

a. State programs should contain provisions that any required waste sampling follow appropriate sampling procedures, and any required laboratory analysis be performed by qualified laboratories in order to produce valid and reliable results. A state may rely on field testing to satisfy waste characterization requirements where it can be determined that such testing will produce valid and reliable results.

b. Testing methods should produce data that are valid for the purpose intended. By example, EPA's Toxicity Characteristic Leaching Procedure (TCLP) may not accurately predict the leachability of oily E&P wastes.

5.3 Waste Management Hierarchy

As in any aspect of waste management, there are some general, sound practices that should be employed. These practices, which emphasize waste minimization, not only serve to protect human health and the environment, but also tend to protect waste generators from long-term liabilities associated with waste disposal. Additionally, waste minimization may reduce regulatory compliance concerns for E&P operators and result in cost savings. Generally, the choice of an E&P waste management option should be based upon the following hierarchy of preference:

a. Source Reduction: Reduce the quantity and/or toxicity of the waste generated;

b. Recycling: Reuse or reclaim as much of the waste generated as possible, and whenever possible, combine hydrocarbons with crude oil, condensate, or natural gas liquids;

c. Treatment: Employ techniques to reduce the volume or the toxicity of waste that has been unavoidably generated.

d. Proper Disposal: Dispose of remaining wastes in ways that minimize adverse impacts to the environment and that protect human health.

5.3.1 Source Reduction Opportunities

There are significant source reduction opportunities in E&P waste management. State programs have a variety of available resources which provide proven source reduction techniques. Categories of source reduction opportunities and examples include:

a. Equipment Modifications: Many technically and economically feasible equipment modifications are available. For example, retrofitting glycol dehydration units with volatile organic vapor recovery units can result in the recovery, in certain circumstances, of economically viable quantities of volatile hydrocarbons that would otherwise be released to the atmosphere. In addition, compliance concerns regarding air emission regulations may be reduced considerably.

b. Procedure Changes: Many times a simple change in the procedure used in an operation can result in significant source reduction. A simple example with significant results is the change one operator made in produced water filter replacements in an EOR project. The original procedure of bi-monthly filter replacements was changed to a procedure based on filter differential pressure. The result was a 98% reduction in the quantity of generated waste filters. At production sites where NORM-scale formation is expected, implementing a procedure of scale inhibitor injection may reduce its occurrence.

c. Product Substitution: The careful selection of chemical products used in exploration and production can reduce the toxicity of E&P wastes. Potential product substitution candidates include biocides, coagulants, dispersants, emulsion breakers, scale and corrosion inhibitors, gas sweetening and dehydration agents, catalysts, and pipe dope. In particular, many substitute drilling fluids have been developed to replace oil-based drilling fluids.

d. Reduction in the Use of Fresh Water: A significant example of the reduction of freshwater use is the use of produced water for EOR whenever possible (See Section 11 for additional discussion of fluid reuse and recycling). Another simple example is the use of high-pressure, low-volume nozzles on rig wash hoses.

e. Good Housekeeping and Preventive Maintenance: In addition to product substitution, source reduction can be achieved by minimizing the generation of clean-up wastes from production facilities and waste management facilities. An evaluation of potential spills and mitigation measures may identify effective spill and release prevention techniques. These techniques include good housekeeping practices, routine inspections of equipment, equipment innovations, and containment systems. Radiation surveys of equipment and sites can be helpful in preventing or minimizing the spread of above-background levels of E&P TE/NORM that may be encountered during routine equipment maintenance and servicing and site cleanup.

f. Planning: The first opportunity to accomplish source reduction is in the planning stage of an operation. For example, careful planning of a well stimulation can result in the reduction of leftover chemical that may be disposed. Also, careful planning of a drilling site's construction to control stormwater runoff may reduce the quantity of contaminated stormwater that may be generated as waste.

g. Training: Training is possibly the most important source reduction opportunity. Personnel in the E&P conduct the activities that generate waste. Training in waste identification, classification, and source reduction techniques provides the field personnel with the tools necessary to effectively reduce waste generation.

h. Selection of Contractors: Service companies perform a wide variety of functions in the E&P on behalf of E&P operators. An important source reduction opportunity for operators is the selection of service companies that implement source reduction opportunities as a business practice.

5.3.2 Recycling and Reduction Opportunities

Many opportunities now exist to recycle E&P wastes. State programs are encouraged to develop or coordinate with recycling programs developed by other agencies responsible for waste management. For example, many states' agencies provide listings of companies that recycle wastes common to E&P and, in some instances, operate waste exchange programs.

Wastes generated at E&P facilities that may be recycled include drilling fluids, used lubricating oil, used lubricating oil filters, antifreeze, wooden pallets, spent solvents, unused chemicals, liners, aggregate, and scrap metal. Also, recycling opportunities include the use of produced water for enhanced recovery, and the recovery of hydrocarbons in crude oil tank bottoms, skim oils, gas pipeline drips, slop oil emulsions solids and sludges, and other oily sludges.

Recycling also includes reuse of materials that would otherwise be managed as waste. For example, a natural gas company found that partially spent caustic sweetening solution was suitable for use as reagent in sulfur dioxide scrubber units at a natural gas processing plant.

See Section 11 for guidance specific to the reuse and recycling of fluids generated during the drilling, completion (e.g. hydraulic fracturing flowback), and production stages of a well.

5.3.3 State Program Elements

State programs should contain mechanisms to encourage waste management consistent with the hierarchy of this section. A variety of mechanisms may be used, such as the following:

a. Program requirements or policies that encourage source reduction and recycling;

b. Improved training of state personnel so they can identify source reduction opportunities;

c. Technical assistance or incentives to operators; and

d. Educational activities aimed at informing facility operators of the options available.

The waste management hierarchy should be integrated into the other elements of a state program. For example, spill and release prevention should be incorporated into facility management regulations. Similarly, state requirements should address the segregation of waste streams that have a higher pollution potential from those with a lower pollution potential. State information program elements should include a component related to hierarchy planning and implementation.

State program planning activities should include goals and objectives that provide for substantial progress in this area over a reasonable time. States should have sufficient information to evaluate whether the mechanisms used to encourage source reduction and recycling are achieving those goals and objectives. State program requirements should be reviewed for consistency with the waste management hierarchy and the established goals and objectives.

State agencies should also coordinate their efforts with other agencies that are responsible for waste management.

5.4 Quantitative Elements

Specific quantitative guidelines have been included for some waste management practices. The numbers cited are considered to be conservative values for protection of human health and the environment. However, they are not intended to be the basis for nationwide standards. Regulatory agencies may approve either less stringent or more stringent requirements where circumstances warrant, as long as they afford the protections described in Section 5.1.a, and in the goals statement of Section 3.2.

5.5 Technical Criteria for Pits

5.3.1 Definitions

The terms “pit” and “impoundment” are used to describe earthen depressions constructed to contain fluids or other materials. For the purpose of these Guidelines, the term “pit” is used to describe such structures. The following are generally accepted definitions for different types of pits and their uses:

a. Reserve Pits:

   i. Store additional drilling fluids for use in drilling operations; and/or

   ii. Dispose of wastes generated by drilling operations and initial completion procedures.

b. Production Pits

iii. Skimming/Settling: Pits used to provide retention time for settling of solids and separation of residual oil.

iv. Produced Water: Pits used for storage of produced water prior to injection for enhanced recovery or disposal, off-site transport, or surface-water discharge.

v. Percolation: Pits used to dispose of waste liquids via drainage or seepage through the bottom and/or sides of the pits into surrounding soils.

vi. Evaporation: Lined pits used to contain produced waters which evaporate into the atmosphere by natural thermal forces.

c. Special Purpose Pits

i. Blowdown: Pits used for collecting material resulting from the emptying or depressurization of wells or vessels.

ii. Flare Pits: Pits used exclusively for flaring gas.

iii. Emergency Pits: Pits used to contain liquids on a temporary basis due to process upset conditions.

iv. Basic Sediment: Lined pits used for temporary storage of production wastes from tank batteries or production vessels which may contain residual oil.

v. Workover: Pits used to contain liquids during the performance of remedial operations on a producing well in an effort to increase production.

5.5.2 Permitting

a. A permitting or review process should be in place for all pits. Pits may be authorized by rule, general permit, individual permit, or as a part of an operational permit or program.

b. Pits may be permitted by rule based upon specific requirements in areas where geologic, topographic, hydrologic or other conditions are similar.

c. Authorization for a pit may be included in operational, facility, or other environmental permits (e.g., drilling, workover, gas plant, NPDES discharge). The permit application process may have to be expanded to include certain additional information concerning the pit (i.e., intake volume, soil type, fluid makeup, topography, geology, hydrology, climatology, and such other factors as may be necessary to protect human health and the environment).

d. Construction and use of rule-authorized pits should require prior notification of the appropriate regulatory agency to ensure that proper construction, operation, and closure methods are used to protect human health and the environment.

e. State programs should include provisions to accommodate approval of pits for emergency situations.

5.5.3 Construction

General standards for construction of pits should be included in area or statewide regulations and should contemplate the following:

a. Size should be sufficient to ensure adequate storage until closure, taking into account historical precipitation patterns.

b. Depth should be such that the bottom has sufficient separation between base of impoundment and shallow-most water bearing zone (seasonal high), or such that the pit contents do not adversely impact groundwater or surface water. A review of available information or a study should be made of the area where the pit is to be located to determine if aquifers are present and should be protected.

c. Berm height, slope, and material should be such that the pit is structurally sound and that pit integrity is not compromised by terrain or breached by heavy rains, winds, seepage, or other natural forces.

d. If a salt section is anticipated or oil-based muds are used during a drilling program, reserve pits should be designed to accommodate those fluids.

e. Construction standards for pits may differ depending upon the wastes they receive, the length of time they are used, and site-specific conditions.

   i. Pits should be sited consistent with the provisions of Section 5.1.e.

   ii. In the case of reserve and workover pits, liners should be required in certain instances based upon fluid type and site-specific characteristics (e.g., unconsolidated soils and/or hydro-geologic conditions that create a potential for adverse impact to surface water or groundwater, and proximity to environmentally sensitive areas).

   iii. Special purpose pits and other pits such as dehydration, tank drain, pipeline drip collector, and compressor scrubber pits should be lined.

   iv. The use of production pits is declining nationally due to changes in industry practice and concerns about potential contamination of air, soils, and groundwater. In many instances, equipment consolidation, process modifications, or tanks can be used in lieu of pits. The use of alternatives is generally encouraged. Where production pits are used, they should generally be lined, except as provided below in 5.5.3.e.v.

   v. Blowdown, flare and emergency pits may be unlined where the removal requirement of Section 5.5.4.k. will prevent adverse groundwater quality impacts.

   vi. Variances to the above liner requirements should only be provided, and percolation pits should only be used, where it is clearly demonstrated that pit contents do not contain constituents that may harm water, soil or air.

   vii. Liners may consist of natural or synthetic materials, should meet accepted engineering practices, and should be compatible with expected pit contents.

   viii. State programs should have the ability to specify additional construction requirements such as double-liners and leak detection and notification technology where deemed necessary.

f. Requirements for fencing, netting, and caging, or any other method to secure a pit, should be set by area or statewide regulations, as necessary, to protect the public, domestic animals, and/or wildlife. Netting of a pit is recommended as the preferred method to protect wildlife.

g. Where feasible, reserve pits should be placed to directly receive the discharge from solids separation equipment and to collect rigwash water, spills, and leaks from drilling equipment.

5.5.4 Operational Requirements

a. Specific restrictions on the type of wastes that can be placed in the different types of pits should be included in area or statewide regulations. Restrictions should consider salinity, hydrocarbon content, pH, radionuclides associated with E&P NORM, or other characteristics that may be detrimental to the environment.

b. General security guidelines should protect the public, the environment, and wildlife.

c. Liquids should be maintained at a freeboard level determined by the state that takes into account extreme precipitation events or other possibilities and prevents overtopping or un-permitted discharges.

d. Lined pits should be operated in a manner that ensures liner integrity.

e. Inspections and monitoring should be conducted at regular intervals or as necessary to ensure that pits meet all operating and structural integrity requirements and to ensure that pit contents do not adversely impact groundwater or surface water.

f. Hydrocarbons that inadvertently accumulate in a reserve pit should be skimmed off the pit at the cessation of drilling and completion operations.

g. Separated oil or accumulated wastes should be periodically removed from skimming/settling pits.

h. Produced water pits should be used only for storage of produced water prior to injection or off-site transport.

i. Percolation pits should be used only for disposal of produced waters when it is clearly demonstrated that pit contents do not contain constituents that may harm water, soil or air, and only when area or statewide restrictions established under Section 5.5.4.a. above are met.

j. Evaporation pits should be periodically inspected for compliance with permitted input volumes and liner integrity. Evaporation pits should be skimmed as necessary to maintain an optimum evaporation rate.

k. Blowdown, flare, and emergency pits should not be used for long-term storage or disposal. The regulatory agency should be notified promptly of the use of emergency pits. Fluids diverted to emergency pits should be removed as quickly as practical following the end of the emergency.

l. Unlined basic sediment pits should only be used when it is clearly demonstrated that pit contents do not contain constituents that may harm water, soil or air.

m. Unlined basic sediment pits should not be used for storage of oily wastes; they should be replaced by lined pits or tanks.

n. Workover pits should be open only for the duration of workover operations and should be closed within 120 days after workover operations are complete.

o. Pit wastes that exhibit oilfield NORM above regulatory action levels should be managed in accordance with the criteria of Section 7 and any other applicable criteria of these Guidelines.

5.5.5 Closure

a. Pits should be closed in accordance with local, state, and federal regulations and, if on private property, consistent with lease obligations.

b. Reserve pits should be closed as soon as practical but no later than 12 months after cessation of drilling operations. However, the closure of reserve pits beyond 12 months after cessation of drilling operations may be allowed in unusual circumstances if good cause can be demonstrated.

c. Pit liquids should have free oil removed and, when appropriate, should be sampled prior to closure for salinity, hydrocarbon content, pH, radionuclides associated with E&P NORM, or other characteristics which may be detrimental to the environment. On-site disposal of pit contents should be conducted in accordance with the landspreading, burial, and landfilling criteria of Sections 5.6. and 5.7, or by NPDES or UIC permit.

d. Liquid and nonliquid materials not satisfying the on-site criteria for landspreading or burial (Sections 5.6. and 5.7.) should be disposed in federal or state approved disposal facilities.

e. Pit sites should be capped, compacted, contoured, vegetated, and remediated where necessary, in accordance with applicable state or area regulations to ensure ground support stability, prevent erosion and ponding, and protect the environment.

f. Records should be permanently kept by the regulatory agency of all pit locations.

5.6 Technical Criteria for Landspreading

5.6.1 Definition and Applicability

a. Landspreading is a method of treatment and disposal of low toxicity wastes in which the wastes are spread upon and sometimes mixed into soils to promote reduction of organic constituents and the dilution and attenuation of metals. Landfarming or multiple applications are covered under Section 5.10.

b. These criteria apply to waste disposal at or near E&P locations and do not apply to commercial disposal operations. Commercial facilities used for disposal of E&P wastes are covered in Section 5.10.

c. On-site landspreading of E&P wastes containing TE/NORM above regulatory action levels should be prohibited.

5.6.2 Regulatory Requirements

When landspreading practices are used at E&P sites, they should be conducted consistent with local, state, and federal regulations. General standards for landspreading should be included in area or state regulations and should address the operational requirements of Section 5.6.3.

5.6.3 Operational Requirements

a. Free oil should be removed to the extent possible before the wastes are landspread.

b. Landspread liquids should have a pH of 6 to 10 S.U. Where needed, liquids should be neutralized to obtain this range.

c. Solid wastes should be spread evenly and disked into the soil.

d. E&P wastes should be subject to loading rates, location restrictions, and/or other appropriate requirements that promote biodegradation of organic constituents; will not result in waste pooling, ponding, or runoff; will prevent the contamination of groundwater or surface waters; and will protect air quality.

e. Where enhancement of biodegradation is desired, nitrogen and other nutrients should be added to the soil before disking. Nutrient application can be repeated over time.

f. Amounts of waste added to soil during landspreading are generally limited by the electrical conductivity (EC), exchangeable sodium percentage (ESP), and sodium absorption ratio (SAR). The state should determine its criteria based on site-specific and waste-specific conditions. For example, some plants tolerate higher or lower salt levels, higher rainfall areas encourage salt movement out of the root-zone, or shallow groundwater may severely limit application.

g. After landspreading of hydrocarbon containing waste, the waste-soil mixture should not exceed one percent by weight oil and grease, unless the state regulatory agency approves a less or more stringent requirement where circumstances warrant.

h. Salt- and hydrocarbon-loading criteria apply to the final waste-soil mixture and are not an application standard. The operator should be required to demonstrate that these criteria are met within 12 months of cessation of drilling or production. If these criteria are not met, remediation will be required. Nothing in this paragraph is intended to delay any requirement for erosion control and/or site reclamation or re-vegetation.

i. Soil analyses should be performed prior to landspreading and again upon closure of the site. Upon site closure, waste constituents should not be present at levels that pose a significant risk to human health and the environment.

j. Enhanced techniques, such as repetitive disking and nutrient addition, may be needed to meet the salt and hydrocarbon criteria of the final waste-soil mixture.

k. Under special or abnormal conditions, additional limitations and analysis requirements should be considered for wastes that may contain toxic constituents derived from formation liquids, cuttings, drilling muds, or drilling-mud activities. Records should be permanently maintained by the agency of all waste analyses conducted pursuant to such additional requirements.

5.7 Technical Criteria for Burial and Landfilling

5.7.1 Definitions and Applicability

a. Burial of wastes involves placing the wastes in an excavation and covering the wastes with a layer of soil.

b. Landfilling of wastes involves placing the wastes on the ground and covering them with a layer of soil.

c. These criteria apply to waste disposal at or near E&P sites and do not apply to commercial disposal facilities. Criteria for commercial disposal facilities are contained in Section 5.10.

5.7.2 Regulatory Requirements

When burial or landfilling is used at E&P sites, either should be conducted consistent with lease and landowner obligations and with local, state, and federal regulations. General standards for burial or landfilling should be included in area or statewide regulations and should address the operational requirements in Section 5.7.3.

5.7.3 Operational Requirements

a. Wastes or waste-soil mixtures may be buried or landfilled without a protective bottom liner only when they meet the landspreading criteria of Section 5.6 prior to burial. The contents of such waste or waste-soil mixtures should be limited to materials such as fresh water-based drilling muds, drill cuttings, spent iron sponge, gas plant catalyst, or molecular sieve. Closure should be consistent with Sections 5.5.5.a and 5.5.5.e.

b. A protective bottom liner, solidification, fixation, or encapsulation should be required for burial or landfilling of wastes whose salt and/or hydrocarbon content exceeds the landspreading criteria of Section 5.6.3. A protective bottom liner, solidification, fixation, or encapsulation should be required for burial or landfilling of E&P wastes containing NORM above regulatory action levels. The regulatory agency may grant a variance from this requirement for fields or portions of fields, upon a showing by the operator that groundwater either is not present beneath the waste site or is naturally protected from the threat of contamination.

c. Agency records should be permanently maintained for any required analytical data taken, sites used, and types and quantities of waste disposed. Site locations should be located on plat maps.

5.8 Technical Criteria for Roadspreading

5.8.1 Definition

Roadspreading is the placement on roads of E&P wastes that exhibit properties similar to commercial road oils, mixes, dust suppressants, or road compaction or deicing materials. Roadspreading of E&P wastes that do not exhibit such properties should be prohibited. Roadspreading of E&P wastes containing NORM above regulatory action levels should be prohibited. Generally, materials that will harm soil, water, or air should not be roadspread.

5.8.2 Regulatory Requirements

When roadspreading is used, it should be conducted consistent with local, state, and federal regulations. General standards for roadspreading should be included in area or state regulations and address the operational requirements in Section 5.8.3.

5.8.3 Operational Requirements

a. Exempt wastes such as tank bottoms, emulsions, heavy hydrocarbons, and crude oil-contaminated soil may be used for road oil, road mix, or asphalt if they are not ignitable and have a mixed density and metal content consistent with approved road oils or mixes.

b. Roadspreading should be subject to loading rates and/or other appropriate requirements that prevent pooling, ponding, or runoff; prevent the contamination of groundwater and surface water; and protect air quality.

c. Roadspreading should be subject to appropriate buffer zones established to protect waters of the state, water wells, and wetlands.

d. Produced water should be tested and should exhibit properties similar to commercial roadspreading products that are regulated by federal, state, or local agencies.

5.9 Technical Criteria for Tanks

5.9.1 Scope

This section applies to permanently installed E&P waste tanks and to produced water storage tanks located at enhanced recovery operations. Where some waste tanks are regulated under the Spill Prevention Control and Countermeasures (SPCC) requirements of the federal Clean Water Act, states may defer to the SPCC requirements for those tanks. The regulatory agency may adjust or exempt from the requirements of this section small-capacity tanks. Except as provided in Section 5.9.3.b., this section does not apply to:

a. Condensate and crude oil tanks;

b. Process vessels, such as separators, heater treaters, dehydrators or freewater knockouts, except that stacks or vents on such vessels should be equipped, where necessary, to protect migratory birds and other wildlife; and

c. Tanks used temporarily in drilling and workover operations.

5.9.2 General Requirements

a. States should have information, where available, on the locations, use, capacity, age and construction materials (e.g., steel, fiberglass, etc.) of tanks as needed to administer and enforce state program requirements effectively. Such information may be obtained through registrations, inventories, or other appropriate means.

b. Tanks covered by this section should be sited consistent with applicable local land-use requirements, and should not be located within the 100-year flood plain or areas where other surface drainage issues may impact surface impoundment in the event of a significant storm event, unless the tanks have adequate floodproofing in accordance with state requirements.

c. Tanks should be subject to spill-prevention, preventive maintenance and inspection requirements.

5.9.3 Construction and Operation Standards

a. A principal goal of construction and operation standards for tanks is to minimize the occurrence of and the environmental impacts from spills and leaks.

   i. New tanks should be constructed in a manner that provides for corrosion protection consistent with the intended use of the tanks. All tanks covered by this section should be operated in a manner that provides for corrosion protection consistent with the use of the tanks.

   ii. Tanks should exhibit structural integrity consistent with their intended use. Wooden tanks should receive increased scrutiny in this regard.

   iii. Tanks should be operated in a manner that protects against overtopping.

   iv. Secondary containment systems or other appropriate means, such as leak detection, should be employed to minimize environmental impacts in the event of releases.

b. Covered tanks are preferred to open tanks. Open E&P waste and product tanks should be equipped to protect migratory birds and other wildlife in a manner consistent with the wildlife-protection criterion of Section 5.5.3.d.

c. Tanks located in populated areas where emissions of hydrogen sulfide can be expected should be equipped with appropriate warning devices.

5.9.4 Tank Removal and Closure

a. Tanks should be emptied prior to their retirement and the resulting materials should be managed properly.

b. Tanks and associated above ground equipment should be removed upon cessation of operations. For good cause, a state may allow tanks to be removed as soon as practical thereafter. Site reclamation should meet all landowner and lease obligations and any other applicable requirements.

c. Prior to removal, closure, or release for unrestricted use, tanks and associated piping and equipment should be surveyed for TE/NORM. When regulatory action levels are exceeded, TE/NORM and the equipment containing TE/NORM should be managed in accordance with the state's NORM regulatory program. See Section 7 for full TE/NORM criteria.

5.10 Technical Criteria for Commercial and Centralized Disposal Facilities

5.10.1 Definitions and Exemptions

a. Commercial Disposal Facility: A facility whose owner(s) or operator(s) receives compensation from others for the temporary storage, reclamation, treatment, and/or disposal of produced water, drilling fluids, drilling cuttings, completion fluids, and any other RCRA exempt E&P waste, and whose primary business objective is to provide these services. These facilities may, under certain circumstances, also accept non-exempt, non-hazardous wastes generated from E&P operations. This definition also includes facilities whose owner(s) or operator(s) receives compensation from others for E&P NORM-related storage, decontamination, treatment, or disposal.

b. Centralized Disposal Facility: A facility, other than a commercial disposal facility, that is:

   i. Used exclusively by one owner or operator; or

   ii. used by more than one operator under an operating agreement, and

   iii. receives for collection, treatment, temporary storage, and/or disposal of produced water, drilling fluids, drill cuttings, completion fluids, and any other RCRA exempt E&P wastes that are generated from two or more production units or areas or from a set of commonly owned or operated leases.

   iv. These facilities may, under certain circumstances, also accept non-exempt, non-hazardous wastes generated from E&P operations. This definition covers the surface storage and disposal facilities that are present at Class II disposal well sites. This definition also covers TE/NORM related storage, decontamination, treatment, or disposal.

c. Exemptions: The definitions and technical criteria of Section 5.10 do not apply to Class II injection wells or to enhanced oil recovery projects. The definitions and technical criteria of Section 5.10 are not intended to apply to emergency cleanup situations at a Class II injection facility. The regulatory agency may adjust or exempt from the standards and requirements of this section centralized facilities that receive a limited number of substantially similar waste streams and limited volumes of wastes, or commercial or centralized tank-only facilities.

5.10.2 Technical Standards and Regulatory Requirements

Commercial and centralized off-site disposal facilities should meet the technical and regulatory requirements of this section and the general standards of Section 5.1 of these criteria. Compliance with these requirements should be demonstrated in the permit application required in subsection 5.10.2.1. Because commercial disposal facilities use advanced methods of waste treatment and disposal, the regulatory agency should establish, where applicable, numerical requirements for the design of pond liners and leachate collection systems, for landfarming operations (i.e., repeated land applications), and for E&P waste reclamation facilities. The requirements of this section are intended to furnish the regulatory agency with sufficient and meaningful information such that permitting decisions will lead to no environmental impact or public health impact once the facility has commenced operations and following its closure.

The regulatory agency may adjust or exempt from these requirements centralized facilities that receive a limited number of substantially similar waste streams and limited volumes of waste, such as the consolidated produced water disposal facilities in a large multi-operator field. Administrative criteria for centralized facilities also may be less extensive than those for commercial facilities.

5.10.2.1 Regulatory Agency Responsibilities in Permitting

The regulatory agency should authorize off-site commercial and centralized disposal facilities for E&P wastes by permit. An individual permit should be required for E&P waste reclaimers and other commercial facilities where waste is placed on the land (e.g., in pits and in landfarms). The agency should use the data and information required by the technical standards of this section to approve or deny applications for permits, to ensure compliance with permit conditions, to order corrective actions in order to prevent or abate violations of the standards, or for any other purpose deemed necessary by the agency.

5.10.2.1.1 Acceptable Wastes

The agency should prescribe the range of E&P wastes that can be disposed at commercial and centralized facilities and at municipal solid-waste landfills.

5.10.2.1.2 Waste Characteristics and Disposal

The agency should identify the chemical characteristics of wastes likely to be disposed at commercial and centralized facilities on the basis of published scientific data and on knowledge about regional or site-specific waste characteristics. The agency should consider the types of waste management appropriate for each waste type, and the extent to which additional protective measures (e.g., leachate collection) are needed to protect groundwater, surface water and air.

The agency should prescribe these waste disposal facilities and waste stream relationships by rule or in the permitting process and ensure that operators of commercial or centralized facilities comply with them. For sampling and testing, refer to Section 5.10.2.2.3.f., g. For determining radiological content, refer to Sections 7.3.3 and 5.2.2.

5.10.2.2 Permitting Requirements

A permit should be issued only upon compliance with the general requirements of Section 5.1 and the technical requirements of this section, and upon submittal and approval of an application that contains a Siting Plan, Construction Plan, Operating Plan, and Closure Plan. Operation of a facility should comply with the terms and conditions of the permit. The regulatory agency may tailor the technical requirements for all existing facilities and for centralized disposal facilities to the conditions present at the locations of such facilities. In the case of centralized facilities, the regulatory agency may adjust the requirements of this section in light of the volume and characteristics of wastes received by the facility.

5.10.2.2.1 Siting Plan

The specific site for a commercial facility and, to the extent possible, the site for a centralized facility, should have natural features that prevent or minimize release of pollutants to waters, land, and air. Those natural features could include isolation from or considerable depths to groundwater, protection against flooding, the presence of low permeability soils, and topography conducive to protection against erosion. Additional safeguards may be required by the regulatory agency for centralized facilities that are located on sites that do not exhibit natural protective features or are located in close proximity to residences, schools, hospitals or commercial buildings. An application for a permit for a commercial or centralized facility should, at a minimum, contain the following information:

d. Names, addresses, and telephone numbers of owner(s) and the operator(s) of the facility, the owner(s) and occupant(s) of properties within close proximity of the site, or any nearby person who may reasonably be adversely affected by release from the site;

e. Topographic map showing the location of the site and any highways or roads that abut or traverse the site and depicting all water courses, flood plains, water wells, pipelines, and dwellings located within one mile of the site;

f. Geologic, hydrologic, engineering, chemical, and any other data or information that demonstrate disposal of wastes and operation of the facility will not contaminate fresh water, the surrounding soils or air, endanger public health, safety or the environment, or cause property damage;

g. Average annual precipitation and evaporation rate at the disposal site;

h. Nature and permeability of vadose zone; description of the subsurface strata, identification of the areal extent of underlying aquifer(s), and depth to groundwater; direction of groundwater movement; baseline data on water quality of nearby surface waters, underlying aquifer(s) and soils prior to commencement of operations; and points of past or current use of surface water or groundwater;

i. Proof that all public notice requirements have been met; and

j. Certification by an authorized representative of the applicant that information submitted in the application is true, accurate, and complete to the best of the applicant's knowledge.

5.10.2.2.2 Construction Plan

In general, commercial and centralized disposal facilities should be constructed to prevent or minimize releases of wastes or waste byproducts to surface water, groundwater, soils, and air. Design should allow for the segregation, separation and containment of free oil to minimize emissions, where appropriate. The need for additional protective measures (e.g., barriers) at facilities in close proximity to residences, schools, hospitals, or commercial buildings should be considered. Pits at these facilities should at least meet the construction requirements of Section 5.5.3 In the case of E&P waste reclamation facilities, construction requirements to prevent or minimize releases should also apply to wastes stored before and after reclamation. For commercial facilities, detailed engineering drawings and diagrams of engineered disposal facilities should be required; for centralized or one-owner facilities, such extensive construction details may not be needed. Construction should follow guidelines and rules adopted by the regulatory agency.

5.10.2.2.3 Operating Plan

Applications for permits for existing or new facilities should be accompanied by an Operating Plan that describes the wastes that will be accepted at the facility and the methods by which those wastes will be managed and disposed. The need for groundwater, air, or other monitoring at commercial or centralized disposal facilities where wastes are placed on the land should be evaluated by the state as part of this program development and implementation and should depend upon the nature and size of the disposal activities. At facilities that manage TE/NORM, monitoring should be sufficient to determine compliance with maximum permissible doses to workers and to members of the public in unrestricted areas.
The Operating Plan should contain the following information:

a. Volume, rate of application, and type of material to be disposed at the facilities and the facilities that will be used to dispose of each waste stream (i.e., unlined or lined pits, above- or below-grade tanks, etc.);

b. Contingency plan for reporting, responding to and cleaning up spills, leaks, and releases of wastes or waste byproducts, including provisions for notifying emergency response authorities and for taking operator-initiated emergency response actions;

c. Plan for routine inspection, maintenance, and monitoring to ensure and demonstrate compliance with permit requirements. At commercial and centralized facilities where wastes are placed on the land, such as in pits or landfarms, groundwater monitoring should be required in the absence of site-specific or facility-specific conditions that minimize the potential for adverse impacts to groundwater. Specific plans for preventing or minimizing air emissions from sources such as

   i. The volatilization of organic materials in the waste;

   ii. Particulate matter (dust) carried by the wind; and

   iii. Chemical reactions (e.g., production of hydrogen sulfide from sulfur-bearing wastes) should be considered.

d. Monitoring to ensure organic wastes are treated effectively should also be required for landfarming operations.

e. Waste acceptance policy for the facility that details the types of wastes that the facility will accept(exempt E&P wastes and/or non-exempt, non-hazardous wastes from E&P operations), how the facility will determine whether a shipment of wastes meets its acceptance criteria including whether on-site sampling and testing will be employed, and the procedures that will be followed if unacceptable wastes arrive at the facility;

f. Plan to characterize wastes received for disposal. Waste characterization requirements for small centralized facilities may be more limited, based on the limited types and volumes of wastes received. At a minimum, waste characterization should comply with the requirements of Section 5.2. States should determine additional minimum testing criteria applicable to their regions;

g. Plan for periodic removal and subsequent handling of free oil;

h. Security plan for the facility;

i. In the case of landfarming operations, loading rates, location restrictions, and/or other appropriate requirements that ensure the treatment of organic constituents, prevent the contamination of groundwater or surface waters, and protect air quality. Operations should comply with the requirements of Section 5.6.3;

j. A community relations or public information plan should be considered; and

k. Environmental, Health, and Safety Plan. Where applicable, an environmental, health, and safety plan should be developed for commercial disposal facilities. Such plan should describe site sampling methods and procedures to determine the potential risks to human health and the environment posed by the site. State regulatory programs should take into consideration the size and nature (treatment and disposal processes) of each facility when determining whether or not this environmental, health, and safety plan is applicable.

5.10.2.2.4 Closure Plan

Applications for permits for existing or new facilities should be accompanied by a Closure Plan that describes the methods to be used to reclaim the facility following the cessation of operations. Closure should comply with the general requirements of Section 5.1 and with any other requirements established by the regulatory agency. The plan should include a closure schedule, a cost estimate for reclamation, and a schedule for authorized financial assurance instrument. The cost estimate and authorized financial assurance instrument schedule should be used to establish a financial surety level for the facility prior to permit approval. The level of financial surety requested should cover the full estimated cost of facility closure and reclamation.

For commercial disposal facilities and centralized disposal facilities of comparable nature or size, the plan should describe the site sampling methods that will be used to determine the risks to human health and the environment posed by the site, if any, once closure is completed; and any further measures that may be necessary to address remaining site contamination at that time. The plan should also include post-closure monitoring and maintenance requirements where the wastes remaining on-site after closure may adversely affect groundwater or surface waters, or otherwise pose a significant risk to human health and the environment. The duration of the post-closure care period and the nature of the post-closure requirements should correspond to the continuing risks posed by the facility after closure.

5.10.2.3 Waste Tracking Requirements

To assure that only acceptable wastes are disposed of at commercial or centralized facilities, a waste tracking system that documents the movement of wastes from the site of their origin to their final disposition should be implemented. The following elements should be included in the waste tracking system:

a. Multi-Part Form or Equivalent Documentation: State regulatory programs should require operators to use a multi-part form or equivalent documentation that contains the names, addresses, and phone numbers of the generator (producer), hauler, and disposal facility operator; a description of the waste; the time and date it was collected, hauled, and deposited at the disposal facility; and the volume of the waste hauled.

b. Maintenance of Waste Tracking Information: The waste tracking information should be maintained by the generator, hauler, and operator of the disposal facility for inspection by the regulatory agency for a period of three years after the shipment date. This record retention period should be automatically extended for any person who is the subject of an unresolved enforcement action regarding the regulated activity from the date such person receives notice of the enforcement action until it is resolved.

c. Attest to No Illegal Dumping: The waste hauler should certify in writing that no unauthorized wastes were dumped illegally or at a location or facility not designated by the generator and that no unauthorized wastes were mixed with the exempt wastes during transport. The disposal facility operator should certify in writing that the facility is authorized to receive the waste for disposal.

d. Reporting of Discrepancies: The operator of the disposal facility should immediately report to the regulatory agency and the generator, any discrepancy in waste descriptions, volumes, or place of origin based on personal observations or documentation.

e. Permitting of Waste Haulers: Waste-hauling companies should be permitted by the regulatory agency based on a showing of basic knowledge about the regulatory requirements for disposition of E&P wastes transported from their point of generation to their final disposal site. The regulatory agency may issue permits to individual waste haulers or to waste hauling firms.

5.10.2.3.1 Applicability of Waste Tracking Criteria

These waste tracking requirements do not apply to wastes moved by pipeline. Operators who transport wastes by pipeline should periodically report waste quantities to the regulatory agency.

SECTION 6 | Abandoned Sites

6.1 Abandoned Oil and Gas Sites Introduction

States with current or historic oil and gas operations should develop and implement a program to inventory, prioritize, and remediate, as necessary, abandoned sites. The purpose of this section is to provide guidance for that program. It is not the intent of these guidelines to preclude an abandoned site from being returned to operation in accordance with state requirements.

6.2 Definition of "Oil and Gas Site" and "Abandoned Site"

The terms "Oil and Gas Site" and "Abandoned Site," as used herein, have the following meanings:

a. An Oil and Gas Site is land or equipment, including a wellbore, that is now or has been used primarily for oil or gas exploration or production, or for the management of oil and gas wastes from exploration and production.

b. An Oil and Gas Site is considered an Abandoned Site if the site:

i. Was not adequately plugged or closed at conclusion of operations such that it constitutes or may constitute a threat to public health or the environment; and

ii. Has no owner, operator, or other responsible person (hereinafter called "responsible party") who can be located, or such responsible party has failed or refused to undertake actions, where required by law, to abate the threat. A responsible party cannot be located, among other circumstances, where no liability for remedial actions is imposed by the state upon past or current owners and operators.

6.3 Identification of Abandoned Sites

A state should have a procedure for identifying sites that may constitute a threat to public health or the environment and for determining whether a responsible party exists. The state should develop and maintain an inventory of abandoned sites. Examples of elements that may be considered in identifying sites that may constitute a threat to public health or the environment include agency reviews or inspections, referrals by other agencies, or citizen or landowner inquiries. Classifications or rankings may be used to separate these sites into relative risk categories. Examples of elements that may be considered in determining whether a responsible party exists include the failure to file required data or reports, the failure to respond to agency inquiries, tax defaults, information in public records, or landowner or public inquiries. In developing an inventory of abandoned sites, the state should have procedures for attempting to notify the last known responsible party, and providing legal notice.

Emergency protocols should be included, so that remedial action can be initiated prior to legal notice on sites that are judged to present an immediate threat to the public health or environment. Where there are agencies with overlapping jurisdiction for abandoned sites, inventory procedures should be coordinated among these agencies as further discussed in Section 4.4 of these guidelines.

6.4 Funding for Abandoned Site Remediation

An effective state program to address abandoned sites should have adequate funds available to permit the state to undertake any necessary assessment, plugging, closure, or remediation of such sites.

Adequate funding involves the development of a financial assurance program as provided in Section 4.2.4. To ensure the continuity of financial assurance in the event of a change of operator, notice to the state of any such change should be required. Any financial assurance provided by the previous operator should remain in effect until the new operator's compliance with the state's financial assurance program is verified.

Section 4.2.4 describes some of the types of financial assurance a state should consider in designing a program to provide it with the necessary economic resources while facilitating operator compliance. As part of a financial assurance program, a state should consider establishing a special purpose fund to plug, close, or remediate an abandoned site. The state should have the authority to recover costs from the responsible party, where such party exists. The state should evaluate its needs and establish such funding mechanisms as are appropriate to satisfy those needs. A wide variety of funding mechanisms have been employed to support existing special purpose funds in various states. Those mechanisms include bond forfeitures; legislative appropriations to the responsible state agency; a percentage of the taxes on oil and gas production; fines and penalty assessments; equipment salvage; and a host of fees, among them fees or charges based on the value of oil and gas, fees or charges based on units of production of oil and gas, operator fees, supplemental fees in lieu of bonds, inactive well fees, permit fees, and waste generation fees.

6.5 Criteria for Prioritizing Remediation

The state program should include criteria for determining whether an abandoned site constitutes a threat to public health or the environment and the site's priority for remediation. Among other things, the following criteria may be used: (1) the occurrence of or potential for an imminent release from the site; (2) the nature, extent, and degree of contamination; (3) the proximity of the site to populated areas, surface water, and/or groundwater; (4) whether the site is in an environmentally sensitive area; and (5) wellbore lithology and condition. Where appropriate, the state should perform a more detailed site evaluation. The state agency should have flexibility and discretion to consider the factors associated with the individual sites, including cost savings associated with simultaneous remediation of multiple sites that otherwise would have different priorities or similar financial considerations, in assigning them a priority on the inventory of abandoned sites.

6.5.1 Goal for Remediation

A goal of the state program should be to remediate the abandoned sites on its inventory in a manner that assures that reasonable and measurable progress is made.

6.5.2 Liability for Remediation

The state should establish a liability scheme that will ensure that the goals of its abandoned sites program will be achieved. States should consider a range of options with respect to liability for remediation, which may include among others: (1) liability for all current and past owner(s) and operator(s); (2) liability for the owner(s) and operators(s) found to be responsible for the contamination at an abandoned site; or (3) no liability for past or current owner(s) and operator(s) should the state choose to finance the abandoned sites program.

Any liability scheme established by a state should clearly define the responsibility for remediation. A state should allow remediation of an abandoned site by a party that would not otherwise be responsible for the remediation.

6.6 Standards for Remediation

The state should ensure that abandoned sites, including well bores, be plugged or closed in a cost-effective manner that minimizes or removes the threat to public health and the environment and that restores the land to an environmentally stable condition.

6.6.1 Well bore Remediation

The state should consider existing rules and regulations when determining proper plugging procedures for abandoned sites. However, the state should have the flexibility to modify those plugging procedures, while maintaining mechanical integrity of the well bore adequate to ensure that public health and the environment are protected.

In carrying out well bore remediation, the state should use existing information from well records including depth of well, depth of any old plugs, presence of casing and tubing and depths set, perforations, existence of groundwater and hydrocarbon-bearing zones, existence of over-pressured zones, and any junk in the hole to determine the condition of the well and the proper plugging procedure. In the absence of the above information, data such as existing geological and engineering field studies, water well records, interviews with nearby landowners, corporate records, and historical literature can be reviewed.

6.6.2 Site Remediation

The extent of surface remediation of an abandoned site should be determined based on surface and subsurface resources and land use. Consultation by the state regulatory agency with the surface owner, surface tenant, and other federal, state and local agencies, as appropriate, should take place prior to remediation.

As appropriate, abandoned sites should be re-vegetated in accordance with state regulatory agency rules, and with consideration given to recommendations from the surface owner, surface tenant, and federal and local agencies. As appropriate, soil should be evaluated to determine if hydrocarbons, chemicals, or NORM were spilled or leaked, and to determine remediation.

Surface equipment or materials on an abandoned site should be removed, and salvaged when possible, unless the state determines otherwise. Procedures should be identified for handling NORM, if present. Due to the expense and potential damage to the land, there may be situations where equipment or materials would not be removed, e.g., a gathering system might be abandoned in place with appropriate protection. When reclaiming a pit, the state should determine the contents of the pit and how the pit can best be remediated. Once emptied, cleaned and tested as appropriate, pits should be backfilled and contoured to prevent erosion from or ponding of surface water. Monitoring wells at an abandoned site should be as necessary to protect groundwater resources. The state should develop additional remediation criteria for commercial disposal sites, as appropriate.

6.6.3 Record of Remediation

Once remediation of an abandoned site has been completed, reports on how the site was remediated should be maintained by the regulatory agency.

6.7 Public Participation

The state abandoned sites program should provide for public participation. At a minimum, the public should have: (1) access to information about the program; (2) the opportunity to participate in any rulemakings associated with the program; and (3) a statutory or regulatory mechanism to petition the state agency to change a site's status on the inventory and/or the level of remediation required on a site.

6.7.1 Access to Information

The state should maintain and make available to the public, records related to the abandoned sites inventory, including: (1) the location of an abandoned site; (2) the extent and degree of contamination of the abandoned site; and (3) the method of remediation that has been or will be required for an abandoned site. In addition, the state should maintain public records on the state's progress with respect to implementing the abandoned sites program.

6.7.2 Participation in Rulemaking

The state program should provide an opportunity for the public to participate in any rulemakings associated with the program.

6.7.3 Participation Regarding Priority on the Inventory and Level of Remediation

The state program should include a mechanism by which an affected person could petition the state to: (1) add a site to the abandoned sites inventory; (2) change the priority for remediation of a site on the inventory; and (3) conduct or require additional remediation of a site.

6.8 Avoid Future Abandoned Site Problems

Since abandoned sites may constitute a threat to public health and the environment, the state should:

a. Establish and implement an abandoned site program consistent with the guidance in this section; and

b. Enforce its existing regulatory program, with modifications, if necessary, consistent with this guidance.

c. Evaluate its programs for financial assurance, inspection, compliance tracking, and monitoring of inactive sites to determine whether or not the state should make adjustments to prevent an increase in abandoned sites.

SECTION 7 | Naturally Occurring Radioactive Materials

7.1 Background

Naturally occurring radioactive material (NORM) is present above background levels at some oil and gas E&P facilities and E&P service company locations. NORM found in E&P operations originates in subsurface oil and gas formations and is typically transported to the surface in produced waters. NORM may deposit in well tubulars, surface piping, vessels, tanks, pumps, valves, and other producing or processing equipment and may be found in scales, sludges, contaminated soil, and other associated E&P wastes. NORM is also referred to as Technologically Enhanced Naturally Occurring Radioactive Material or TENORM.

7.2 General

States should adopt an E&P NORM regulatory program that addresses identification, use, possession, transport, storage, transfer, decontamination, and disposal to protect human health and the environment. States may choose not to adopt such a program if they find, based on field monitoring data and other scientific information, that no NORM is present in oil and gas operations in the State, or that the levels of NORM present in oil and gas operations in the State do not present such a risk to human health or the environment to warrant a regulatory program. States that make such a finding should periodically reevaluate the basis for the determinations.

If a state determines that a regulatory program is necessary, it should tailor its program to NORM occurrence in the oil and gas E&P industry and an assessment of risks to human health and the environment. The program should include the elements listed in Section 7.3. E&P NORM should be managed in accordance with the pollution prevention and waste management hierarchy provisions of these guidelines. In addition, the other sections of these guidelines apply, where applicable, to NORM as a constituent of E&P waste.

7.3 Elements of an E&P NORM Program

7.3.1 Definition

States should develop a definition for NORM that is consistent with that which occurs in the oil and gas E&P industry. For purposes of these guidelines, NORM is defined as any naturally occurring radioactive materials (not including byproduct, source or special nuclear material, or low level radioactive waste) not subject to regulation under the Atomic Energy Act, whose radionuclide concentrations have been enhanced by human activities such that potential risk to human health or the environment are increased.

7.3.2 Action Levels

States should establish risk-based numerical action levels above which NORM is regulated taking into consideration the risk of exposure to human health and the environment. Such action levels should also be used to regulate the transfer or release of equipment, materials, and sites.

7.3.3 Surveys

States should develop standards for survey instruments and procedures for identifying and documenting equipment, materials, and sites that may contain NORM above the action levels. States should consider the types of facilities to be surveyed, when surveys should be performed, when survey results should be reported to the state regulatory agency, and any necessary training of surveyors. State survey requirements should provide data necessary to meet the purposes described in Section 5.2.1 and to administer and enforce state program requirements effectively.

7.3.4 Worker Protection

State regulatory programs should include applicable state and federal standards for worker protection from exposure to radiation, including worker protection plans, and other standards necessary for the protection of workers from exposure to NORM. States should establish NORM training or certification requirements based upon E&P work related duties and their associated NORM exposure risk (i.e., NORM awareness training may be sufficient for many common E&P work activities).

States that have not implemented a Federal OSHA-Approved State Plan cannot enforce Federal OSHA standards for worker protection. In such "non-agreement" states, Federal OSHA administers job safety and health programs. States with Federal OSHA jurisdiction should be aware of the limitations this may place on worker protection programs implemented by the state and should communicate with Federal OSHA to ensure that any worker protection program implemented by the state is enforceable under Section 18 of the OSH Act.

7.3.5 Licensing/Permitting

a. General licensing/permitting: Persons who possess E&P NORM in concentrations or at exposure rates that exceed state-adopted action levels should be generally licensed or permitted.

b. Specific licensing/permitting: Specific licenses or individual permits should be required for commercial storage, removal, decontamination, remediation, treatment or disposal of E&P NORM. A state may require specific licenses or individual permits for the management of E&P NORM at centralized facilities as defined in Section 5.10.

7.3.6 Removal/Remediation

States should consider performance standards for removal, decontamination, and remediation that are protective of human health and the environment.

7.3.7 Storage

States should establish standards for storage of NORM that are protective of human health and the environment. NORM storage facilities should be constructed to prevent or minimize releases. Tanks used to store E&P NORM should meet the requirements of Section 5.9. A state should consider adoption of limits on the amount of time NORM that exceeds action levels can be stored, depending on factors such as quantity, radioactivity, climate, proximity to the public, and protective controls.

7.3.8 Transfer for Continued Use

State regulatory programs should allow for the transfer of land and equipment containing NORM for continued operations in the production of crude oil and natural gas, with appropriate notification to affected parties.

7.3.9 Release of Sites, Materials, and Equipment

State regulatory programs should address the levels below which, and conditions under which, equipment, materials, and sites containing NORM may be released. State regulatory programs should authorize the release of equipment, materials, and sites for unrestricted use only if NORM is below action levels. Such regulations should provide for appropriate notification to affected persons.

7.3.10 Disposal

State regulatory programs should authorize disposal alternatives within the state's jurisdiction for various E&P wastes containing NORM, including contaminated equipment, and should include regulatory requirements for NORM disposal that are protective of human health and the environment. Landowner or other notification may be required as a condition of disposal. Commercial and centralized NORM disposal facilities should meet the criteria of Section 5.10.

7.3.11 Interagency Coordination

State radiation programs, oil and gas programs, and waste management programs are frequently distributed among separate agencies. Therefore, in many states, multiple agencies may regulate NORM. The various agencies should coordinate their regulatory and enforcement activities under the guidance given in Section 4.4 of these guidelines.

7.3.12 Public Participation

State regulatory programs for NORM should meet the public participation guidelines established in Section 4.2.2.

7.4 Regulatory Development and Research

The Conference of Radiation Control Program Directors has prepared suggested state regulations for NORM, and a number of states have developed or are in the process of developing NORM regulations. States that are developing their own NORM programs are encouraged to consult these sources as well as applicable federal radiation guidance and requirements for information and assistance. In addition, states should encourage and keep abreast of ongoing and future research on NORM, including risk assessment.

SECTION 8 | Stormwater Management

8.1 General

Stormwater can become contaminated from contact with spilled or stored materials, from contact with E&P waste, or from the erosion of soils. E&P waste management practices that have a potential of contaminating stormwater include land application, landfarming and roadspreading. States usually have statutory authority for stormwater management programs through general pollution prevention or water pollution control legislation. States should implement programs to minimize the potential for contamination of surface water from sediment and other E&P contaminants contained in stormwater.

Stormwater management requirements should be adapted to regional characteristics. These characteristics include variations in topography, rainfall (annual average, episodic and seasonal), major soil types, proximity to surface waters, floodplains, seasonal and permanent swamps, wetlands and marshes, and vegetative cover.

States should adopt a stormwater management program based on the potential effects on human health and the environment. States may choose not to adopt such a program if they find, based on field monitoring data and other scientific information, that stormwater runoff does not pose a significant risk to human health or the environment. States that make such a finding should periodically reevaluate the basis for the determination. The state program need not duplicate applicable federal regulations for stormwater management.

Stormwater management regulatory activities should be coordinated with activities of other interested parties including landowners, soil conservation agencies, land management agencies, agencies with NPDES jurisdiction, and agencies with spill response authority.

8.2 State Regulatory Elements

The state agency with stormwater management or erosion control authority should require an operator to minimize environmental impacts caused by stormwater. These requirements should include a description of the action the operator will take to meet state program goals for the geographic location in which the activity will take place. These requirements may be spelled out in specific regulations or they may be required to be included in operator- or site-specific plans developed by operators. State program requirements should specify time frames when stormwater control measurements are to be in place and when any state notifications are to occur.

In regions where stormwater has a high potential for causing environmental degradation, states should consider the use of permits or other authorizations to assure that adequate measures will be put in place. Such permits or authorizations should conform to Section 4.1.1. (Permitting).

State stormwater management programs should contain compliance evaluation capabilities as outlined in Section 4.1.2. (Compliance Evaluation), contain enforcement capabilities as outlined in Section 4.1.3. (Enforcement), be applicable to responses to spills and releases as outlined in Section 4.2.1. (Contingency Planning and Spill Risk Management), and contain data management capabilities as described in Section 4.2.8. (Data Management).

States programs should provide for outreach and training on stormwater management requirements and practices for operators, landowners and the public. These activities should conform to Section 4.2.2.2. (Public Participation). Similarly, training should be provided for state agency personnel as outlined in Section 4.3.1.5. (Training Requirements). Where stormwater management and E&P regulatory authority reside in different agencies, oil and gas agency staff should be trained so that they can, as time and staffing patterns allow, provide information and referrals to operators.

State stormwater management programs should be evaluated periodically in accordance with Section 4.2.3 (Program Planning and Evaluation). Such evaluations should include an analysis of all aspects of the program, and procedures for making any necessary program changes identified during the evaluation.

8.3 State Agency Regulatory Program Criteria

8.3.1 Planning

Within the context of an E&P program, selection of the location for a well site, roadway, pipeline or other E&P facility is a critical component of a stormwater management program. Factors to be considered during the development of site requirements with respect to stormwater management include: minimization of the area to be disturbed, current land uses, site gradient, the type of facility to be constructed, springs and seeps, floodways, stream crossings, and the management of E&P wastes.

Other factors that should be considered in the development of stormwater management requirements include well density, distance between wells, existing roads, necessary temporary and permanent roads to be constructed, road alignment, slope, grade and length, the availability of vegetative filter strips, and the management or disposal of trees and stumps to be removed during construction.

8.3.2 Construction

The construction of well sites, access roads, pipelines, stream crossings and crossings of wetlands, swamps and marshes can result in the contamination of stormwater and/or adjacent surface waters. Consequently, state agencies should develop standards or management practices appropriate for these activities. Similar practices may be necessary when responding to spills and releases when soils are disturbed or contaminants are mobilized by stormwater.

Standards or management practices should be appropriate for the region in which the construction activity will occur. Examples of such requirements include the construction of upgrade diversion channels and the collection of construction site runoff; the use of brush and other barriers and the stockpiling of topsoil and subsoil during clearing and grubbing; and the grading of cut and fill slopes, road embankments, road surfaces (crowned, insloping or outsloping) and roadside ditches to control water.

Similarly, requirements should be developed for bridges, causeways, cofferdams, fords and bank stabilization when surface waters are encountered. Requirements for temporary road or stream crossings and use of rock at construction entrances may be necessary.

Practices to be considered for stormwater controls during construction include drainage ditches, basins, sediment traps, berms, vegetative filter strips, sediment barriers, turnouts, culverts and cross-drains, broad-based dips and swales, waterbars, rock filters, straw bale barriers and fabric filter fence. Outlet protection should be provided for devices with outlets to surface waters.

Additional practices to be considered for pipeline construction include the use of ditchline barriers, timing of backfilling, materials used for trench backfill, location of staging areas, and the use of trench plugs. In fragile soil, wetland and marshy areas, and at stream crossings, construction mats, board roads or geo-textiles should be considered.

Criteria should be developed for temporary stabilization if permanent stabilization will be delayed. Temporary stabilization practices such as seeding with annual grasses and mulching, or seed/filter fabric combinations should be considered. Permanent stabilization can occur through the application of rock to well sites and roads, and achieving adequate growth of (or sodding with) permanent vegetation. Factors to be considered during revegetation include calculation of acreage, soil types and distribution, seed bed preparation, seed mixtures (temporary, permanent), soil amendments, and mulching and anchoring.

8.3.3 Operation and Maintenance

States should require that stormwater control measures be operated and maintained in a manner that will assure their effectiveness during site preparation, well drilling and production, and until the site is restored. These measures should be operated and maintained to control sediment as well as E&P waste and spills. Requirements regarding the frequency and type of inspection, preventative maintenance and repairs are appropriate.

8.3.4 Restoration and Reclamation

Where appropriate, states should incorporate stormwater management during the development of standards for site restoration and reclamation. These requirements should apply to the restoration of recently active sites, orphan sites, remediation sites, and sites where prior restoration efforts failed.

Where appropriate, stormwater management criteria should be developed for the removal of equipment, restoration of pits, disconnection and abandonment of pipelines, backfilling and grading, and access road reclamation.

SECTION 9 | Hydraulic Fracturing

9.1 Background

The practice of completing oil and gas wells through hydraulic fracturing, while not new, has evolved into a key technology in the development of unconventional oil and gas resources, such as coal bed methane or shale gas. This has resulted in questions about the potential impacts on water resources due to the volume of water needed for hydraulic fracturing, the potential impacts to groundwater by the hydraulic fracturing process, or the proper management or disposal of waste and other fluids associated with hydraulic fracturing.

9.2 General

States should evaluate potential risks associated with hydraulic fracturing, taking into account factors such as depth of the reservoir to be fractured, proximity of the reservoir to freshwater resources, well completion practices, well design, and volume and nature of fluids. Where necessary and recognizing the local and regional differences discussed in Section 3.3, states should have standards to prevent the contamination of groundwater and surface water from hydraulic fracturing. State programs for hydraulic fracturing should ensure establishment and maintenance of well control; protection of groundwater zones, other mineral resources.

9.2.1 Standards

State programs for hydraulic fracturing should include standards for casing and cementing to meet anticipated pressures and protect resources and the environment. The state should have the authority as necessary to require the performance and/or submittal of diagnostic logs or alternative methods of determining well integrity. The state program should address the identification of potential conduits for fluid migration in the area of hydraulic fracturing and the management of the extent of fracturing where appropriate. The program should require monitoring and recording of annular pressures during hydraulic fracturing operations. The program also should address actions to be taken by the operator in response to operational or mechanical changes that may cause concern, such as significant deviation from the fracture design and significant changes in annular pressures.

State programs for hydraulic fracturing should consider baseline groundwater monitoring protocols that address appropriate factors which may include distance/radius from the well, timing/frequency of testing, test parameters, reporting and management of and access to data, existing/new development or existing production in area, responsibility for sample collection, testing, cost, location/gradient, surface owner consent, laboratory accreditation, and remedial actions.

Surface controls, such as dikes, pits or tanks, should meet the criteria in Sections 5.5 and 5.9. In addition to pit technical criteria for authorization, construction, operation, pit integrity monitoring, and closure contained in Section 5.5, states should address unique characteristics of impoundments associated with hydraulic fracturing, including the use of centralized and commercial facilities, operatorship, size, location, duration, closure, retention for other use, and characteristics of contained fluids. States should consider erosion and safety issues such as embankment integrity associated with freshwater impoundments associated with hydraulic fracturing.

Contingency planning and spill risk management procedures that meet Section 4.2.1 should be required. Waste characterization should be consistent with Section 5.2. The waste management hierarchy contained in Section 5.3 (source reduction, recycling, treatment and disposal), including the provisions relating to toxicity reduction, should be promoted. The tracking of waste disposed at commercial or centralized facilities should meet the requirements of Section 5.10.2.3. Procedures for receipt of complaints related to hydraulic fracturing should be consistent with Section 4.1.2.1.

9.2.2 Reporting

The regulatory agency should require appropriate notification prior to, and reporting after completion of, hydraulic fracturing operations. Notification should be sufficient to allow for the presence of field staff to monitor activities. Reporting should include the identification of materials used, aggregate volumes of fracturing fluids and proppant used, and fracture pressures recorded.

State programs should contain requirements for public disclosure of information on type and volume of base fluid and additives, chemical constituents, and actual or maximum concentration of each constituent used in fracturing fluids. States are encouraged to require disclosure of such information online. State programs should contain mechanisms for disclosure of chemical constituents used in fracturing fluids to the state in the event of an investigation and to medical personnel on a confidential basis for diagnosis and/or treatment of exposed individuals. Where information submitted is of a confidential nature, it should be treated consistent with Section 4.2.2.

9.2.3 Staffing and Training

In addition to the personnel and funding recommendations found in Section 4.3, state staffing levels should be sufficient to receive, record and respond to complaints of human health impacts and environmental damage resulting from hydraulic fracturing. Staff should receive adequate training to stay current with new and developing hydraulic fracturing technology.

9.2.4 Public Information

State agencies should provide for dissemination of educational information regarding well construction and hydraulic fracturing to bridge the knowledge gap between experts and the public as provided in Section 4.2.2.2. This is especially important in areas where development has not occurred historically and in areas where high volume water use for hydraulic fracturing is occurring.

9.2.5 Coordination

In addition to coordination as contained in Section 4.4, states should consider interstate coordination of regional multi-state issues such as source water, transportation and waste management related to hydraulic fracturing.

9.3 Water and Waste Management

Fundamental differences exist from state to state, and between regions within a state, in terms of geology and hydrology. The state should evaluate and address, where necessary, the availability of water for hydraulic fracturing in the context of all competing uses and potential environmental impacts resulting from the volume of water used for hydraulic fracturing. The use of alternative water sources, including recycled water, acid mine drainage and treated wastewater, should be encouraged.

Waste associated with hydraulic fracturing should be managed consistent with Sections 4.1.1 and 7.

States should encourage the efficient development of adequate capacity and infrastructure for the management of hydraulic fracturing fluids/wastes, including transportation (by pipeline or otherwise), recycling, treatment and disposal. State programs should address the integrity of pipelines for transporting and managing hydraulic fracturing fluids off the well pad.

SECTION 10 | Air Quality

10.1 Background

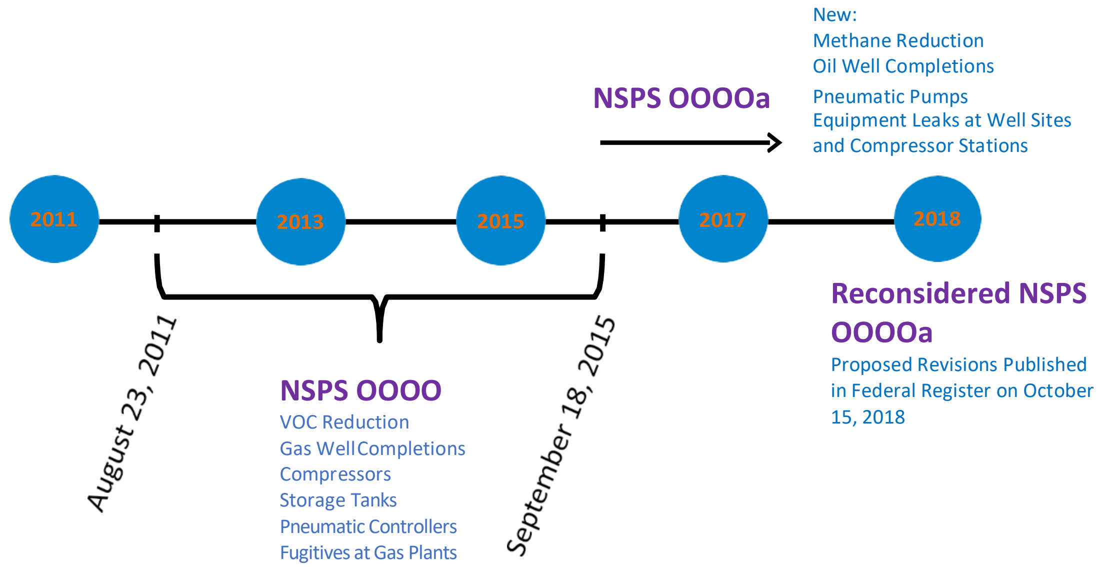
As a result of the increased development of oil and natural gas from shale formations, concerns about air emissions from the oil and gas sector have become more focused. The criteria of this Guidelines section are focused on air emissions from upstream oil and gas exploration and production (E&P) operations. The term “upstream” is used throughout to describe the full array of operations, activities, facilities, and sources in this sector.

On August 16, 2012, EPA published three final rules for the Oil and Natural Gas Sector: NSPS OOOO for the control of VOC and SO_2 emissions; and NESHAP HH/HHH for the control of hazardous air pollutant emissions. For VOC sources, NSPS OOOO applies to affected sources that are new, modified or reconstructed on or after August 23, 2011, and on or before September 18, 2015. NSPS OOOO requires that companies reduce completion flowback emissions from hydraulically fractured and refractured gas wells by employing reduced emissions completions (aka “green completions”), control emissions from storage vessels by 95%, use low or no bleed pneumatic controllers in the production segment, use no bleed controllers at gas plants, replace reciprocating compressor seals every 26,000 hours of operation or three years, reduce wet seal centrifugal compressor emissions by 95%, and implement more stringent NSPS Subpart VVa leak detection and repair (LDAR) programs at natural gas processing plants. NSPS OOOO also revised SO_2 emissions maximum control requirements for sweetening units affected facilities from 99.8 percent to 99.9 percent.

The NESHAP HH/HHH rules amended provisions to previously codified rules. In particular, the amendments set new standards for small glycol dehydrators, lowered the leak detection threshold at gas plants and amended the definition of “associated equipment” used in making major source determinations at well sites.

EPA published minor amendments to NSPS OOOO on September 23, 2013 and December 31, 2014. In response to petitions for administrative reconsideration of certain provisions in NSPS OOOO and in the amendments, EPA granted reconsideration for certain issues and subsequently proposed revisions to the rule on September 18, 2015. In the proposed rule, EPA revised the regulated pollutant to be both methane and VOC across the oil and natural gas source category (i.e., production, processing, transmission and storage). EPA also added control requirements for completion flowback emissions from hydraulically fractured and refractured oil wells, emissions from pneumatic pumps, and fugitive emissions from well sites and compressor station sites (LDAR). On June 6, 2016, EPA published a final NSPS OOOOa. The initial compliance date was August 2, 2016.

NSPS OOOO/OOOOa Applicability Timeline



New petitions for administrative reconsideration of certain provisions in NSPS OOOOa were filed and, after additional input from public and industry stakeholders, EPA published proposed revisions to NSPS OOOOa on October 15, 2018. EPA has not proposed removing any of the current regulated sources. EPA requested public comments on the proposed revisions and for questions the agency has asked in the preamble. A final revised NSPS OOOOa will likely be published in the second quarter of 2019.

10.2 Administrative

While state oil and gas regulatory agencies have many environmental responsibilities, air quality programs are typically administered by state environmental protection or health agencies and are given statutory and regulatory powers as described below.

Recognizing the local and regional differences discussed in Section 3.3, states should have standards to prevent the contamination of air from pollutants such as nitrogen oxides (NOx), volatile organic compounds (VOC), carbon monoxide (CO), methane, hydrogen sulfide (H2S); and air toxics or hazardous air pollutants (HAP) such as sulfur dioxide (SO2), benzene, normal hexane (N-Hexane), and formaldehyde.

10.2.1 Scope of Authority

An effective state program for the regulation of air emissions from upstream operations should include, at a minimum:

1. Statutory authority that adequately details the powers and duties of the respective regulatory body or bodies;
2. Statutory authority that grants the regulatory body or bodies the power to oversee air emissions from upstream operations such as production, gathering,

compression and processing. This authority should include the ability to promulgate appropriate rules and regulations and meet the state's obligations under federal law;

3. Statutory authority to promulgate specific requirements that are more stringent than required under the federal Clean Air Act, or regulations where necessary and appropriate to protect public health and the environment (for example, additional requirements on new and/or existing facilities or sources within ozone nonattainment areas);

4. Authority to accept delegation and authority for implementation of federal air quality programs specific to upstream operations;

5. Authority to consider cost effectiveness in setting air emission standards when appropriate, as well as to exempt facilities or sources based on criteria such as de minimis emissions, or by type of source or facility;

6. Statutes and implementing regulations which adequately and clearly define necessary terminology;

7. Provisions to ensure adequate funding for the staff and program to carry out its objectives and duties;

8. Mechanisms for coordination among stakeholders (including the public, federal and state agencies, and the regulated industry); and

9. Technical criteria for air emission controls that are flexible and forward-looking to encourage and accommodate advancements in technology.

10.2.2 Jurisdiction and Cooperation Between Agencies

The Clean Air Act establishes a dual federal/state system for establishing requirements to protect public health and the environment, and to oversee air pollution sources, including upstream oil and gas exploration and production operations. Under this framework, states are required to establish State Implementation Plans (SIPs) that contain sufficient requirements to attain and maintain compliance with National Ambient Air Quality Standards (NAAQS). Separate from the SIP process, states may, but are not required to, accept delegation of certain federal air quality requirements such as the preconstruction Prevention of Significant Deterioration (PSD) permitting program, the Title V permit program or New Source Performance Standards (NSPS). Even if a state does not accept delegation to implement and enforce a particular federal requirement, EPA retains responsibility for implementing and enforcing that requirement. Part of EPA's role is to ensure a level playing field across the country, therefore where a state accepts delegation of federal regulations, EPA continues to provide oversight to ensure adequate programmatic and compliance efforts across states.

Within states that accept delegation from EPA, jurisdiction over air quality issues related to upstream operations may be split between the state air quality agency, local air quality agencies and/or the agency with jurisdiction over oil and gas drilling and production. Because states do not have jurisdiction over air pollution sources on tribal lands, EPA or the tribes hold responsibility for implementation and enforcement of air quality requirements for upstream operations on these lands.

Where multiple state, federal or tribal authorities have jurisdiction over air quality issues in the same landscape, mechanisms should be in place to avoid duplication, regulatory gaps, or inconsistent air quality requirements or enforcement of such requirements. Consistent with EPA and state agency authority, such mechanisms could include formal Memoranda of Understanding, established interagency task forces, regular periodic meetings between agency staff, and joint inspections of facilities.

In addition to ensuring proper coordination, agencies should communicate with the regulated community and the public to make it clear which agency or agencies have jurisdiction over a particular area, or responsibility for enforcing a given set of air quality requirements.

10.2.3 Permits, Authorizations and Exemptions

The Clean Air Act prohibits the construction of a major source without a permit. State permits should clearly establish what performance standards and/or emission control requirements are required for each covered source. State programs should establish clear permit exemption criteria and employ construction general permits or permits by rule that also serve as final permits to operate.

When emissions are difficult to estimate due to uncertainty of source throughput and composition, states should consider mechanisms that allow operators to construct and operate certain source types for a limited but sufficient period of time to determine actual facility emissions prior to permitting (similar to federal rules such as the storage vessel provisions of OOOO and OOOOa that allow an established period for emissions determination before requiring control). Such mechanisms should be designed to ensure that permit conditions, including emission control requirements and Federal applicability, are properly informed, but that regulatory emissions thresholds are not exceeded during the evaluation period. States should have flexibility to re-visit emissions calculations as necessary.

States with approved Clean Air Act permitting authority should adopt a program for upstream emission sources that:

1. Is designed to protect human health and the environment;
2. Is legally and practicably enforceable;
3. Harmonizes with federal requirements to avoid confusing and duplicative requirements for operators; and

4. Allows the state to develop additional requirements beyond federal requirements to address state-specific air quality issues.

The permitting process should be efficient. Therefore, state air quality permitting programs should be:

5. Straightforward for operators to understand and implement;

6. Administratively efficient for the regulatory agency to minimize cost in time and resources; and

7. Transparent for public understanding.

To accomplish this, states are encouraged to simplify the application process by providing:

8. Accepted emission estimation methods and supporting documentation;

9. Guidance on air quality modeling requirements; and

10. Permit application assistance tools.

10.2.4 Compliance Monitoring, Demonstration & Assurance

State programs should contain the following compliance monitoring, demonstration and assurance capabilities:

1. Procedures for the receipt, evaluation, retention, and investigation of all notices and reports required of permittees and other regulated persons. These procedures should ensure that the notices and reports submitted are adequate in both content and frequency to assess compliance with applicable requirements. States should integrate electronic reporting systems to improve efficiency and timeliness of data received. Duplicative or unnecessary reporting should be minimized. Investigation for possible enforcement action should include determination of failure to submit complete notices and reports in a timely manner. Effective data management systems, as described in Section 4.2.7, should be used to track compliance.

2. Inspection and monitoring procedures that are independent of information supplied by regulated entities and which allow the state to determine compliance with program requirements, including:

   a. The capability to conduct comprehensive investigations, that may include advanced monitoring techniques as appropriate, of facilities and activities subject to regulation in order to assist with the evaluation of operational compliance;

   b. The authority to obtain information from regulated entities and investigate information obtained regarding potential violations of applicable program and permit requirements; and

   c. The capability to conduct regular inspections of regulated facilities and activities at a frequency that is commensurate with state priorities based on the protection of health, safety and the environment.

3. Procedures to receive and evaluate information submitted by the public about alleged violations and to encourage the public to report perceived violations. Such procedures should not only involve transparent communications with the public, (to apprise it of the process to be followed in filing reports or complaints) but should also communicate how the state agency will assure an appropriate and timely response.

4. Authority to conduct unannounced inspections at a reasonable time of any regulated site or premises where operations are being conducted, including the authority to inspect, sample, monitor, or otherwise investigate compliance with permit conditions and other program requirements, such as proper operation of control devices, process operating conditions and control device operating parameters.

5. Authority to enter locations where records are kept during reasonable hours for purposes of copying or obtaining electronic copies and inspecting such records.

6. Procedures to ensure that documents and other evidence are maintained and/or managed such that they can be admitted in any enforcement proceeding brought against an alleged violator, noting that some information may be entitled to confidential treatment.

   a. Operators and the state should presume that all records submitted to the state are public. It is the operator's obligation to identify which information is confidential business information, to take adequate steps to safeguard that information, and to demonstrate to the state that the release of such information would cause substantial harm.

7. Authority to require regulated persons to conduct stack testing or other measurements to establish or verify compliance with applicable requirements; to provide for state presence at such tests, be given adequate notice of the tests, and to conduct its own tests when deemed appropriate.

8. Authority to require, under statute, regulation or permit, regulated persons to:

   a. Establish and maintain records;

   b. Make reports;

   c. Install, use, and properly maintain monitoring equipment, and use audit procedures, or methods;

d. Sample emissions in accordance with prescribed methods;

e. Provide stack test protocols and test reports;

f. Perform parametric monitoring where direct emissions measurement is impracticable;

g. Submit compliance certifications; and

h. Provide other information needed to determine compliance on a one-time, periodic or continuous basis.

10.2.5 Enforcement

10.2.5.1 Enforcement Tools

The state agency should have effective enforcement tools to address any violations of the state air program, which may include the following actions:

1. Issue a notice of violation;

2. Restrain, immediately and effectively, any person by order or by suit in state court from engaging in any impending or continuing unauthorized activity which is causing or may cause damage to public health or the environment;

3. Establish the identity of emergency conditions which pose an imminent and substantial human health or environmental hazard that would warrant entry and immediate corrective action by the state agency after reasonable efforts to notify the operator have failed;

4. Sue or cause suit to be brought in courts of competent jurisdiction to enjoin any impending or continuing violation of any program requirement, including any permit condition, without the necessity of a prior revocation of the permit;

5. Require, by administrative order or suit in state court, that appropriate action be undertaken to correct any harm to public health and the environment that may have resulted from a violation of any program requirement, including, but not limited to, establishment of compliance schedules or requiring the source to apply for and obtain permits for previously unpermitted emissions;

6. Encourage Beneficial Environmental Projects or Supplemental Environmental Projects to secure additional environmental benefits through enforcement settlements;

7. After administrative review, revoke, modify, or suspend any permit, or take other enforcement action deemed appropriate by the state, when the state agency determines that the permittee has violated the terms and conditions of the permit, failed to pay an assessed penalty, or used false or misleading information or fraud to obtain the permit;

8. Assess administrative penalties or seek, in court, civil penalties or criminal sanctions including fines and/or imprisonment; or

9. Resolve compliance issues informally, through mechanisms such as settlement agreements or warning letters, in lieu of a formal notice of violation, administrative order, or court order.

Complementing the enforcement tools identified above, state programs should have incentives (such as penalty mitigation and auditing/self-disclosure policies) to encourage operators to voluntarily disclose and correct violations.

10.2.5.2 Penalties

States should develop clear guidance for calculations of penalties that include factors such as the economic benefit resulting from noncompliance, willfulness, harm to the environment and the public, duration of the violation, the operator's compliance history, and the operator's good faith efforts to comply. Some of the benefits of having guidance for calculation of penalties include:

1. An opportunity to encourage voluntary disclosure of violations;

2. Providing consistency and transparency in the assessment of penalties; and

3. Providing for the development of readily defensible assessments.

Penalties should be such that an operator does not benefit financially from unlawful conduct, and should deter noncompliance by other operators. States should evaluate their enforcement options and policies to assure that the full range of actions available to them are applied effectively and consistently.

10.2.5.3 Right of Appeal

The right to appeal or seek administrative and/or judicial review of agency action should be available to any person having an interest which is or may be adversely affected, or who is aggrieved by any such action.

10.2.6 Staffing and Training

In addition to the general personnel and funding recommendations found in Section 4.3, state staffing levels should be sufficient to receive, record and respond to complaints of human health impacts and environmental damage resulting from air emissions. Staff should receive adequate initial and on-going training to stay current with federal and state air regulatory requirements, state airshed goals, and industry production practices and technology, especially new and developing emissions estimation methods, air pollution control and monitoring technology (e.g., gas detection technologies). This training should include an oil and gas industry overview to familiarize state agency staff with the equipment and processes typical to industry operations, the sources of air pollutants, and the pollution control equipment and monitoring equipment they will be regulating and inspecting. Training programs to accomplish these goals could include:

1. Training courses or resource materials available through EPA, multi-state air planning organizations, private sector, industry associations, consortiums and universities;

2. Field visits and tours to oil and gas facilities in the state;

3. Engagement with other state and EPA air regulatory programs;

4. Conference attendance; and

5. Coordination and frequent discussions with other state and federal agencies regulating oil and gas operations, including state oil and gas conservation commissions and divisions.

Additionally, agencies should have a mechanism to assess and implement strategies designed to recruit and retain key agency staff such as:

6. Maintaining competitive salary levels;

7. Creation of new technical positions (air specialists, oil and gas sector specialists, etc.) in the permitting and enforcement programs; and

8. Increasing staff responsibilities via promotion of staff to higher positions (project leaders, team leaders, etc.).

10.2.7 Data Management

In addition to the data management recommendations found in Section 4.2.7, states should ensure that appropriate data is shared between agencies as efficiently as possible. The air quality program should have electronic access to an inventory that includes the level of detail (locations of oil and gas facilities and a unique identifier for the regulated activity such as API well number) necessary to conduct an effective program. Some of the data gathered may be required to be reported electronically, e.g., EPA Central Data Exchange (CDX).

Emissions data and other information should be made available in user-friendly electronic formats after thorough and appropriate quality assurance.

10.2.8 Public Involvement

State agencies should provide for the electronic dissemination of educational and other appropriate information regarding air emissions from oil and gas activities to bridge the knowledge gap between experts and the public. This should occur as part of an ongoing process through which information is exchanged in an open forum as provided in Section 4.2.2.2. This is especially important in areas where development has not occurred historically. The public should also have the ability to ask questions and receive responses through the agency website. States should also use advisory groups of industry, government, and public representatives, or other similar mechanisms, to obtain input and feedback on the effectiveness of state programs as provided in Section 4.2.2.3.

In addition to the public participation provisions found in Section 4.2.2, states should take measures, such as web postings, FAQs, and distribution of fact sheets, to ensure that the industry, other state agencies and the public are aware of the delineation of responsibilities between the air quality program and the oil and gas program. Provisions should also be made for the availability of speakers to make presentations to interested groups.

10.2.10 Strategic Program and Resource Planning

State air programs for oil and gas will require adequate resources to fulfill state and federal mandates to ensure healthy air quality while providing adequate response time to permit applications and other needs from industry. As with other growing sectors, the oil and gas industry's potential for rapid growth in production basins can challenge the planning process for air programs, since large numbers of facilities can be deployed in production basins and cumulative emissions from new and existing facilities can potentially have significant impacts on air quality.

To address these challenges, and as set forth in these guidelines, states should have adequate resources to conduct necessary regulatory development, permitting, enforcement, monitoring, modeling, inventory development and public outreach activities. Additionally, states should have strategic planning capabilities to ensure that these resources remain adequate in light of dynamic growth in the oil and gas sector and rapid evolution in production technologies.

10.3 Air Program-Specific Elements

10.3.1 Delineation of Sources

States should consider developing an inventory of sources and activities not previously registered or permitted, for example grandfathered facilities and equipment, and non-permitted sources and activities, if information about emissions from those sources is critical for planning and analysis for agency priorities such as efficiently ensuring compliance with air quality standards. The inventory should be comprehensive; however, it should not capture inconsequential (de minimis) sources that do not impact air quality.

10.3.2 Source-Specific Requirements

A state's air quality program should identify emission source types that must be represented in applications for air quality permits or authorizations. Source types and activities may include stationary engines and turbines, well completions or recompletions, handling of associated gas from oil wells, venting and leaking gas from compressors, gas-powered pneumatic devices, dehydration units, gas processing plants, storage vessels and other hydrocarbon fluids handling, wellbore liquids unloading, produced water management facilities, sweetening units, flares, fugitive emissions from components at well sites, compressor stations and gas processing plants, and emissions from all other maintenance activities.

The state requirements for these emission source types should be as stringent as the Federal requirements, where such requirements exist, unless the state deems it necessary to establish additional, alternative, or more stringent requirements. When specific air issues demand more stringent requirements, states may consider adopting, as consistently as possible, provisions by other states or the EPA that have been successfully implemented to address similar air quality issues, to minimize the impact on state resources.

State air quality programs may want to address unplanned and episodic emissions due to such things as fugitive air emissions, abnormal process conditions or malfunctions, wellbore liquids unloading, well maintenance, third party equipment downtime, changes in third party product gathering pipeline capacity or business agreements, and equipment failure. The programs should require incident reporting and corrective actions where possible, to ascertain root causes and avoid incident recurrence. However, the state should also consider safety aspects when developing new requirements for unplanned emissions.

The state air quality regulator should coordinate with the state oil and gas conservation regulator to develop a process to quantify and minimize the flaring, and prohibit the venting of, associated gas from oil wells. Such a process should contemplate both the air quality concerns and financial loss to the state, royalty owners, and operators of wasted gas from drilling operations.

In addition to regulatory efforts, there are several voluntary programs that provide best practices and information sharing. Since 1993, industry partners in the EPA voluntary Natural Gas STAR Program have developed and employed a variety of innovative techniques for mitigating methane emissions in the oil and gas sector. In 2016, EPA updated this program to include the Methane Challenge. The oil and gas industry has developed programs as well, including The Environmental Partnership, ONE Future, and the Oil and Gas Climate Initiative. The Environmental Council of the States (ECOS) has also developed an online Methane and Air Toxics Reduction Information Exchange (E-MATRIX) that provides information on state best practices and cost-effective technologies that reduce emissions at points along oil and gas systems. The state should encourage awareness of the programs.

10.3.3 Air Quality Monitoring Networks

Air quality monitoring is an essential tool both to determine compliance with NAAQS and to assess the impact of air pollution sources on air quality. State programs should have an air quality monitoring network in place that meets these needs. In developing an air quality monitoring network, states should consider several parameters, including but not limited to: the number of monitors, the types of pollutants to be monitored, the location of monitors, specific monitoring instrumentation to be used, frequency of monitoring, and appropriate QA/QC procedures. In placing air quality monitors, states should consider factors such as emission source location, population density, topography and meteorology.

Many of the air quality monitoring requirements for states are set forth in implementing regulations for the various NAAQS. Additionally, federal permitting requirements for major stationary sources include certain source specific monitoring requirements. States should have appropriate mechanisms in place to ensure that this source specific monitoring is conducted in accordance with established standards and methods.

States may also consider whether to conduct ambient air quality monitoring that goes beyond the standards established under federal law. While states should have considerable latitude in determining whether and how to conduct such additional monitoring, appropriate procedures should be established to ensure that such monitoring, if undertaken, accurately assesses ambient air quality levels. As part of this additional monitoring, states should consider, where possible, establishing baseline air quality levels in order to assess the impact of oil and gas development changes.

Areas with significant oil and gas production activity may have few or no regulatory air quality monitors, because these areas may not meet typical criteria for siting of monitors, such as population density. States should consider whether to add monitors in these areas to assess emissions from existing, or anticipated increases in, oil and gas activity.

States should have appropriate monitoring equipment necessary to support emergency response activities as discussed in Section 10.3.5. Monitoring data should be made available consistent with the criteria of 10.2.7.

10.3.4 Reporting, Emission Inventories & Recordkeeping

States should develop and periodically update accurate and robust emission inventories as necessary to conduct good air quality planning and program assessment. States should establish emission-reporting requirements for air pollution sources that adequately support their efforts to develop high quality emission inventories. As states review and update their inventories they should work with industry and other stakeholders to identify the types of oil and gas sources which can produce significant emissions, and determine when updates to inventories are needed due to new information, changes to emission inventory compilation methodologies, or changes in production or operational practices. Consistent calculations methods, based on the gas and oil/condensate compositions for specific formations and basins, should be applied. If included in SIPs, the public review process is a requirement for those current and projected inventories used for both nonattainment area inventories as well as demonstrating attainment through air quality modeling.

States should consider using the EPA's oil and gas emissions tool(s) for computing nonpoint emissions sources. EPA provides the tool, instructions, and other guidance for computing these emissions as part of its National Emissions Inventory (NEI) program available on the Clearinghouse for Inventories & Emissions Factors (CHIEF). The tool allows for local inputs to be added by states to improve their emissions estimates. EPA also develops projection methods available on the CHIEF Emissions Modeling Clearinghouse for use by states. States that have developed emissions estimation techniques beyond those currently available from EPA are encouraged to share their methods with EPA and other states and tribes though channels such as the National Oil and Gas Emission Inventory Committee and the ECOS Shale Gas Caucus.

Every three years, states are required to submit to EPA all sources of emissions of criteria pollutants and their precursors (Air Emissions Reporting Requirements, 40 CFR Part 51, Subpart A). This includes both point and nonpoint sources for the oil and gas sector.

States should also develop well-founded emission projections to ensure that air quality standards will continue to be met in the future. Best available data and methods should be used for these projections. Projections which consider emissions under a range of alternative future conditions, such as the effect of changing industry practices, regulations, and crude oil and gas pricing, will yield better results than those that are based on single factors.

After administrative review, emission inventories and projections and reported emission data should be readily available to the public, including documentation of methodology, data sources, and assumptions made in producing the inventory.

10.3.5 Corrective Actions & Emergency Response

State air quality programs should establish clear criteria for the emergency reporting of significant, non-routine releases. These criteria should consider factors such as the mass and type of constituents released and the proximity of the release to sensitive receptors.

Agencies responsible for receiving emergency notifications of reportable releases to air should be identified and be responsible for the coordination, as appropriate, of any necessary response action with the operator, state and local emergency responders, environmental and/or public health agency and any other agency responsible for public protection.

States should ensure that community residents are notified when potentially hazardous air releases occur and should ensure that operators and emergency responders take necessary actions to minimize public exposure.

States should require operators to submit reports that contain information on the cause of the release, the type(s) and amount(s) of pollutants released and the corrective actions the company implemented, to aid in the prevention of incident recurrence.

10.3.6 Long-Term Planning, Prioritization & Evaluation

The state should develop procedures for regular evaluation and consideration of the appropriateness and adequacy of its air quality regulatory program.

In addition to the program planning and evaluation provisions found in Section 4.2.3, states should have a good understanding of oil and gas operations, including exploration and production; gathering, boosting, processing, and transmission; and accurate inventories and projections of air emissions. Because emissions characteristics, operational requirements, and operational approaches can vary widely by basin, it is critical for regulators to involve stakeholders (including oil and gas producers, environmental and citizen groups, and local governments) in the planning and evaluation processes. Periodic analyses should be completed to ensure that air quality remain protective of public health and the environment, in accordance with state and federal statutes and regulations, as the oil and gas industry evolves and grows.

There are and will be a number of federal regulations applicable to oil and gas operations that must be assessed for state adoption, incorporated by reference into state regulations, or left to EPA for implementation. In most states, these federal regulations become the basis of the state air regulatory program. Airsheds with oil and gas basins that have measured or modeled concentrations of air pollutants near or above the NAAQS, considerable existing or planned development, and/or geographic conditions (topography and meteorology) that can create stagnant air, may require specific, specialized analyses to assess the short-term and long-term status of compliance with the NAAQS. Collaboration with industry and other stakeholders is important to ensure that analyses are comprehensive, scientifically sound, and adequately address the relevant questions and issues. Technical collaborations may be more successful when accomplished within a structured process that clearly defines the roles and responsibilities of participants, procedures for disseminating analysis design, solicitation of comments, processes for responding to comments, and other opportunities for feedback.

Analyses of criteria pollutant trends, comprehensive emissions trends, and projections of pollutant concentrations, visibility, and deposition are important indicators for evaluation of state air programs. In the process of developing a strategic plan, states may develop specific airshed goals to reduce the impacts of pollutants. The development of these goals should be based upon careful analysis of state needs, priorities, available resources, and applicable state and federal regulations.

Additional program goals could include the following:

1. The development and implementation of an effective stakeholder outreach and education program;

2. The development of incentives for additional pollution control, such as streamlined permitting programs, permits by rule, and other permitting options that simplify the application and review process while promoting air pollution control;

3. The development and posting of guidelines, policies and report templates that result in efficiencies in the permitting and compliance assurance processes while encouraging good practice;

4. The creation of voluntary programs that recognize operators adopting additional air pollution measures; and

5. The development or improvement of an air monitoring network in areas with oil and gas activity, emissions inventories and calculation methods, and air modeling tools.

Regarding evaluation, performance metrics could include an evaluation of ambient pollutant concentrations, emissions trends, permit response time, appropriateness of permitting options, and clarity of conditions required for compliance. States should give consideration to the frequency of the evaluation of these types of metrics as well. Evaluation of emissions trends and modeling data may be more suited to an annual or periodic basis, whereas other metrics, such as stakeholder outreach and monitoring, may be done more frequently. The state agency should identify the set of metrics that is most applicable to its goal and then determine a schedule for program evaluation.

SECTION 11 | Reused and Recycled Fluids

11.1 Definitions

State regulatory programs should define fluids that may be reused and recycled. For the purposes of these guidelines, these are fluids that are generated during the drilling, completion (e.g. hydraulic fracturing flowback), and production stages of a well. The term "reused fluids" is commonly used to refer to fluids that require only minimal processing to remove suspended solids. The term "recycled fluids" is commonly used to refer to fluids that typically require more advanced treatment or processing to reduce the salinity of the recycled fluid. Reused and/or recycled fluids are used for well drilling (generally below the base of protected water), well workover, and completion.

11.2 Water Management Planning

Operators should be encouraged to develop Water Management Plans that consider reuse and recycling options. Water Management Plans should address all aspects of water management from acquisition through final disposition. Plans should be tailored to particular projects. State programs should recognize barriers that would limit an operator's ability to reuse or recycle fluids generated during drilling, completion, and production such as technological limitations, fiscal constraints, lease or surface use constraints, stage of development, fluid quality, and agency approval timeframes. States should encourage the use of fresh water alternatives for the drilling and completion of wells where available sources are feasible and where environmental risks can be adequately identified and controlled. See Section 9.3 for additional information concerning water and waste management related to hydraulic fracturing.

Where jurisdictional issues exist between multiple state agencies, river basin commissions, and other parties involved in the management of reused and/or recycled E&P fluids, coordination should be pursued as discussed in Section 4.4.

11.3 Waste Management

Fluids that are to be reused or recycled should be managed and regulated as a waste up to the point the fluids are used in the drilling, workover, or completion of a well. State programs should consider having a regulatory process to designate fluids as a non-waste when they are treated to a level satisfactory to the State and the fluid is reused or recycled. Regulatory responsibility for the reused or recycled fluids should lie with the operator of the facility that is storing, transporting, or processing the fluids. See Sections 5.1 – 5.3 for information concerning technical criteria of waste.

11.4 Transportation

The fluids to be reused or recycled are generally transported through pipelines or by truck.

11.4.1 Pipelines

11.4.1.1 Scope and Definition

a. The term, “pipeline” is used in this section to describe pipelines used to transport produced water and/or reused/recycled/treated water to or from various oil and gas facilities after separation from the oil and gas product. Such facilities may include, but are not limited to, the following:

   i. Water loading point
   ii. Point of discharge to a pit
   iii. Injection/disposal wellhead
   iv. Reuse/recycling/treatment facility
   v. Oil and natural gas well sites
   vi. CWA/NPDES/state permitted point of discharge to surface water

b. Where appropriate, states may consider adopting a definition for such pipelines that is consistent with the risk profile of the fluids being transported. States may consider several factors when determining a fluid’s risk profile, such as constituents of the fluid, potential release quantity, and potential impact to the environment.

11.4.1.2 Siting, Permitting, and Financial Assurance

a. States may address pipelines in facility and infrastructure permitting.

b. States should require operators to maintain information on the location, purpose, capacity, age, and material type of pipelines.

c. Pipeline siting should be designed to minimize or avoid impact on natural habitats and wildlife designated sensitive or protected.

d. Where appropriate, states should provide requirements for buried and aboveground pipelines, including requirements for repurposing.

e. States should ensure that their financial assurance requirements are sufficient to cover pipelines. For pipelines that would not be covered by existing facility and infrastructure permitting and financial assurance, states should add such pipelines to these existing programs, or create a separate program for those pipelines.

11.4.1.3 Construction and Operational Requirements

a. States should provide requirements for aboveground/overland/temporary lines and buried/permanent lines, including permanent and non-permanent buried lines.

b. Pipelines should be constructed, operated, and maintained in compliance with the manufacturer's specifications, the state's mechanical code, and other applicable industry standards.

c. Pipelines should be subjected to pre-operational hydrostatic integrity testing. Additional hydrostatic integrity testing should be required if the pipeline is moved, altered, repaired, or repurposed.

d. States should require integrity testing for pipelines after an appropriate duration of service, based on criteria such as the type and material of the pipeline, and the fluid being transported. The method of integrity testing should be appropriate for the type of pipeline. Testing methods include, but not limited to, the following:

    i. Hydrostatic
    ii. Data metering
    iii. Visual inspection
    iv. Non-destructive testing

e. States should require operators to maintain documentation of integrity testing and provide documentation upon request.

f. States should consider requiring depressurization and duration limits for pipelines not in continuous operation.

g. Pipelines left in place should be purged, physically disconnected, and capped when abandoned. Buried lines left in place should be cut off below ground.

h. States should ensure applicable OneCall legislation and damage prevention programs (to prevent damage to pipelines from excavators) are followed.

11.4.1.4 Spill Response and Remediation

a. There should be a means of accounting for and reporting leaks in accordance with state and EPA requirements.

b. Contingency planning and spill risk management should be addressed in accordance with the criteria of Section 4.2.1.

c. Site remediation should be addressed in accordance with state and EPA requirements.

11.4.2 Trucks

Truck transportation of fluids to commercial or centralized facilities should be addressed in accordance with the waste tracking and reporting provisions of Section 5.10.2.3. States should encourage operators to utilize smart truck routing to minimize traffic through residential areas, damage to roadways, and to avoid problems associated with spill exposure and complaints.

11.5 Treatment and Storage

Rules for the treatment and storage of fluids to be reused and recycled should be based on the potential risk presented by the treatment or storage of the fluid. Risk factors to consider include location and duration of fluid treatment or storage, chemical content and characteristics of the fluid and waste resulting from the treatment process, the volume of the fluid stored or treated, type of storage structure to be used (i.e. pits, tanks, or modular aboveground storage structures).

Permit processes for the storage of reused or recycled fluids should be streamlined and minimized for activities deemed to be of low risk. For example, the temporary storage and reuse of fluids on an Operator’s lease might be approved during the well permitting process, or by other authorization, while facilities used for long-term storage and treatment of fluids may require separate prior authorization by the State.

Reporting requirements should include records of amounts of waste processed and, where appropriate, laboratory results for treated waste. See section 5.10.2.3 for more information on waste tracking requirements. Where appropriate, States should require groundwater monitoring consistent with the provisions of Section 9.2.1.

State regulatory programs should differentiate between centralized and commercial wastewater treatment facilities. See Section 5.10 for additional information regarding the permitting, construction, operation and closure of these facilities.

State regulatory programs should regulate the waste generated during the treatment of fluids in a manner as described in the technical criteria in Section 5. Those criteria address waste characterization, waste management hierarchy, pits, land application, tanks, and centralized and commercial facilities.

State regulatory programs should include a methodology for the determination of whether or not Naturally Occurring Radioactive Material (NORM) is present to the extent that it is regulated. See Section 7 for additional information on the identification, use, possession, transport, storage, transfer, documentation, and disposal of materials containing NORM.

States should evaluate air emissions at facilities used for the storage and treatment facilities of fluids to be reused or recycled and determine whether a permit or exemption is required. See Section 10.2.3 for additional information regarding air quality permits, authorizations and exemptions.

APPENDIX A | References

REFERENCES

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APPENDIX B | Glossary of Terms

The following is a glossary of selected terms used in the Interstate Oil and Gas Compact Commission Environmental Guidelines for State Oil and Gas Regulatory Programs. The glossary is included only as an aid for the convenience of the reader. It is not intended as an exhaustive compilation of the terms used in the Report, nor are the definitions set forth intended to be preclusive of other potential meanings. Terms expressly defined in the text of the Report are not included in this glossary.

A

Acid: A chemical compound, one element of which is hydrogen, that dissociates in solution to produce free-hydrogen ions. For example, hydrochloric acid, HCl, dissociates in water to produce hydrogen ions - H^+, and chloride ions, Cl^-.

Ambient Air Quality – The concentration of pollutants present in the portion of the atmosphere, external to buildings, to which the general public has access, measured in the form of mass of the pollutant per volume of air or as a certain number of parts of the pollutant per million (ppm) or per billion (ppb). *See generally* 40 C.F.R. § 50.1(e).

Aquifer: A geological formation, group of formations, or part of a formation that is capable of yielding water to a well or spring.

B

Barrel: A measure of volume for petroleum products. One barrel is equivalent to 42 U.S. gallons.

Basic Sediment and Water (BS&W): The water and other extraneous material present in crude oil.

Biodegradation: The process of breaking down matter into innocuous products by the action of living things, such as microorganisms.

Blowdown: The material discarded as a result of depressurizing a vessel or well.

Brackish Water: Water that contains relatively low concentrations of soluble solids. Brackish water has more total dissolved solids than fresh water, but considerably less than sea water.

Brine: Water that has a large quantity of salt, especially sodium chloride, dissolved in it; salt water and certain produced water are considered brines.

C

Characteristic Waste: Waste that is considered hazardous under RCRA because it exhibits any of four different properties: ignitability, corrosivity, reactivity, and toxicity.

Clean Air Act (CAA): The federal act that regulates air emissions from area, stationary, and mobile sources codified at 42 U.S.C. Ch. § 7401 *et seq*.

Clean Water Act (CWA): The act that sets the basic structure for regulating discharges of pollutants to surface waters of the United States. CWA imposes contaminant limitations or guidelines for all discharges of wastewater into the nation's waterways.

Climatology: The science that deals with climates (the prevailing influence or environmental conditions characterizing a group or period) and their phenomena.

Completion Fluid: A special fluid used when a well is being completed. It is selected, not only for its ability to control formation pressure, but also for its properties that minimize formation damage.

Completion Operations: Work performed in an oil or gas well after the well has been drilled to total depth. This work includes, but is not limited to, setting the casing, perforating, artificial stimulation, production testing, and equipping the well for production, all prior to the commencement of the actual production of oil or gas in paying quantities, or in the case of an injection or service well, prior to when the well is plugged and abandoned.

Corrosivity: The characteristic which identifies wastes that are acidic or basic (alkaline) and can readily corrode or dissolve flesh, metal, or other materials. The hazardous characteristic of corrosivity, for purposes of RCRA, is defined in 40 CFR 261.22, and generally includes aqueous solutions with a pH less than or equal to 2.0, or greater than or equal to 12.5, and/or liquids which corrode SAE 1020 steel at a rate greater than or equal to 6.35 mm per year.

Crude Oil: Unrefined liquid petroleum. It ranges in gravity from 9 to 55 API and in color from yellow to black, and it may have a paraffin, asphalt, or mixed base. If a crude oil, or crude, contains a sizable amount of sulfur or sulfur compounds, it is called a sour crude; if it has little or no sulfur, it is called a sweet crude. In addition, crude oils may be referred to as heavy or light according to API gravity, the lighter oils having the higher gravities.

D

Delegated Authority – A state's assumption, after US EPA approval, of partial or complete responsibility for administering EPA's CAA programs.

De-listing: A site-specific petition process whereby a handler can demonstrate to EPA that a particular waste stream generated at its facility that meets a listing description does not pose sufficient hazard to warrant RCRA regulation. Owners and operators can also use the de-listing process for wastes that are hazardous under the mixture and derived-from rules that pose minimal hazard to human health and the environment.

Derived-from Rule:A rule that regulates residues from the treatment of listed hazardous wastes. This rule is found at 40 CFR 261.3.

Disking: The process of using a tractor-pulled set of disks to mix surface soil with waste for the purpose of treating and/or disposing of E&P wastes.

Disposal Well: A Class II well permitted under the SDWA which is employed for the injection of produced water and certain other E&P wastes into an underground formation.

Drill Cutting: The formation rock fragments that are created by the drill bit during the drilling process.

Drilling Fluid: The circulating fluid used in the rotary drilling of wells to clean and condition the hole and to counterbalance formation pressure. Drilling fluids are circulated down the drill pipe and back up the hole between the drill pipe and the walls of the hole usually to a surface tank. Drilling fluids are used to lubricate the drill bit, to lift cuttings, to seal off porous zones, and to prevent blowouts. A water-based drilling fluid is the conventional drilling mud in which water is the continuous phase and the suspended medium for solids, whether or not oil is present. An oil-based drilling fluid has diesel, crude, or some other oil as its continuous phase, with water as the dispersed phase. Synthetic drilling fluid has a synthetic material such as esters or olefins as the continuous phase and water as the dispersed phase. In some circumstances air or another gas is used as a drilling medium.

E

Electrical Conductivity (EC): A numerical expression of the ability of a material to carry a current; the reciprocal of resistivity; normally expressed in milliohm/meter. It is frequently used in soil analysis to evaluate a soil's ability to sustain plant growth.

Emulsion: A mixture in which a liquid, termed the dispersed phase, is uniformly distributed (usually as minute globules) in another liquid, called the continuous phase or dispersion medium. In an oil-water emulsion, the oil is the dispersed phase and the water the dispersion medium; in a water-oil emulsion, the reverse holds. For example emulsions occur during production processes where crude oil is prepared for pipeline transportation.

Exploration: The search for reservoirs of oil and gas, including aerial and geophysical surveys, geological studies, core testing, and the drilling of exploratory wells, also known as wildcats.

Exchangeable Sodium Percentage (ESP): The extent to which the absorption complex of a soil is occupied by sodium.

$$ESP = \frac{\text{exchangeable sodium}}{\text{cation exchange capacity}} \times 100$$

Where the units for both the numerator and denominator are in milliequivalents per 100 grams of soil.

F

FAQs – “Frequently Asked Questions” reference document created, updated, and made publically available by a state that clarifies issues involving the delineation of responsibilities between a state’s air quality program and oil and gas program.

Field: A geographic area in which a number of oil or gas wells produce from a continuous reservoir. A field may refer to surface area only or to underground productive formations as well. In a single field, there may be several separate reservoirs at varying depths.

Formation: A bed or deposit composed throughout substantially the same kinds of rock; a lithologic unit. Each different formation is given a name, frequently as a result of the study of the formation outcrop at the surface and sometimes based on fossils found in the formation, and is sometimes based on electric or other bore-hole log characteristics.

Formation Water: The original water in place in a formation at the time production commences.

Fracturing: A method of stimulating production by increasing the permeability of the producing formation. Under hydraulic pressure, a fluid is pumped down the well and out into the formation. The fluid enters the formation and parts or fractures it.

Fracturing Fluids: The fluids used to hydraulically fracture a rock formation. In some cases, a proppant is deposited in the fractures by the fracturing fluid, which is subsequently pumped out and recovered.

G

Gas Processing Plant: A plant for the processing of natural gas, by other than solely mechanical means, for the extraction of natural gas liquids, and/or the fractionation of the liquids into natural gas liquid produces such as ethane, butane, propane, and natural gasoline.

Gas Treating Plant: A plant for the purification of natural gas (e.g., the removal of water and/or acid gases such as hydrogen sulfide) and recovery of condensate.

Generator:Any person whose act first creates or produces a waste.

Groundwater: Water below the land surface where there is sufficient water present to completely saturate the soil or rock.

Groundwater Monitoring: Sampling and analysis of groundwater for the purpose of detecting the release on contaminants.

H

Hazardous Waste: A waste with properties that make it dangerous or capable of having a harmful effect on human health and the environment. Under the RCRA program, hazardous wastes are specifically defined as wastes that meet a particular listing description or that exhibit a characteristic of hazardous waste.

Hydrocarbon: Organic compound of hydrogen and carbon, whose densities, boiling points, and freezing points increase as their molecular weights increase. Although composed of only two elements, hydrocarbons exist in a variety of compounds because of the strong affinity of the carbon atom for other atoms and for itself. The smallest molecules of hydrocarbons are gaseous; the largest are solid.

I

Ignitability (RCRA): The characteristic which identifies wastes that can readily catch fire and sustain combustion. The hazardous characteristic of ignitability for purposes of RCRA is defined in 40 CFR 261.21 and is generally a liquid with a flash point less than 140 F., a non-liquid that causes fire under a friction condition, an ignitable compressed gas, or is an oxidizer.

L

Land Disposal: For purposes of RCRA Subtitle C regulation, placement in or on the land, except in a corrective action unit, and includes, but is not limited to, placement in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation. underground mine or cave, or placement in a concrete vault or bunker intended for disposal purposes.

Landfill: For purposes of RCRA Subtitle C, a disposal unit where non-liquid hazardous waste is placed in or on the land.

Lease: A legal document executed between a landowner (or a lessor) and a company or individual as lessee, that grants the right to exploit the premises for minerals or other products. The lease is sometimes referred to as the area where production wells, stock tanks, separators, and production equipment are located.

Legally and Practicably Enforceable – All terms or conditions included in a permit issued under a federally approved program – including delegated authority – authorizing EPA to enforce such terms or conditions. Federally enforceable programs under the CAA include, but are not limited to, the New Source Review program, the New Source Performance Standards program under Section 111 of the CAA, the Title IV acid rain program, the National Emission Standards for Hazardous Air Pollutants program under Section 112 of the CAA, the Title V program, and state permit programs approved by EPA in the state's SIP.

Liner: Continuous layer of natural or synthetic materials, beneath and on the sides of a surface impoundment, landfill, or landfill cell, which restricts the downward or lateral escape of waste, waste constituents, or leachate.

Listed wastes: Wastes that are considered hazardous under RCRA because they meet specific listing descriptions.

Loading Criteria: A numeric level, normally expressed in pounds per acre, below which a specific chemical compound may be applied to the soil.

Location: Place at which a well is to be or has been drilled.

M

Mixture Rule: A rule that is intended to ensure the regulation of mixture of listed wastes with non-hazardous solid wastes.

Molecular Sieve: Absorbents that are used to remove small amounts of H_2S and/or water from natural gas, capable of being regenerated.

Municipal Solid Waste: Durable goods (e.g. appliances, tires, batteries), non-durable goods (e.g. newspapers, books, magazines), containers and packaging, food wastes, yard trimmings, and miscellaneous organic wastes from residential, commercial and industrial non-process sources.

N

National Ambient Air Quality Standards (NAAQS) – Nationwide air quality levels, promulgated pursuant to section 109 of the CAA ,42 U.S.C. § 7409, for six criteria pollutants – sulfur dioxide, particulate matter, nitrogen oxide, carbon monoxide, ozone, and lead – of which a state is responsible for achieving, maintaining, and enforcing pursuant to section 110 of the CAA, 42 U.S.C. § 7410, through its approved SIP for each given pollutant.

National Emissions Standards for Hazardous Air Pollutants – Nationally applicable standards under section 112(b) the CAA, 42 U.S.C. § 7412(b), for emissions of hazardous air pollutants listed under section 112(d) the CAA, 42 U.S.C. § 7412(d), that apply to major and area stationary sources as defined under section 112 of the CAA, 42 U.S.C. § 7412.

Natural Gas: Naturally occurring mixture of hydrocarbon and non-hydrocarbon gases found in geologic formations beneath the earth's surface. The principal hydrocarbon constituent is methane.

New Source Performance Standards – Nationwide technology-based emissions standards for new or modified stationary sources in specified industrial source categories promulgated pursuant to section 111 the CAA, 42 U.S.C. § 7411. The standards reflect the degree of emission limitation achievable through the application of the best system of emission reduction, taking into account the cost of achieving such reduction and any health and environmental impact and energy requirements, that EPA determines is adequately demonstrated.

O

Operator: The person or company, either proprietor, contractor, or lessee, actually operating a well, lease, or disposal facility.

P

Permeability: The ability of a formation to transmit fluids.

pH: A measure of acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity.

Plug and Abandon (P&A or Plugging): The placement into a well of a plug or plugs designed to restrict the vertical movement of fluids after abandonment.

Process Upsets – unintended mode of operation of a unit which could result in impaired functionality.

Produced Sand: The formation solids which flow into the wellbore with the produced formation fluids. In general, the lower the formation competency, the greater the produced sand volumes.

Produced Water: The fluid brought up from the hydrocarbon-bearing strata during the extraction of oil or gas. It can include formation water, injection water, and any chemicals added downhole or during the oil/water separation process.

Production: The phase of the petroleum industry that deals with bringing the well-fluids to the surface and separating them, and with storing, gauging, and otherwise preparing the product for sale.

Q

QA/QC – "Quality Assurance/Quality Control" are criteria and procedures that must satisfied to ensure the quality of data and the calibration, repair, and evaluation of air quality monitoring instruments.

R

Reactivity: The characteristic identifying wastes that readily explode or undergo violent reactions. The hazardous characteristic of reactivity for purposes of RCRA is defined in 40 CFR 261.23 and generally includes wastes with highly exothermic reactions or wastes which create toxic gases when mixed with water.

Reclaimed: For purposes of defining a material as a solid waste under RCRA Subtitle C, a material is reclaimed if it is processed to recover a usable product, or regenerated by processing it in a way that restores it to usable condition.

Reclamation: The process of returning a site or contaminated soil to an appropriate state of environmental acceptability.

Recycled: For purposes of defining a material as a solid waste under RCRA Subtitle C, a material is recycled if it is used or reused, or reclaimed.

Recycled Fluids: Commonly used to refer to fluids that typically require more advanced treatment or processing to reduce the salinity of the fluid prior to reuse in well drilling, workover, and completion.

Reused Fluids: Commonly used to refer to fluids that require only minimal processing to remove suspended solids prior to reuse in well drilling, workover, and completion.

Recycling: The separation and collection of wastes, their subsequent transformation or remanufacture into usable or marketable products or materials, and the purchase of products made from recyclable materials.

Reservoir: A subsurface, porous, permeable rock body in which oil or gas or both are stored. Most reservoir rocks are limestones, dolomites, sandstones, or a combination of these. The three basic types of hydrocarbon reservoirs are oil, gas, and condensate. An oil reservoir generally contains three fluids; gas, oil, and water-with-oil, the dominant product. In the typical oil reservoir, these fluids occur in different phases because of the variance in their gravities. Gas, the lightest, occupies the upper part of the reservoir rocks; water, the lower part; and oil, the intermediate section. In addition to occurring as a cap or in solution, gas may accumulate independently of the oil; if so, the reservoir is called a gas reservoir. Associated with the gas, in most instances, are salt water and some oil. In a condensate reservoir, the hydrocarbons may exist as a gas, but when brought to the surface, some of the heavier constituents condense to a liquid or condensate. At the surface, the hydrocarbons from a condensate reservoir consist of gas and a high-gravity crude (i.e., the condensate). Condensate wells are sometimes called gas-condensate reservoirs.

S

Safe Drinking Water Act (SDWA): The act designed to protect the nation’s drinking water supply by establishing national drinking water standards (maximum contaminant levels, (MCL’s), or specific treatment techniques), and by regulating UIC wells.

Salinity: The quantitative level of salt in an aqueous medium.

Salt Section: A formation, or part of a formation, which is predominately made up of salt; typically sodium chloride.

Sodium Absorption Ration (SAR): A ratio of the concentration of sodium to the square root of the sum of the concentrations of calcium and magnesium.

$$SAR = \frac{Na+}{-[Ca+ + Mg^{2}+]}$$

Where the cation concentrations are in millimoles per liter. It is a measurement frequently used in soil analysis to evaluate a soil's ability to sustain plant growth.

Solid Waste: Any garbage; refuse; sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility; and other discarded material, including solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. For the purposes of hazardous waste regulation, a solid waste is a material that is discarded by being either abandoned, inherently waste-like, a certain waste military munition, or recycled.

Solids Separation Equipment: Equipment used in drilling and workover/completion operations to remove drill cutting or formation solids from the drilling or workover/completion fluid. May include liquid/solids separation devices such as shale shakers, hydrocyclones, centrifuges, and filtration units.

SPCC: Spill prevention Control and Countermeasures. Regulations establishing spill prevention procedures and equipment requirements for non-transportation related facilities with certain above-ground or underground storage capacities (e.g., crude oil tanks) that could reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines.

Spent Materials: Materials that have been used and can no longer serve the purpose for which they were produced without processing.

State Implementation Plan (SIP) – The body of air quality rules including, but not limited to, enforceable source-specific emissions limitations, monitoring plans, and permit programs established by each state which are designed to either attain or maintain the NAAQS and to implement other requirements established by the Clean Air. Each state's SIP must include, at a minimum, the elements prescribed under CAA section 110(a)(2), 42 U.S.C. § 7410(a)(2), and must be approved by EPA before it becomes effective.

Subtitle C: That portion of the Resource Conservation and Recovery Act (RCRA) which defines and legislates the management of hazardous wastes.

Sweetening – The removal of hydrogen sulfide and other organosulfur compounds from "sour" natural gas. Natural gas is considered "sour" if it contains hydrogen sulfide in amounts greater than 5.7 milligrams per normal cubic meters.

T

Tank Bottoms: Produced sand, formation solids, and/or emulsions that settle-out in production operation process vessels.

Title V Permit Program – A federally mandated operating permit program under the CAA that requires implementation by the states. *See generally* 42 U.S.C. §§ 7661-7661f; 40 C.F.R. Parts 70 and 71. The Title V permit program applies to: all "major sources" as that term is defined in CAA section 501(2), 42 U.S.C. § 7661(2); sources subject to a standard or regulation under the NSPS program, 42 U.S.C. § 7411, or the NESHAP program, 42 U.S.C. § 7412; "affected" sources under the Acid Rain Program; sources required to have a PSD or NSR permit; and any other sources as designated by EPA. *See* 40 C.F.R. § 70.3 (applicability of Title V program). Title V permits consolidate all of these applicable CAA requirements into one legally enforceable document.

Topography: The physical features of a district or region, such as are represented on maps, taken collectively; especially the relief and contour of the land.

Toxicity: The characteristic which identifies wastes that are likely to leak dangerous concentrations of toxic chemicals into groundwater. The hazardous characteristic of toxicity for purposes of RCRA is defined in 40 CFR 261.24 and includes eight metal and thirty-one organic compounds. The toxicity characteristic is determined in accordance with a prescribed test procedure (the toxicity characteristic leaching procedure -TCLP).

Toxicity Characteristic Leaching Procedure (TCLP):A lab procedure designed to predict whether a particular waste is likely to leach chemicals into groundwater at dangerous levels.

Transporter: A person engaged in the off-site transportation of waste.

Treatment: Any method, technique, or process designed to physically, chemically, or biologically change the nature of a hazardous waste.

Treatment, Storage and Disposal Facilities: Facilities engaged in the treatment, storage, or disposal of hazardous waste. These facilities are the last link in the cradle-to-grave hazardous waste management system.

U

Underground Source of Drinking Water (USDW): An aquifer which supplies drinking water for human consumption or for any public water system, or contains fewer than 10,000 mg per liter total dissolved solids, and does not contain minerals or hydrocarbons that are commercially producible, and is situated at a depth or location which makes the recovery of water for drinking water purposes economically or technologically practical. While EPA defines an USDW as containing less than 10,000 mg per liter TDS, certain states, such as California and Texas, have adopted a 3,000 mg per liter TDS definition for the Class II UIC injection well programs.

Universal Wastes: Commonly referred to as recycled wastes with special management provisions intended to facilitate recycling. There are three categories of universal wastes; hazardous waste batteries; hazardous waste pesticides that have been recalled or collected in waste pesticide collection programs; and hazardous waste thermostats.

Used Oil: Any oil that has been refined from crude or synthetic oil that has been used, and as a result of such use, is contaminated by physical or chemical impurities.

V

Vadose Zone: A subsurface soil zone that contains suspended water. The vadose zone is above the zone of continuous water saturation.

W

Waste Minimization: The reduction, to the extent feasible, in the amount of waste generated prior to any treatment, storage, or disposal of the waste. Because waste minimization efforts eliminate waste before it is generated, disposal costs may be reduced, and the impact on the environment may be lessened.

Waterflood: A method used to enhance oil recovery in which water is injected into a reservoir to remove additional quantities of oil that have been left behind after the primary recovery. Usually, a waterflood involves the injection of water into strategically placed wells so that it sweeps through the reservoir and moves remaining oil to the producing wells.

Workover: One or more of a variety of remedial operations performed on a producing well to try to increase production. Examples of workover operations are deepening, plugging back, pulling and resetting the liner, squeeze-cementing, perforating additional horizons, etc.

Workover Fluid: A special fluid used to keep a well under control when it is being worked over. A workover fluid is composed carefully so it will not cause formation damage. Also used to stimulate a well to enhance productive capacity such as a frac fluid, acid, etc.

Workover Wastes: Wastes resulting from well workover operations. The wastes usually include workover fluids, similar to drilling fluids and could include various small volume wastes such as tubing scale, wax/paraffin, and cleaning or painting wastes.

Exhibit 12

COMMISSION SHIFT

Meaningful Public Engagement

Goals of a Public Engagement Session include, but are not limited to:

1. **Educate** the public about the commission's proposed amendments.
2. **Explain** how the rules are changing, why, what benefits are expected and for whom.
3. **Clarify points of uncertainty for the public.** Define jargon. Ensure language used in the amendments are commonly understood and standardized between members of the public, the commission, and the companies. Ensure that the intent and meaning of standardized language is consistent and maintained.
4. **Learn the public's opinion** about specific amendments, especially those proposed by other stakeholder groups including companies and industry associations.
5. **Learn where there are gaps** in the rule that could provide better health and environmental protection and public safety from the public's perspective.
6. **Identify gaps in monitoring and enforcement.** Ensure the commission has a clear understanding of what the rule does, how enforcement will be implemented across various district offices, and the effects that will have on members of the public.
7. **Identify potential unequal outcomes.** Understand areas where the proposed amendments may create situations that are unfair for some members of the public due to a condition that is outside their control (i.e. language accessibility, inability to pay for a lawyer or expert witnesses, working hours, threats of violence or job loss due to lack of confidentiality, lack of access to education, lack of access to high speed internet). Identify possible solutions and get feedback on proposed solutions from members of the public who are affected or are likely to be affected.
8. **Incorporate feedback** learned from members of the public into the proposed amendments.

Steps the commission can take to create the opportunity for meaningful public engagement:

1. **Rebuild trust with the public.** Apologize for past and present failures. Plan and explain how you will prevent failures of monitoring and enforcement again in the future.
    a. This is NOT: a public relations campaign that says the commission is doing a great job without acknowledging past harms.
    b. Be open and transparent. Show respect and reciprocity. Make an effort to be inclusive. Consider a variety of methods to ensure the sessions are accessible, and consider different needs and circumstances of different members of the public.
    c. Commit to allowing for public input to substantively change the proposed amendments.
2. **Select appropriate locations.** Plan in-person public engagement sessions in locations that are accessible to people who have lived near waste pits or who have protested waste pit permit applications.
3. **Ensure the sessions are convenient for members of the public to attend.** Select times when people who work a typical 8 am - 6 pm job can attend.
    a. Provide water and refreshments so that people can have energy to participate and pay attention.
    b. Choose a location that is accessible by public transportation.
    c. Plan to hold one or more virtual events to allow for different segments of the population to attend.
4. **Publicize with ample time.** Give notice of public engagement sessions at least two weeks prior to the meeting and make sure an annotated copy of the draft rules has been provided for review by the time notice is issued.
5. **Publicize the notice using modern communication methods,** in places where people are likely to see the notice, including by email and on social media.
    a. Begin collecting an email list of people who are interested in receiving updates about these public engagement sessions at least one month prior to giving notice. Send the notice to this email list when the notice is ready.
    b. Share concise fact sheets about the proposed amendments using plain language and defining jargon when the meeting notices are published.
6. **Provide notices in English and Spanish, at a minimum**, and offer translation of the notice in other languages that are known to be spoken in the area.

7. **Request that industry not participate in these meetings**. The public has been excluded from all previous rulemaking meetings related to Statewide Rule 8 and Chapter 4; these meetings should be an opportunity to level the playing field / even the score so industry should be prohibited from attending.
8. **Plan to respond to questions during the public workshops.** Don't just create a forum for the public to provide comments; give a presentation about the rulemaking to inform the public and then allow for questions and answers. Ensure the relevant RRC staff with expertise are present to be able to answer questions.
    a. Consider providing a list of questions for the public to answer related to key changes that you want feedback on.
9. **Allow the public to file written comments after the workshops are over** and make staffers available to the public during that time to answer follow-up questions.
10. **Host separate workshops for changes to Statewide Rule 8 and Chapter 4** so that there is ample time to discuss the changes to each.

Exhibit 13

Paul Dubois
FW: Proposed Rule Changes
August 22, 2022 at 9:44 AM EDT
To: Jay Allison

Jay,
Here is the email I distributed to several associations a week or so ago. This is an informal review of the proposal… I will forward you a meeting invite for next Monday afternoon. We are looking for feedback at this time… in writing would be good but not necessary. RRC staff will take this feedback and consult with leadership on next steps.

The meeting on Monday will be in Austin, but you will be able to join virtually also.

Regards,

Paul Dubois, P.E.
Assistant Director, Technical Permitting | Oil & Gas Division
Railroad Commission of Texas
512-463-6778
[Take our Customer Service Survey]

From: Paul Dubois
Sent: Thursday, August 11, 2022 12:16 PM
Subject: Proposed Rule Changes

Good Afternoon,

Railroad Commission staff is considering revisions to 16 Texas Administrative Code §3.8 (Rule 8) and 16 Texas Administrative Code Chapter 4. The rulemaking would incorporate elements required by recent legislation as well as update the Commission's environmental rules. The updates would include incorporating recommendations from an industry task force, which mostly revive proposed amendments from a contemplated but not completed rulemaking in 2002; moving environmental regulations from Rule 8 into Chapter 4, where the Commission's other environmental regulations are located; and incorporating requirements from the online Surface Waste Management Manual (SWMM) guidance used for environmental permitting.

Your organization is being invited to participate in an informal review of the following draft documents, and to provide feedback before the Commission decides to proceed with rulemaking. The following documents are included for your consideration:

- An annotated version of Rule 8, which details where the provisions of Rule 8 appear in proposed new Subchapter A in Chapter 4.
- Proposed language for new Subchapter A in Chapter 4. Subchapter A includes the provisions from Rule 8, the recommended changes from the industry task force as well as recommendations from the 2002 rule draft, and provisions from the SWMM.
- Proposed amendments to Subchapter B in Chapter 4 to incorporate legislative requirements from House Bill 2201 and House Bill 3516 from the 87th Legislature as well as SB 1541 from the 85th Legislature.

Your participation is requested as follows:

- A virtual workshop will be held on August 15, 2022, at 1:30 p.m., at which time staff will provide an overview of the attached documents--how and why they are structured, concepts underlying the proposal, etc.--and will take related structural questions on the proposal. Please share the meeting invite to those who will be reviewing the documents for your organization.
- You may submit written comments on this proposal to me by August 26, 2022.
- We will hold a second workshop on Monday, August 29, 2022, from 1:30 to 3:30 to discuss the proposal and your comments.

Please direct any questions to me. Thank you.

Regards,

Paul Dubois, P.E.
Assistant Director, Technical Permitting | Oil & Gas Division
Railroad Commission of Texas
512-463-6778
Take our Customer Service Survey

Exhibit 14

From:	Michael Lozano PBPA <Michael@pbpa.info>
Sent:	Wednesday, September 20, 2023 1:15 PM
To:	Paul Dubois
Cc:	Wei Wang; Ben Shepperd PBPA
Subject:	Feedback from operators re: Chapter 4
Attachments:	Chapter 4 Feedback PBPA 92023.docx

Attached is the feedback I have received. Appreciate your consideration and look forward to visiting.

Best,

MDL

Michael D. Lozano
Permian Basin Petroleum Association
1122 Colorado Street, Suite 2320, Austin, Texas 78701
O: 512.297.2693| C: 956.778.1815
Michael@pbpa.info|www.pbpa.info

General Considerations

Below are a collection of comments that we have received and are providing to continue to inform Commissioners and Commission staff about improvements to the proposed reform of “Rule 8” into a Chapter 4 addition by the Railroad Commission of Texas.

First, we would like to thank the Commission and staff for your work in considering prior and ongoing feedback as we digest this big shift from current practice and analyze the goals and impacts of this effort.

Make no mistake, this is a significant shift that stands to increase the standards of construction, use, closure, and monitoring of these facilities and given the vast change being proposed, it takes time and consideration by a wide range of operational divisions within our member’s organizations to provide the prudent feedback that has been requested.

In addition to that, the changes for commercial facilities that engage in transport, treatment, and disposal are also significant changes that warrant great consideration.

I have asked our members to set aside a significant amount of time from their daily duties to work internally to provide this feedback and know that the Commission recognizes the amount of analysis that a proposal like this demands from operators.

With that said our members appreciate the Commission noting that the goals are to continue to improve on environmental standards without unduly burdening the oil and gas industry in the state of Texas and that these increasing standards do not intend to prohibit the protective burial of waste in authorized facilities nor establish unattainable standards that incent the use of specific vendors without environmental benefits.

Definitions:

Our members have noted that the existence of Rule 8 far preceded the growth in water treatment and recycling as well as the creation of various partnerships and affiliations that allowed the expansive innovation of water management. For those reasons the definition of commercial facility must ensure that it does not hinder growth in the water management sector, nor penalize the myriad of organizational structures that operators have engaged in to manage their produced water.

The definition of a commercial facility ought to consider a situation where a third party manages a facility for the operator but the operator holds the permit and the liability for the facility. Commercial facility could be defined best to ensure that the definition of a third party does not include an entity that owns or operates, or is affiliated with the owner or operator of the facility permitted under this chapter.

Mapping of pipelines:

In the most recent proposal the Commission would require, at a date uncertain, the registration of buried saltwater pipelines. Our members are concerned that this request seems outside the parameters of the general provisions of Chapter 4 as have been offered over the last year. They also note that its current linking to operating facilities if the registration is incomplete seems punitive considering there is not currently a process in place to register. Existing provisions that penalize an operator for failing to file proper forms exist and if this registration is put into place those provisions seem most appropriate. But at this time our members have expressed that there is already a requirement to notify the Commission about spills and absent any new or significant past challenges with this process, this proposal requires significant new requirements with little or no benefit.

Surface owner notification:

As is practice with notifications to operators and other general government advisements, it offers more sense to notify surface owners what regulatory framework does exist for the practice, not what the framework does not exist. More frankly, these facilities; including their construction, use, closure, and monitoring, will be governed by Chapter 4. Notice of that is sufficient and notification of sections of law or governing bodies that do not regulate these facilities are likely to create more confusion. Additionally, the sections of law that do not apply are logically larger than those that do, but will appropriately not be included in this proposed notice.

On-site burial

Our members have heard consistently that this rule is not intended to prohibit on-site burial and have several suggestions to ensure that remains the case.

Pit closure parameters and limits are better managed in a guidance document that is broken out by region. This guidance document can accommodate the different needs across the state.

If the closure standards remain in the rule, they should be amended to contemplate burial in a liner. Currently, the standard assumes that the liner does not offer any environmental protection when buried. In addition, the parametric limits for testing prior to closure with a liner are more protective than the spill standards in 3.91. Pits properly buried with liners offer more protection than if they are buried without a liner and the parametric limits should reflect this.

A recommendation would be to use the current tables for pits buried without liners and pits with liners would have a multiplier on the different constituents (e.g., 4x for TPH, 2x for Chlorides).

Lastly, if 1 or 2 are not amenable, the RRC should include an exception to the pit closure requirements specified in 4.114(g)(5) and Figure 16 TAC 4.114(g). Similar to the language in 3.65, there would be a new subsection 4.114(i) that covers this variance request. The proposed regulatory language is shown below.

“(f) Pit-closure exception

An authorized pit may apply for an exception to 4.114(g)(5) if, in addition to the requirements in 4.114, the following conditions are met. The Commission will determine whether the requested exception is adequate for compliance within 30 calendar days of receipt of the request and issue either an approval or disapproval in writing to the requestor. Approvals may be considered site-specific or more broadly applicable. If the Commission fails to provide the requestor a decision on approval or disapproval within 30 calendar days, the exception will be considered administratively approved.

A review of surrounding shallow lithology and groundwater data indicates that either (1) groundwater is deeper than 100ft, or (2) shallow lithology and boring logs indicate there is an impermeable layer (caliche, clay, etc.) between the bottom of the pit contents and the top of the first groundwater bearing unit, demonstrating a reduced possibility for pit contents to migrate to groundwater over time.

The site-specific location has minimal risk exposure to public receptors

No potable water wells within a ¼ mile radius.

No residential or commercial properties within a ¼ mile radius

Pit is constructed with a double liner."

Comments and considerations related to on-site burial:

RRC pit closure standards are more protective than the spill remediation guidance in 3.91. These limits assume that liners do not provide any protection to groundwater or surface pollution. If the pits are buried according to the manufacturer specifications and regulatory standards, they provide a level of protection that should be considered in the creation of these parameter limits.

Operators are liable for waste from cradle to grave, regardless of where the waste is disposed. Operators are better suited to manage their own waste at location than sending to a third party where they still retain liability, regardless of that third parties' practices. If a concern does arise from the surface owner, that concern can be managed contractually between the two parties.

It is unclear whether the RRC has evaluated the offset impacts of moving to this standard. The current parametric limits mirror the remediation requirements for spills. This standard would require most operators to truck off-site to a third party. The RRC should consider the impact of the increased truck traffic, road degradation, and the offset emissions when contemplating these parametric limits of burial on-site with a liner.

Comments to specific provisions:

4.114(d)(2) "Equipment, machinery, waste, or other materials that could reasonably be expected to puncture, tear, or otherwise compromise the integrity of the liner shall not be used or placed in lined pits."

Comment: We agree that equipment and machinery should not be placed in lined pits during the construction and operation of the lined pit. However, certain pits must be entered with equipment to properly close them. Under this proposed rule, the RRC requires dewatering of all fluids, allows for mixture of pit contents with clean material, requires stabilization, and requires the contents to pass a paint filter test. A common practice is to stage equipment within the pit to effectively meet these closure requirements.

During the pit closure, the liner may be punctured by the equipment entering the pit. However, the combination of stabilization of the waste and a cap would prevent leaching. It is a widely accepted practice by various state and federal environmental agencies to allow soil capping. The cap is designed to restrict surface water and rainwater infiltration into the subsurface waste body. This reduces the potential for leaching of site contaminants.

Proposed language: 4.114(d)(2): "Equipment, machinery, waste, or other materials that could reasonably be expected to puncture, tear, or otherwise compromise the integrity of the liner shall not be used or placed in lined pits during construction and operation of the pit."

4.114(g)(6)(B) install a geomembrane cover over the waste material in the pit.

(i) The operator shall install the geomembrane cover in a manner that prevents the collection of infiltration water over the pit and on the geomembrane cover after the soil cover is in place.

(ii) The geomembrane cover shall meet the requirements of subsection(c)(6)(E) of this section.

Comment: We believe the natural and synthetic liner requirements outlined in Section 4.114(c)(6) are equally protective. We request the ability to use the same cap material requirements as the liner material requirements.

We propose the ability to utilize cap methods prescribed in 4.114(c)(6)(A-E).

4.114(c) General design and construction requirements for authorized pits. All authorized pits shall comply with the following requirements.

Comment: 4.114(c) (2), (5) & (6) does not include "except for small sumps". We believe that similar to the above rules on 4.114(c)(3) & (4) small sumps should be excluded from the requirements.

We propose adding "Except for small sumps, an authorized pit shall…" onto (2), (5) & (6)

4.114(d)(1) A freeboard of at least two feet shall be always maintained in authorized pits, except for small sumps which shall maintain a minimum of one foot.

Comment: We believe the one-foot freeboard requirement significantly reduces the functional capacity of a small sump. For example, a 6" deep secondary containment partially buried beneath a transfer pump would be defined as a small sump under this rule and could not meet the one-foot freeboard requirement. The sumps should be operated as engineered and designed. Reporting of all unauthorized discharges maintains RRC oversight.

Proposed language: "A freeboard of at least two feet shall be always maintained in authorized pits, except for small sumps." which shall maintain a minimum of one foot

4.114(h)(1) For all authorized pits except small sumps "and fresh makeup water pits", the operator shall…

Comment: Under 4.115(d)(2)(B), fresh makeup water pits with chloride concentrations ≤ 3,000 mg/L are not required to have a liner. We believe fresh makeup water pits with chloride concentrations ≤ 3,000 mg/L should also be exempt from groundwater monitoring.

Proposed language: "For all authorized pits except small sumps and fresh makeup water pits with chloride concentrations ≤ 3,000 mg/L, the operator shall…"

4.109(a) An applicant or permittee may request an exception to the provisions of this subchapter by submitting to the Director a written request and demonstrating that the requested alternative is at least equivalent in the protection of public health and safety, and the environment, as the provision of this subchapter to which the exception is requested. The following provisions are ineligible for exceptions:

Comment: We believe the rule is not clear that this applies to the operators as well. Adding "operator" to the language to clarify that exceptions are available for all provisions of the rule including authorized pits. The current language of “applicant or permittee” implies applicability limited to permitted activities.

Proposed language: “An operator, applicant or permittee may request an exception to the provisions of this subchapter by submitting to the Director a written request…”

The above comments are not all inclusive of the broader comments that exist, but they are of the highest priority as the Commission considers presenting this rule for informal comment and we greatly appreciate the Commission affording us the opportunity to provide these comments.

Exhibit 15

of soil and water conservation which has been approved or requested by soil and water conservation districts (16 Texas Water Code §11.502.).

DIVISION 3 OPERATIONS AUTHORIZED BY RULE

§4.111. Authorized Disposal Methods for Certain Wastes

(a) Surface owner informed consent. All authorized disposal requires the written consent of the surface owner of the property on which the disposal will occur. Without surface owner consent, oil and gas waste shall be removed from the property and disposed of in an authorized manner.

(1) The operator shall inform the surface owner in writing that disposal authorized under this section may not necessarily meet the requirements of TCEQ's Texas Risk Reduction Program (30 Texas Administrative Code Chapter 350) regarding protective concentration levels for residential or commercial land use, or other land use restrictions.

(2) The operator shall obtain written consent from the surface owner authorizing disposal on the property.

(b) Water condensate. A person may, without a permit, dispose of by land application water which has been condensed from natural gas and collected at gas pipeline drip stations or gas compressor stations. The disposal is authorized provided:

(1) the disposal is not a discharge to surface water;

(2) representative samples are collected and analyzed for the list of parameters established by the Director for the land application of water condensate;

(3) analytical methods used are documented and all parameters are reported in mg/liter unless otherwise specified; and

(4) analyte concentrations do not exceed the concentration limits on the list of parameters established by the Director for the land application of water condensate.

(c) Inert oil and gas wastes. A person may, without a permit, dispose of inert oil and gas wastes on the property on which the waste was generated provided disposal is by a method other than disposal into surface water of the state.

(d) Low chloride water-based drilling fluid. A person may, without a permit, dispose of the following oil and gas wastes by landfarming: water-based drilling fluids with a chloride concentration of 3,000 mg/liter or less; drill cuttings, sands, and silts obtained while using water-based drilling fluids with a chloride concentration of 3,000 mg/liter or less; and wash water used for cleaning drill pipe and other equipment at the well site. The disposal is authorized in accordance with the following:

(4) the waste meets the analytical requirements in the Figure in §4.114(e)(1)(D) of this title.

(f) Completion/workover pit wastes. A person may, without a permit, dispose of in an authorized pit specified in §4.113 of this title the following materials: solids from spent completion fluids, workover fluids, drilling fluid, silt, debris, water, brine, paraffin, and the materials cleaned out of the well bore of a well being completed, worked over, or plugged, and reservoir fluids removed during wellbore cleanup. The disposal is authorized provided:

(1) the wastes have been dewatered;

(2) the wastes are disposed of at the same well site where they were generated;

(3) the burial complies with the closure standards for authorized pits in §4.114(e) of this title; and

(4) the operator maintains documentation demonstrating closure standards have been met. The operator shall maintain these records for at least three years from the date of closure and provide copies of these records to the Commission upon request.

(g) Contents of non-commercial recycling pits. A person may, without a permit, dispose of the solids from a non-commercial recycling pit by burial in the pit, provided:

(1) the pit has been dewatered and the fluids are recycled or disposed of in accordance with Commission rules;

(2) synthetic liners have been removed and disposed of in a commercial waste disposal facility;

(3) the residual solid (sediment) material meets the requirements for burial in §4.614(c) of this title (relating to Authorized Disposal Methods); and

(4) pits are closed pursuant to §4.114(e) of this title.

(h) Hydrostatic test water from a new pipeline. A person may, without a permit, apply to the ground surface hydrostatic test water from a new pipeline provided:

(1) the pipe is new;

(2) the source of the test water is a good quality water source, such as a drinking water source, an irrigation well in the immediate area, or a surface water source in the immediate area;

(3) the volume of the test water to be discharged is 50,000 gallons or less;

(4) the test water is applied to the ground surface in such a manner that it will not leave the boundaries of the pipeline right of way or, if it is discharged such that it will leave the right of way and enter adjacent property, the person has obtained written permission from the surface owner of the adjacent property;

(5) the test water is discharged in such a manner that the water will not reach surface water;

(6) the area where the hydrostatic test water will be discharged is at least 500 feet from a public water system well or intake, and 300 feet from any surface water or residential or irrigation water supply well;

(7) the test water is filtered during discharge through hay bales, filter bag, or equivalent filter media and discharged in such a manner as to prevent significant erosion and runoff; and

(8) any test water that is not covered by the oil and gas exemption in Subtitle C of the Resource Conservation and Recovery Act (RCRA) is determined to be nonhazardous.

§4.112. Authorized Recycling

(a) No permit is required for non-commercial fluid recycling if:

(1) treated fluid is recycled for use in drilling operations, completion operations, hydraulic fracturing operations, or as another type of oilfield fluid to be used in the wellbore of an oil, gas, geothermal, or service well;

(2) non-commercial fluid recycling pits are operated in accordance with §§4.113, 4.114, and 4.115 of this title (relating to Authorized Pits, Requirements Applicable to All Authorized Pits, and Specific Requirements Applicable to Authorized Pits, respectively);

(3) the operator registers the location of buried pipelines connecting non-commercial fluid recycling pits within 30 days of the pipelines entering service after the Director has established a registration system; and

(4) non-commercial fluid recycling is limited to oil and gas waste; commingling of treated oil and gas waste with other treated fluid from sources outside of the Commission's jurisdiction requires the Director's authorization.

(b) Pits that do not meet the definition of a non-commercial fluid recycling pit in §4.110 of this title (relating to Definitions) may be connected to non-commercial fluid recycling infrastructure, but such pits require a permit as follows.

(1) Commercial fluid recycling pits shall be permitted pursuant to Divisions 5 or 6 of Subchapter B of this chapter.

(2) Fluid recycling pits that do not meet the definition of non-commercial fluid recycling pits and are not commercial pits shall be permitted pursuant to Divisions 4 and 6 of this subchapter.

(2) The operator shall ensure that any waste that will be disposed of in the pit as authorized by §4.111 of this title is buried in a manner such that the waste will remain below the natural ground surface.

(3) The operator shall backfill and compact the pit.

(4) The operator shall mound or slope the former pit site to encourage runoff and discourage ponding.

(5) The operator shall, where necessary to ensure ground stability and prevent significant erosion, vegetate the former pit site in a manner consistent with natural vegetation in undisturbed soil in the vicinity of the pit.

(6) The operator shall notify the District Director a minimum of 7 days prior to closure of the authorized pit and shall maintain for a period of three years documentation to demonstrate that the requirements of this section have been met.

Commented [PD1]: Removed "cap" language.

(7) The Commission may require the operator to close an authorized pit in a manner other than the manner described in this section if it determines that oil and gas wastes or oil field fluids are likely to escape from the pit, that oil and gas wastes or oil field fluids may cause or are causing pollution, and/or that the pit is being used in a manner inconsistent with Commission rules.

(f) Groundwater monitoring requirements for authorized pits.

(1) Groundwater monitoring is required for authorized pits that do not have a leak detection system.

(2) An authorized pit with an active life of more than one year shall have at least three groundwater monitoring wells, at least two of which are installed in a downgradient location and one of which is installed in an upgradient location relative to the pit.

(3) An authorized pit with an active life of less than one year shall have at least one groundwater monitoring well that is installed downgradient to the pit.

(4) Groundwater monitoring wells shall be sited, installed, and constructed according to §4.131 of this title (relating to Monitoring Standards).

§4.115. Specific Requirements Applicable to Authorized Pits

(a) Additional specific requirements. In addition to the general requirements described in §4.114 of this title (relating to Requirements Applicable to All Authorized Pits), an operator of any authorized pit shall comply with the following applicable requirements.

(b) Reserve pits and mud circulation pits.

(1) Authorized pit contents. A person shall not deposit or cause to be deposited into a

Figure: 16 TAC §4.114(e)(1)(D)

STANDARD SOIL SAMPLING CLOSURE PARAMETERS	
PARAMETER	LIMITATION
pH *EPA Method 9045C or equivalent*	6 to 10 standard units
Electrical Conductivity (EC)[1]	≤ 4.0 mmhos/cm
Total Petroleum Hydrocarbons (TPH) *EPA Method 5035A/TX1005*	≤ 10,000 mg/kg or 1% by weight
Total benzene, Toluene, Ethylbenzene, Xylenes (BTEX) *EPA Method 5035A/8021/8260B or equivalent*	≤ 30 mg/kg
Metals (Total) Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver *EPA Method 6010/6020/7471A or equivalent*	 ≤ 10 mg/kg ≤ 10,000 mg/kg ≤ 10 mg/kg ≤ 100 mg/kg ≤ 200 mg/kg ≤ 10 mg/kg ≤ 10 mg/kg ≤ 200 mg/kg

[1] Louisiana Department of Natural Resources (LDNR) Lab Procedures for Extraction and Analysis of E&P Waste or equivalent.

Exhibit 16

From:	Paul Dubois
To:	Haley Cochran; Kellie Martinec; Christine A. Peters
Subject:	FW: Informal Comments RE: Chapter 4
Date:	Wednesday, June 7, 2023 7:41:52 AM
Attachments:	image002.png image003.png image004.png image005.png image006.png image007.png

From PBPA, for your records.

Regards,

Paul Dubois
Assistant Director, Technical Permitting | Oil & Gas Division
Railroad Commission of Texas
512-463-6778
Take our Customer Service Survey

From: Michael Lozano PBPA <Michael@pbpa.info>
Sent: Tuesday, June 6, 2023 5:08 PM
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Subject: Informal Comments RE: Chapter 4

Paul,

Thank you for the opportunity to provide informal comments to the Commission regarding Chapter 4 amendments. We all recognize that this is the start of this informal process, the opportunity to address some of the most pressing and sensitive issues, and appreciate the opportunity to provide them for you below.

We would like to emphasize that these are only cursory and initial reactions to the proposal that we have not had the opportunity to review in great detail and we will continue to discuss how to improve upon the processes provided throughout the rule to ensure that these are reasonable and feasible processes that accomplish the same environmental impact in the least restrictive manner for operators.

Also as a note, we would be remiss if we did not note the ongoing importance of ensuring that the definitions are accurate to existing and future facilities, consistent within these new Subchapters A and B, consistent with existing RRC rules, and do not create a framework that would inhibit the ability of operators to benefit from their innovations under existing rules or stifle innovation moving forward. Definitions are critically important to matching the Commission's leadership and stated mission to promote recycling which has spurred numerous innovations in this field. We hope to continue that work to ensure definitions like 'commercial facility' and others do not adversely shutdown or curtail further breakthroughs in treatment and reuse.

There are initial requirements that seem to prescribe a manner of informed consent from surface owners. Our members raise several concerns including that there exist any number of surface use agreements that contain a multitude of specific provisions that are agreed to between two parties. There is also concern that this could require existing or future parts of a surface use agreement to be filed with the RRC that could then be made public. It is contradictory to standard practice to report such an agreement or parts of that agreement to RRC. We should prioritize allowing consenting parties to engage in contract terms that meet their needs. If there is a compelling interest to ensure specific information is provided, perhaps a notice provision that can be attested to in the permit application as well as clarity that this would only be required of assets upon the effective date of the rule. Our members also raise concerns that there is provision that could require the commission to consider market necessity prior to approving facility permits.. Asking the Commission to effectively become arbiters of market conditions or regulating the commerce seems to be out of line with the Commissions interest in allowing private sector markets to exist as well as encourage competition and innovation. A system that can be regulated like this could be manipulated and increase cost without environmental or commercial benefits and is a concerning concept that we would respectfully request be removed.

There have also been thoughts about the language requiring the characterization of generated wastes. Commercial and non-commercial operators would benefit from the Commission's clarification on the types of general characterization that would be required of generators of waste in order to comply, as well as the requirements for other operators in the transport and disposal segments, including at such times that chemical characterization through lab analysis would be required. Some note that there ought to be clarity on the types of testing that the commission would approve. Additionally there is a concern that this rule should not be more prescriptive or set additional restrictions beyond what is already required by state and federal RCRA regulations. The waste profile should be allowed to be a generic profile that can be applicable per waste stream, and not specific to generator location but specific to the waste stream(s) that would be the same for multiple generator locations. While separate from characterization this concern for clarity extends to sampling requirements for the general closure of authorized pits. These provisions seem unclear and about what should be sampled and clarity of both intent and purpose would be helpful.

We recognize the statutory requirement that the Commission consider the 10 year flood history, and the difficulty in determining how best to accomplish that goal. While we have not had the opportunity to reach consensus, we believe that a requirement that applicants attempt to contact prior owners, some who may not be easy to contact or some that have passed, presents concerns. We also note that much of the data available in these areas are likely lacking in flooding data, disaster claims, or insurance claims because they are most likely remote and undeveloped tracts of land. We also have concerns that even a property owner of more than 10 years may not possess knowledge of flooding with any degree of certainty. We encourage the Commission rule to allow for the use of publicly available data, where available, or potentially certification from the operator that the landowner is or is not aware of flooding in the preceding 10 years to the best of their knowledge if the landowner can be reached. At this time it would be prudent for the commission to generally note this consideration and as parties continue to work through the rulemaking process, more clear and concrete requirements can be bolted on this loose framework to ensure proper compliance in the least disruptive manner.

The new requirement for commercial applications to disclose surface or subsurface karsting for siting imposes new burdens on operators in the western side of the state with extensive publicly known formations in the Permian Basin, Panhandle and North Texas. Ground conditions and construction are fully addressed by the requirements proposed in Chapter 4 and additionally by individual district communications with the operator making their inclusion in the siting requirements unnecessary.

Additionally, many have noted that the requirements for groundwater monitoring are very new and seemingly unclear in their application and potentially benefit. This is another area where we believe it would behoove the rulemaking process to speak generally to these new requirements while we continue to determine in what situations this would be required. There is confusion about which instances these would be required as well as what type of testing would be sufficient as well as the intervals between tests. It should also be clearer that pits that can be sufficiently demonstrated to not impact groundwater like those that are sited in areas where there is no identifiable groundwater sources within 100-ft below ground surface, or between a certain distance of low permeability confining layers between surface and the groundwater source.

Again, thank you for the opportunity to provide this feedback as well as recognizing that these are initial concerns. We look forward to providing more information between now and informal publication and please us know if you have any questions.

Best,

MDL

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Exhibit 17

UNDER WATER & UNAWARE

Outdated Regulations Leave the Texas Petrochemical Industry Vulnerable to Severe Storms

Adrian Shelley

Texas Office

June 2022

PUBLIC CITIZEN

ACKNOWLEDGEMENTS

This report was written by Adrian Shelley, director of Public Citizen's Texas Office, with assistance from Simon Youngbloom. It was edited by Michael Coleman.

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KEY FINDINGS

Texas regulations have not kept pace with the modern frequency and volume of heavy rain events. The Texas Gulf Coast regularly experiences extreme weather that exceeds worst case predictions and leads to flooding, infrastructure damage, and industrial accidents. Texas must update its regulations with new data to minimize the harm caused by future extreme weather events.

- In Harris County, a 100-year, 24-hour storm is defined as 12 inches and a 25-year, 24-hour storm is defined as 9 inches.
- The Houston region has experienced four 100-year storms and six 25-year storms in the last twenty-two years.
- Texas regulations generally rely on Technical Paper 40, which uses sixty-year-old data leading to inadequate definitions for "100-year storm" and "25-year storm."
- During Hurricane Harvey, at least nine petrochemical facilities experienced floating roof tank failures due to heavy rain, causing them to release a combined three million pounds of air pollution. Updates to regulations related to heavy rain could prevent this pollution.
- The American Petroleum Institute construction standards for floating roof tanks rely on outdated data from Technical Paper 40.
- The U.S. National Oceanographic and Atmospheric Administration has published Atlas 14 with newer rainfall data.
- Updating state regulations with data from Atlas 14 would increase the 25-year storm by 2.6 inches, the 100-year storm by 5 inches, and create a new definition for a 1,000-year storm of 29.8 inches.
- Updated regulations should lead to construction and work practices that better prepare industry for more frequent extreme rainfall events.

INTRODUCTION

Texas has suffered more billion-dollar climate and weather disasters than any other state.[1] Since 1980 there have been 291 billion-dollar disasters in the United States, 129 of which have hit Texas. That means nearly half (44 percent) of major U.S. weather disasters harm Texans.

Many of Texas' most costly—and deadly—storms have been hurricanes. The worst of them have reshaped our understanding of weather extremes. In August 2017, Hurricane Harvey dumped as much as 51 inches of rain on the Texas Gulf Coast. The deluge was so unprecedented that weather maps were changed on the fly to record the event.[2]

Harvey was an extraordinary hurricane, one the National Hurricane Center called "the most significant tropical cyclone rainfall event in United States history[.]"[3] One publication hyperbolically labeled Harvey a once-in-a-half-a-million-years' event.[4]

[1] *See* NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73.
[2] National Weather Service, *see* https://twitter.com/NWS/status/902174274571689984?s=20.
[3] Blake, Eric S. and David A. Zelinsky, "National Hurricane Center Tropical Cyclone Report: Hurricane Harvey," (May 9, 2018) at p. 6, *available at* https://www.nhc.noaa.gov/data/tcr/AL092017_Harvey.pdf.
[4] *See* https://www.livescience.com/60378-hurricane-harvey-once-in-500000-year-flood.html.

In Houston, any storm with at least twelve inches of rain in a 24-hour period is deemed a "100-year storm." The next 100-year storm would come just two years after Harvey. Tropical Storm Imelda dumped 24 to 26 inches on the Texas Gulf Coast on September 19, 2019. Two other 100-year storms have walloped Houston since 2000, as well as another six 25-year storms.

Climate change has us living in unusual times. The increasing frequency of these supposedly rare rainfall events is not just bad luck. It is a clear sign that our climate is changing and that our assumptions about rainfall frequency and volume are wrong. **This report will show that Texas' definitions of extreme rainfall events—including 100-year and 25-year storms—are outdated and inaccurate.**

Public Citizen's Texas office reviewed state regulations related to rainfall. Our research shows that industries that rely on outdated assumptions about rainfall volume and frequency often contribute to some of the worst environmental pollution during such storms. Moreover, Texas legislators have stubbornly refused to update our laws and regulations to prepare for the impact of climate change. This is one reason Texas cities and people suffer so greatly during severe storms.

Each time we get it wrong, there are grave consequences. Major storms and floods cost dozens of lives, thousands of homes, and billions of dollars in damage. Houston is home to the largest concentration of petrochemical facilities in the United States. As a result, the region is especially vulnerable to catastrophic damage from severe storms and flooding.

It is time to rethink these outdated benchmarks. It is also time to update Texas' industrial standards for rainfall so infrastructure, such as petroleum storage tanks, can be designed to a more stringent standard. Ignoring this urgent need will only exacerbate the economic, environmental, and public health problems these storms inflict on Texas.

I. MAJOR RAINFALL EVENTS ON THE TEXAS GULF COAST SINCE 2000 SHOW THAT THE DEFINITIONS OF 25- AND 100-YEAR STORMS ARE OBSOLETE

Rainfall events are defined by their frequency, duration, and volume. A 100-year, 24-hour rainfall event is the maximum amount of rain that should be expected to fall over any 24-hour period during a span of 100 years.[5]

The Houston region has experienced four 100-year storms and six 25-year storms since 2000.

Another way to state this is that a 100-year flood should have a one in one-hundred chance (that is, a 1% chance) of occurring in a given year. This will be true whether the last 100-year flood was 1 year ago or 99 years ago. Similarly, a 25-year flood should have a one in twenty-five chance (4%) of occurring in a given year.

State regulations define a 100-year storm in Harris County as 12 inches. A 25-year storm is defined as 9 inches. Using these definitions, the Houston region has experienced four 100-year storms and six 25-year storms since 2000.

Table 1: Severe Storms in Harris County

Date	Storm	Rainfall	Frequency	Fatalities	Damage (est.)
Aug. 27, 2020	Hurricane Laura[6]	10-15″	25 year	42	$19 billion
Sept. 19, 2019	T. S. Imelda[7]	24-36″	100 year	5	$5.1 billion
Aug. 27-29, 2017	Hurricane Harvey[8]	60.5″[9]	100 year	89	$125 billion
Apr. 18, 2016	Tax Day Flood[10]	17"	100 year	8	$2.9 billion

[5] Federal Emergency Management Agency Region 10, "The 100 Year Flood Myth" *available at* https://training.fema.gov/hiedu/docs/hazrm/handout%203-5.pdf.
[6] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73.
[7] *Id.*
[8] *Id.*
[9] "National Hurricane Center Tropical Cyclone Report: Hurricane Harvey" (9 May 2018) *available at* https://www.nhc.noaa.gov/data/tcr/AL092017_Harvey.pdf.
[10] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73.

Oct. 31, 2015	Halloween Flood[11]	10-15"	25 year	2	$30 million
May 25, 2015	Memorial Day Flood[12]	10"	25 year	31	$2.8 billion
July 14, 2012	n/a[13]	10"	25 year	-	-
Apr. 28, 2009	n/a[14]	10"	25 year	1	-
Sept. 13, 2008	Hurricane Ike[15]	11"	25 year	112	$36.9 billion
June 8, 2001	T. S. Allison[16]	30-40"	100 year	43	$12.7 billion

Note that this list does not include Hurricane Rita, which hit Texas and Louisiana in September 2005 and caused 119 deaths and $25.2 billion in property damage.[17] Rainfall totals reached 16 inches in Louisiana but did not meet the 25-year or 100-year storm definitions in Texas.

Together, these storms killed hundreds of people and caused hundreds of billions of dollars in damage. Often, the natural disaster is followed by a man-made disaster of petrochemical incidents. Hurricane Harvey led to a significant man-made environmental disaster as petrochemical facilities released millions of pounds of unauthorized pollution. If Texas is to avoid these disasters in the future, it must update its assumptions about the size and volume of heavy rainfall in the state.

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[11] *See* https://www.weather.gov/media/hgx/climate/summary/2010Top10.pdf.
[12] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73.
[13] *See* https://www.cbsnews.com/news/100-year-rainfall-event-drenches-houston-area/.
[14] *See* https://www.weather.gov/hgx/pns_memorable_events2000s.
[15] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73.
[16] *Id*.
[17] *Id*.

II. INDUSTRIAL ACCIDENTS AND SEVERE STORMS

Hurricane Harvey's Unprecedented Rain Overwhelmed Industrial Facilities and Led to Large Pollution Releases

Some severe storms in Texas have caused major industrial accidents. Hurricane Harvey led to the release of 8.3 million pounds of air pollution and 150 million gallons of wastewater.[18] Much of this pollution was from facilities that were overwhelmed by Harvey's unprecedented rainfall.

The tendency of floating roof petroleum storage tanks to fail under heavy volumes of rain was first identified after Hurricane Harvey. Floating roof tanks are large, cylindrical tanks for storing crude oil or other petroleum products. They have a roof that sits within the tank walls and floats on top of the petroleum products inside. Heavy rain can cause tank roofs to become submerged or flip. Tank roof drains can become overwhelmed or clogged. All these failures can lead to massive discharges of pollution.

At least nine companies experienced storage tank failures due to excessive rain during Hurricane Harvey. These failures resulted in the release of more than three million pounds of air pollution. A summary of these events as reported to the TCEQ's Air Emissions Event Reporting Database is below.

Table 2: Floating Roof Tank Failures duirng Hurricane Harvey

Incident Number[19]	Company	Pollution released (lbs.)	Cause
267578	Arkema Crosby Plant	23,608	Two tanks capacity exceeded, spill into containment dike, dike leak into floodwaters.
267063	Crude Product Port Neches	1,368	Product on internal floating roof.
266294	ExxonMobil Baytown Ref.	185,808	Partial roof submergence.

[18] Environmental Integrity Project "Preparing for the Next Storm" (16 Aug. 2018) *available at* https://environmentalintegrity.org/wp-content/uploads/2018/08/Hurricane-Harvey-Report-Final.pdf.

[19] Events reports retrieved from the TCEQ's Air Emissions Event Reporting Database at https://www2.tceq.texas.gov/oce/eer/ (9 Jan 2021).

266754	Galena Park Terminal	2,471,401	Two tanks floated and released contents into floodwater.
266570	Marathon Petroleum Texas City Refinery	7,927	Tilting roof due to excessive rain.
266263	Phillips 66 Pasadena Product Terminal	119	Two external floating roof tanks experienced product draining into secondary containment.
266269	KM Liquids Pasadena Terminal	144,601	Partial submergence of two external floating roofs.
266266	Shell Oil Deer Park	67,933	Contents spilled on tank roof, "cause unknown."
266275	Valero Partners Houston	235,412	Partial sinking of tank roof.
	TOTAL	**3,138,177**	

Over time, the environmental fallout from Hurricane Harvey became more widely known.[20] The Texas House of Representatives Committee on Environmental Regulation held a hearing on April 25, 2018, to take testimony on Harvey response and cleanup efforts.[21] At that hearing, Harris County Pollution Control Services Director Bob Allen gave testimony, as did others. [22]

Mr. Allen testified about an apparent weakness in the design of floating roof tanks. There are roughly 400 external floating roof tanks in Harris County. The county identified nine tank failures during Harvey and questioned the tank owners about a cause. Some companies responded that the drains on the roofs of their floating roof tanks were too small. Mr. Allen testified that while industry standard is a four-inch drain, companies with six-inch drains on their tanks did not experience tank failures during Harvey, even after forty-five inches of rain. Notably, the largest single event during Hurricane Harvey, the Galena Park Terminal release, was not due to a drain failure, but to floodwaters causing tanks to float.

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[20] *See, e.g.,* Troy Griggs et. al. "More Than 40 Sites Released Hazardous Pollutants Because of Hurricane Harvey (8 Sept. 2017) *available at* https://www.nytimes.com/interactive/2017/09/08/us/houston-hurricane-harvey-harzardous-chemicals.html.

[21] *See* https://capitol.texas.gov/tlodocs/85R/schedules/pdf/C2602018042509001.PDF.

[22] House Committee on Environmental Regulation, 85th R. S. (25 April 2017) *available at* http://tlchouse.granicus.com/MediaPlayer.php?view_id=40&clip_id=15092 *(Mr. Allen's testimony begins at 2:34:00).*

In his testimony, Mr. Allen recommended that new tanks be required to have larger drains, and that existing tanks could be required to enlarge their tank drains during their next turnaround.

Petroleum storage tank failures released more than three million pounds of air pollution during Hurricane Harvey.

The drain size of floating roof tanks is not proscribed by TCEQ,[23] which has not established construction standards for oil and gas infrastructure. The controlling authority is the American Petroleum Institute Standard 650: "Welded Tanks for Oil Storage" API Standard 650, Eleventh Edition, June 2007 (citing authority form 40 CFR 195.132(b)(3), Design and construction of aboveground breakout tanks).[24]

API 650 speaks to floating roofs, rainfall, and drains twice:

> "Floating roofs shall have sufficient buoyancy to remain afloat…for the following conditions: (a) 250 mm (10 in.) of rainfall in a 24-hour period" API 650, C.3.4.1 (2007).
>
> "Emergency Roof Drains…shall be sized to handle the rainfall specified by the Purchaser." API 650, C.3.8.2 (2007).

API 650 says nothing about roof drain sizes of four inches or otherwise. There is further discussion of industry standards in Part VI below.

Given Houston's record of storms since 2000, the guideline to construct for "10 in. of rainfall in a 24-hour period" is clearly out of date. The rainfall assumptions in API 650 come from "Technical Paper Number 40, Rainfall Frequency Atlas of the United States."[25] Technical Paper 40 or "TP-40" was published in May 1961 by the

[23] *See* 30 TAC 115.112.
[24] 40 CFR 195.132(b)(3), "Vertical, cylindrical, welded steel tanks with internal pressures at the tank top approximating atmospheric pressures…must be designed and constructed in accordance with API Standard 650."
[25] Hershfield, David M. "Technical Paper 40: Rainfall Frequency Atlas of the United States" U.S. Department of Commerce, Weather Bureau (May 1961) *available at* https://www.nws.noaa.gov/oh/hdsc/Technical_papers/TP40.pdf (referred to as "Technical Paper 40" or "TP40" throughout).

Weather Bureau of the U.S. Department of Commerce and relies on rainfall data from 1938 to 1958.[26]

Tank Failures also Occurred before Hurricane Harvey

Hurricane Harvey was the first time that the systemic weakness of petroleum storage tanks to high volumes of rain was recognized.[27] There had, however, been similar incidents previously reported to the TCEQ. During the April 18, 2016 "Tax Day Flood," the Nustar Logistics Texas City Crude Tank Farm experienced tank rain failures leading to 5,136 pounds of pollution. The side drains in Tank 84 became plugged. Tank 85, which was not in service at the time, was hampered by a faulty roof drain.[28]

During the "Memorial Day Flood" of May 25-26, 2015, two reported incidents were directly attributed to rainfall. At the Phillips 66 Pasadena Product Terminal, Tank 120 released 3,238 pounds of pollution due to a floating roof drain failure.[29] Nine inches of rain fell overnight, leading to a drain clog likened to "leaves clogging a rain gutter." Water accumulated on the roof, causing one side of the external floating roof to sink into the gasoline stored within. Gasoline then floated to the top of the rain on the tank roof and was released into the air.

Also, during the Memorial Day Flood, the Magellan Pipeline Terminals East Houston Tank Farm released 34,836 pounds of pollution from Tank 1222. Eleven inches of rain caused the external floating roof tank to submerge, forcing petrochemicals onto the roof.[30]

Storms have also caused air pollution releases from sources other than tanks. The Halloween Flood of 2015 led to a power outage[31] and an emergency

[26] The actual data set is slightly more nuanced. *See* TP-40 at p. 1.
[27] *See e.g.* Blum, Jordan "Failures of floating-roof oil tanks during Harvey raise concerns" Houston Chronicle (11 Oct. 2017) *available at* https://www.houstonchronicle.com/business/energy/article/Failures-of-floating-roof-tanks-during-Harvey-12269513.php.
[28] *See* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=231845.
[29] *See* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=214703.
[30] *See* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=214682.
[31] *See* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=222447.

shutdown/startup.[32] A storm on July 17, 2012, caused an emergency shutdown at the Pasadena Refinery, where a power failure led to "heavy flaring" and the release of nearly a half million pounds of pollution.[33]

Although most of the pollution incidents in this report are from tanks due to rain volume, a few other common causes are apparent. Severe storms regularly cause power failures and emergency shutdowns that lead to large releases of pollution. Power outages are common during storms, and emergency backup power could blunt their impact. Emergency shutdowns can be prevented by shutting down safely before a storm makes landfall.

Since Hurricane Harvey, other storms have led to the release of considerable amounts of pollution. More than two dozen facilities reported releases after Hurricane Laura, totaling 768,882 pounds of pollution (although nearly half of that was carbon dioxide pollution from one incident). Notably, pollution from facility shutdown and startup exceeded pollution from accidental "upset" events. This means that companies emitted more pollution preparing for the storm than they did in accidents caused by the storm.

Facility startups and shutdowns often release copious amounts of pollution. The decision to shut down or ride out a storm is a difficult one. But when it is made hastily, the potential for large-scale pollution increases. We recommend plant managers decide early, leaving enough time to shutdown safely before the storm hits.

[32] *See* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=222453 *(shutdown),* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=222460 *(startup).*

[33] *See* https://www2.tceq.texas.gov/oce/eer/index.cfm?fuseaction=main.getDetails&target=171159.

III. STATE REGULATIONS ARE BASED ON OUTDATED DATA

Texas' petrochemical industry is unprepared for severe rainfall because our laws and regulations have not kept pace with our new climate reality. Climate change has led to more water vapor in the air, which in turn leads to heavier rain.[34] Texas policy makers have obstinately refused to plan for climate change. Our regulations related to severe rainfall are hopelessly outdated. Texas must update these regulations to reduce the petrochemical industry's vulnerability to future storms.

Many of Texas' construction standards, control technologies, and work practices are based on definitions such as "100-year storm," "25-year storm," and "100-year flood plain." Technical Paper 40 is the most cited source in Texas regulations for these definitions. It defines a 100-year, 24-hour storm in Houston as one with 12 inches of rain. A 25-year, 24-hour storm has just 9 inches of rain.

TP-40 is not the most current source for these definitions. On September 27, 2018, The National Oceanographic and Atmospheric Association (NOAA)[35] published "NOAA Atlas 14, Volume 11 Precipitation-Frequency Atlas of the United States, Texas," known as "Atlas 14."[36]

When releasing Atlas 14, NOAA acknowledged that major rainstorms are getting larger. NOAA explained that it, "finds significantly higher rainfall frequency values in parts of Texas, redefining the amount of rainfall it takes to qualify as a 100-year or 1000-year event."[37]

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[34] *See* https://www.climate.gov/news-features/featured-images/prepare-more-downpours-heavy-rain-has-increased-across-most-united-0.

[35] The successor to the Weather Bureau, *see* Reorganization Plan No. 4, 84 Stat. 2090 (Eff. Oct. 3, 1970) *available at* https://uscode.house.gov/view.xhtml?hl=false&edition=prelim&req=granuleid%3AUSC-prelim-title5a-node84-leaf179&num=0&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU1YS1ub2RlODQtbGVhZjE3OQ%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim.

[36] "NOAA updates Texas rainfall frequency values," National Atmospheric and Oceanographic Administration, U.S. Department of Commerce (Sept., 27, 2018) *available at* https://www.noaa.gov/media-release/noaa-updates-texas-rainfall-frequency-values.

[37] *Id*.

Atlas 14 defines a 100-year storm in Houston as 17 inches and a 25-year storm as 11.6 inches. Atlas 14 also introduces a new category of event: the 1,000-year storm, which brings 29.8 inches of rain. A comparison of these two sources gives a vastly different picture of how much rain Houston can expect:

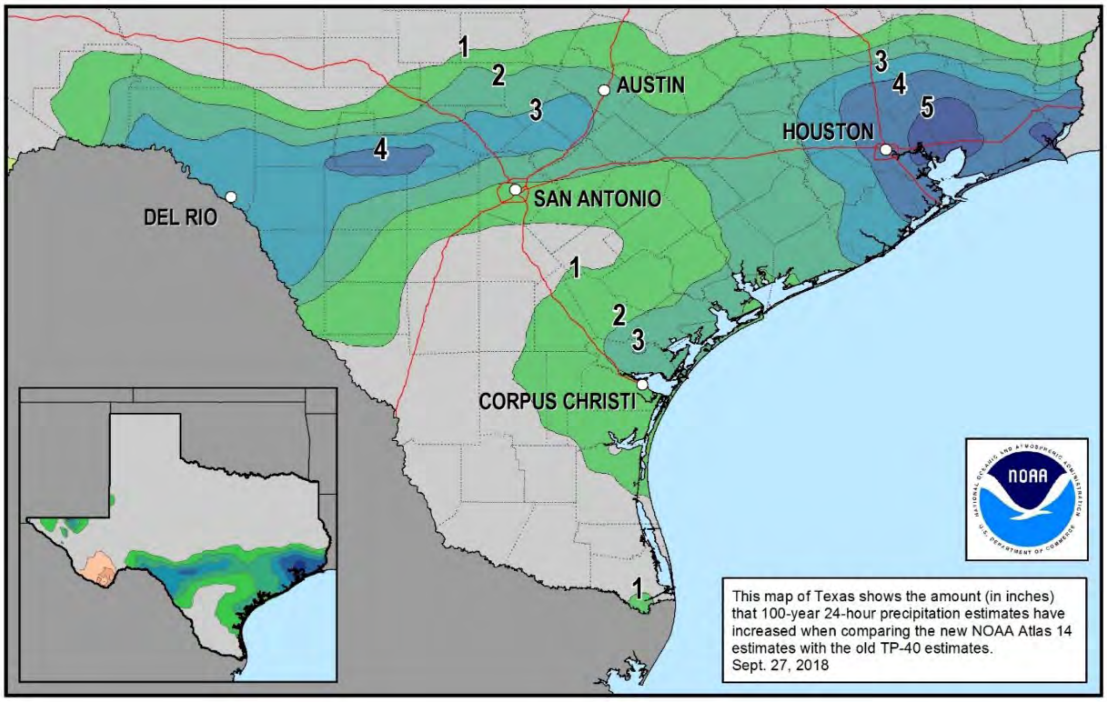
Table 3: Comparison of TP-40 to Atlas 14

Event	TP-40	Atlas 14
25-year, 24-hour	9″	11.6″
100-year, 24-hour	12″	17″
1,000-year, 24-hour	*undefined*	29.8″

Although Atlas 14 is the newest dataset available, it still relies on the North American Datum of 1983.[38] Using the definitions in Atlas 14, Houston would have experienced, since 2000, three 25-year storms, one 100-year storm, and three 1000-year storms.

Even though Atlas 14 data is itself data, adopting the Atlas 14 definitions would be a significant improvement over current regulation. As the following map shows, an update from TP-40 to Atlas 14 would add several inches to the 100-year storm definition across south Texas:[39]

[38] *See* https://www.ngs.noaa.gov/datums/horizontal/north-american-datum-1983.shtml.
[39] "NOAA updates Texas rainfall frequency values," National Atmospheric and Oceanographic Administration, U.S. Department of Commerce (Sept., 27, 2018) *available at* https://www.noaa.gov/sites/default/files/styles/watermark/public/thumbnails/image/GRAPHIC%20-%20Comparison%20map%20of%20new%20rainfall%20values%20to%20old%20estimates%20-%20NOAA.jpg?itok=XdQ-AweL



Another comparison of TP-40 to Atlas 14 is included as Appendix A to this report. Public Citizen overlaid the 25-year and 100-year rainfall event maps in from TP-40 and Atlas 14. These combined maps provide a detailed comparison of rainfall event definitions across Texas from these two sources.

IV. TWO IMPORTANT STATE AGENCIES HAVE OUTDATED REGULATIONS

Industries regulated by the Railroad Commission and the Texas Commission on Environmental Quality are at risk due to outdated regulations that use old rainfall data.

Two state agencies—the Railroad Commission and the Texas Commission on Environmental Quality—have the majority of regulatory references to rainfall volumes. Both agencies rely most frequently on Technical Paper-40 for data supporting their regulations. TP-40 was issued in 1961 and relies on rainfall data from 1938 to 1958.

Texas is the largest petrochemical producing state in the United States. The petrochemical industry is regulated by the both the Railroad Commission of Texas and the Texas Commission on Environmental Quality. These two state agencies enact regulations that rely on outdated data about rainfall frequency and volumes. As a result, the petrochemical industry is not being adequately protected from the risk of extreme weather events.

The Railroad Commission of Texas

Title 16, Part 1 of the Texas Administrative Code covers the Railroad Commission of Texas, which is Texas' oil and gas regulatory agency. The Railroad Commission references 10-year and 100-year storms but does not cite any authority for the size of rainfall events. The Railroad Commission discusses flood plain maps in several chapters and sites to the Federal Emergency Management Agency (FEMA).

In Chapter 3, authorized pits[40] may not be located within the 100-year flood plain without approval by the district director.[41] The "100-year flood plain" is defined by reference to FEMA maps or U.S. Department of Agriculture soil maps.[42]

[40] A list that includes reserve pits, mud circulation pits, completion/workover pits, basic sediment pits, flare pits, fresh makeup water pits, fresh mining water pits, and non-commercial fluid recycling pits.

[41] 16 TAC § 3.8(d)(4)(H)(iv)(I).

[42] 16 TAC § 3.8(a)(46).

Chapter 4 defines the "100-year flood plain" as "An area that is inundated by a 100-year flood, which is a flood that has a one percent or greater chance of occurring in any given year."[43] Subchapter B of Chapter 4 covers commercial oil and gas waste recycling facilities, which should not be in the 100-year flood plain.[44] Permits for on-site commercial oil and gas waste recycling must include a stormwater runoff plan that protects against a 25-year, 24-hour rainfall.[45]

Chapter 12 covers surface mining activities. Hydrologic balance is maintained in part with stream diversions, which must be designed to pass runoff from a 10-year, 6-hour precipitation event for temporary diversions and a 100-year, 6-hour event for permanent diversions.[46] Surface water runoff from valley fills must pass runoff from a 100-year, 24-hour event.[47]

Finally, the timeline for the extended responsibility period for a revegetation project is based in part on an area's rainfall total, specifically whether it receives more or less than 26 inches of rain a year.[48] This regulation does not include a map of these areas or any other reference.

The Texas Commission on Environmental Quality

TCEQ regulations, found in Title 30 of the Texas Administrative Code, usually cite Technical Paper-40 for definitions of rainfall. A representative example is the definition of a "25-year, 24-hour rainfall event" found in Title 30 of the Texas Administrative Code, Chapter 312, "Sludge Use, Disposal, and Transportation":[49]

> 25-year, 24-hour rainfall event--The maximum rainfall event with a probable recurrence interval of once in 25 years, with a duration of 24 hours as defined by the National Weather Service in Technical Paper Number 40, Rainfall Frequency Atlas of the United States, May 1961, and subsequent amendments, or equivalent regional or state rainfall information developed from it.

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[43] 16 TAC § 4.204(1).
[44] 16 TAC §§ 4.219 et. seq.
[45] 16 TAC §§ 4.214, 4.234, 4.250, 4.266, 4.282.
[46] 16 TAC § 12.341(b)(3), (c)(3).
[47] 16 TAC § 12.364(e).
[48] 16 TAC § 12.395(c)(2), (3).
[49] 30 TAC § 312.8(1).

There are two references in TCEQ's code to Technical Paper 49, both in the subchapter on Concentrated Animal Feeding Operations. In one instance, the definition of "Design rainfall event" references Technical Paper 40 or 49.[50] The other reference is in a definition of "25-year, 10-day event:"[51]

> Twenty-five-year, ten-day rainfall event--The maximum rainfall event with a probable recurrence interval of once in 25 years, with a duration of ten days, as defined by the National Weather Service in Technical Paper Number 49 United States Weather Bureau and United States Department of Agriculture, Two-to-Ten Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States (1964); or equivalent regional or state rainfall information.

TP-49 was published in 1964 and is also outdated. Appendix B includes a plain language explanation TCEQ regulations referencing rainfall events and definitions.

Other state agencies also rely on outdated regulations.

There are a few other state agencies with regulations that are similarly outdated. Several state agencies refer to FEMA maps of the 100-year flood plain that are often themselves dated.

The Texas Department of Agriculture restricts eligibility for disaster relief funds based on a property's location in the flood plain. Specifically, no funds will be awarded under FEMA's Hazard Mitigation Grant Program for buyouts of properties that were constructed or purchased after being officially mapped and included in a designated flood plain area.[52]

The Coastal Coordination Advisory Committee has policies for construction and operation of solid waste treatment storage and disposal facilities. These facilities should not be located in a 100-year floodplain as mapped by the Federal Emergency Management Agency.[53] If a hazardous waste landfill is located in a special hazard area, it must be designed to withstand a 100-year flood event. The size of a 100-year flood event is undefined.

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[50] 30 TAC §321.32(20).
[51] 30 TAC §321.32(58).
[52] 4 TAC § 30.60(b)(3).
[53] 31 TAC § 501.19(a).

Rainfall events in the Houston area since 2000 show that TP-40's definitions are outdated. They lead to Houston having experienced four 100-year storms and six 25-year storms since 2000. This is an absurd result that will likely only continue as climate change makes extreme weather events more common.

The failure to properly define large rainfall events has grave consequences for public health and safety. During Hurricane Harvey, three million pounds of air pollution was released by floating roof tanks overwhelmed by rain. This may be the largest and most high profile such event, but regulations across Texas suffer from inadequate definitions of extreme rain events.

We recommend that the Texas Administrative Code be updated to use definitions of extreme rain events from Atlas 14 or a subsequent authority. Doing so will increase the size of events, particularly the 25-year and 100-year storm, which would increase on the Gulf Coast by 2.6 and 5 inches, respectively. These more robust definitions should lead to construction and operation of facilities that can withstand large rain events.

V. AMERICAN PETROLEUM INSTITUTE STANDARDS ARE NOT PROTECTIVE BECAUSE THEY ALSO RELY ON OUTDATED ASSUMPTIONS

Industry standards established by the American Petroleum Institute also rely on the outdated assumptions in Technical Paper 40 regarding rainfall frequency.

Neither the Railroad Commission nor the Texas Commission on Environmental Quality have regulations concerning the construction of petrochemical facilities. The American Petroleum Institute has developed industry standards that have been incorporated by reference into the Code of Federal Regulations. API Standard 650 applies to Welded Steel Tanks for Oil Storage.[54]

API Standard 650 relies on Technical Paper 40 for its assumptions about rainfall volume and frequency.[55] Appendix C of Standard 650 is for external floating roof tanks. The design criteria for floating roof tanks recommend they be built to remain afloat during 250 mm (10 inches) of rainfall in a 24-hour period.[56] The standard states that, "This condition does not apply to double-deck roofs provided with emergency drains designed to keep water to a lesser volume that the roofs will safely support. Such emergency drains shall not allow the product to flow onto the roof."[57]

The primary roof drain of a floating roof tank is intended to safely drain accumulated rainwater from the roof of the tank. API Standard 650 states that:

> Primary roof drains shall be sized and positioned to accommodate the rainfall rates specified on the Data Sheet, Line 33, while preventing the roof from accumulating a water level greater than design, without allowing the roof to tilt excessively or interfere with its operation.[58]

API Standard 650 provides a Data Sheet for purchasers to use to standardize specifications when requesting bids from contractors. API Standard 650 provides

[54] American Petroleum Institute, "API 650: Welded Steel Tanks for Oil Storage" (2007) *incorporated by reference at* 49 C.F.R. §195.132(b)(3).
[55] API Standard 650, Section 2—References at p. 2-4.
[56] API Standard 650, Appendix C.3.4.1(a) at p. C-2.
[57] *Id.*
[58] API Standard 650, App. C.3.8.1 at p. C-3.

guidance for filling out the Data Sheet; Line 33 covers details for external floating roofs. The following guidance is provided on rainfall:

- Design Rainfall Intensity: Specify a rainfall rate, a minimum period of duration, and an association with a statistically occurring storm such as that found in Technical Report No. 40 (e.g., 0.5 in. per hour for 5 minutes for the 2-year storm).
- Design Accumulated 24-hour Rainfall: Specify height of water accumulated in 24 hours associated with a statistically occurring storm (e.g., 12 in. in 24 hours for the 100-year storm). See C.3.4 for minimum requirements.[59]

Line 33 of the Data Sheet appears as follows:[60]

33. **Additional Data for External Floating Roofs:**

Weather Shield? Yes ❑ No ❑ Suppl. Spec. ____________________

Rolling Ladder Req'd? Yes ❑ No ❑ Field Adjustable Legs? Yes ❑ No ❑

Design Rainfall Intensity ________In./Hr. (mm/hr) Based on a ________ Minute Duration Associated with the ____________ Storm

Design Accumulated 24-Hour Rainfall ________In. (mm) Based on the ____________ Storm

Distortion and Stability Determinations Required? Yes ❑ No ❑ Supplemental Specification ______________________________

Landed Live Load* ______

A purchaser completing the Data Sheet must specify design rainfall intensity in inches per hour (or millimeters per hour), the duration of the rainfall intensity, and the frequency of the storm. The purchaser must specify design accumulated 24-hour rainfall in inches (or millimeters) and the frequency of the storm. So, the Data Sheet requires purchasers to assume the volume and frequency of rainfall events. The guidance for completing the Data Sheet refers to TP-40.

Double-deck roofs are equipped with emergency drains. API Standard 650 dictates that emergency roof drains should be, "designed to provide drainage to prevent sinking the roof during severe rainfall events."[61] API Standard 650 does not define

[59] API Standard 650, Appendix L.3.1 at p. L-12.
[60] *Id.*at L-19.
[61] API Standard 650, App. C at C.3.8.2.

"severe rainfall events," stating instead that, "The drains shall be sized to handle the rainfall specified by the Purchaser, with a minimum diameter of NPS 4."[62]

"NPS 4" is Nominal Pipe Size 4, which has an outer diameter of 4.500 inches.[63] API Standard 650 dictates that NPS 4 pipe have a thickness dictated by Schedule 40S, which is 0.237 inches.[64] This means that emergency roof drains must have a minimum inner diameter of 4.263 inches.

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62 *Id.*

63 *See, e.g.*, https://www.engineersedge.com/pipe_schedules.htm.

64 *Id.*

CONCLUSION

Hurricane Harvey showed the consequences of failing to prepare for severe storms. Although the vulnerability of floating roof petroleum storage tanks was unknown before 2017, there is no longer any excuse not to prepare the industry for a future of larger, more intense storms.

As this survey of state regulations has shown, there are many industries that rely on outdated assumptions about rainfall volume and frequency. Texas lawmakers have steadfastly refused to update our laws and regulations to prepare for the impact of climate change. Our vulnerability to severe storms is one consequence of this refusal.

The sheer number of so-called 25-year and 100-year storms that Texas has experienced since 2000 shows that these terms are outdated and based on faulty assumptions. Updating these definitions is one way to prepare for even more extreme weather resulting from climate change.

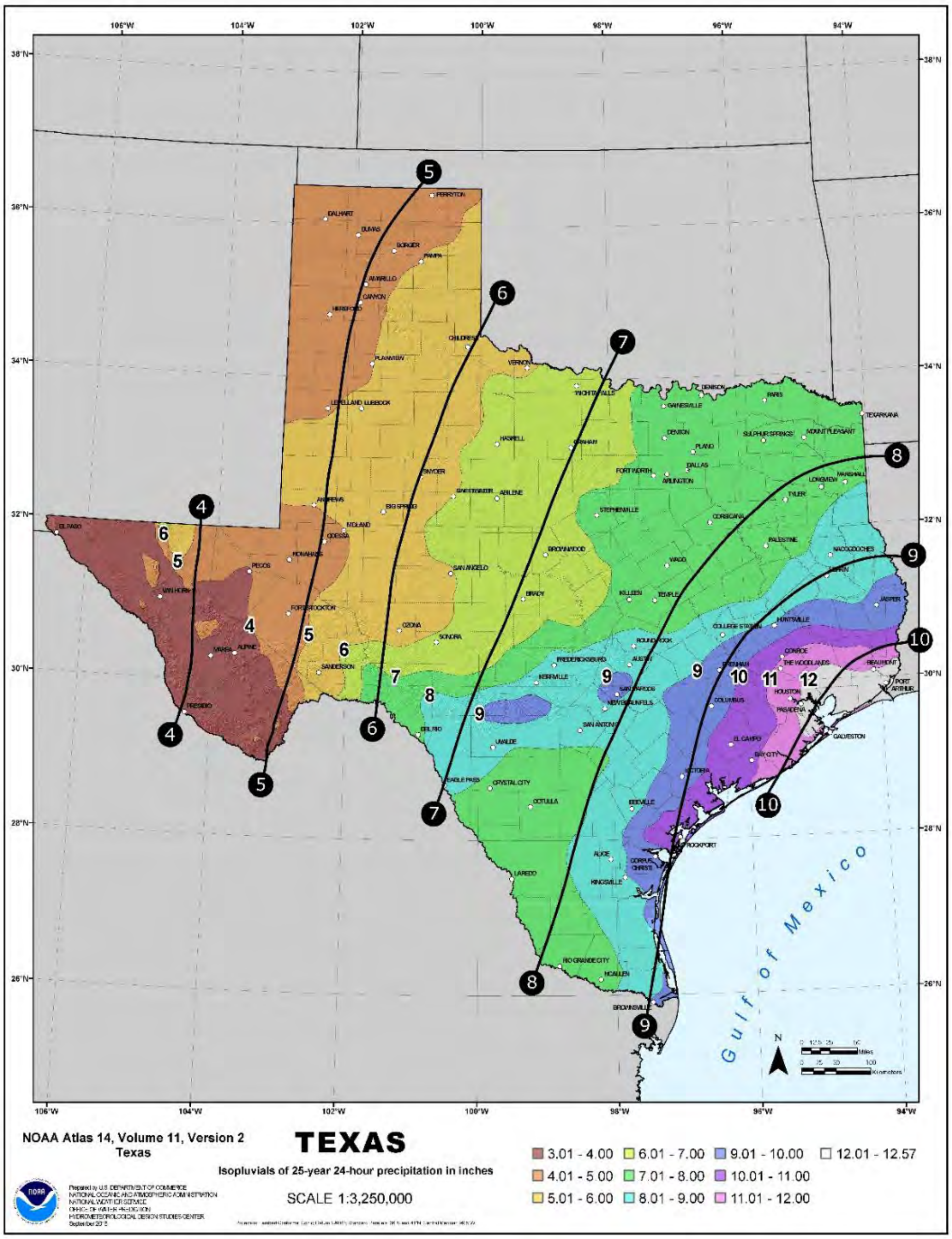
Just as the National Weather Service has redrawn its maps, it is time for Texas to redefine extreme weather. We recommend that all state codes that reference rainfall frequency and volume be updated to include definitions that cite Atlas 14. Specifically, we recommend definitions such as the following:

> 25-year, 24-hour rainfall event--The maximum rainfall event with a probable recurrence interval of once in 25 years, with a duration of 24 hours as defined by the National Oceanographic and Atmospheric Association in "NOAA Atlas 14, Volume 11 Precipitation-Frequency Atlas of the United States, Texas" or equivalent regional or state rainfall information.

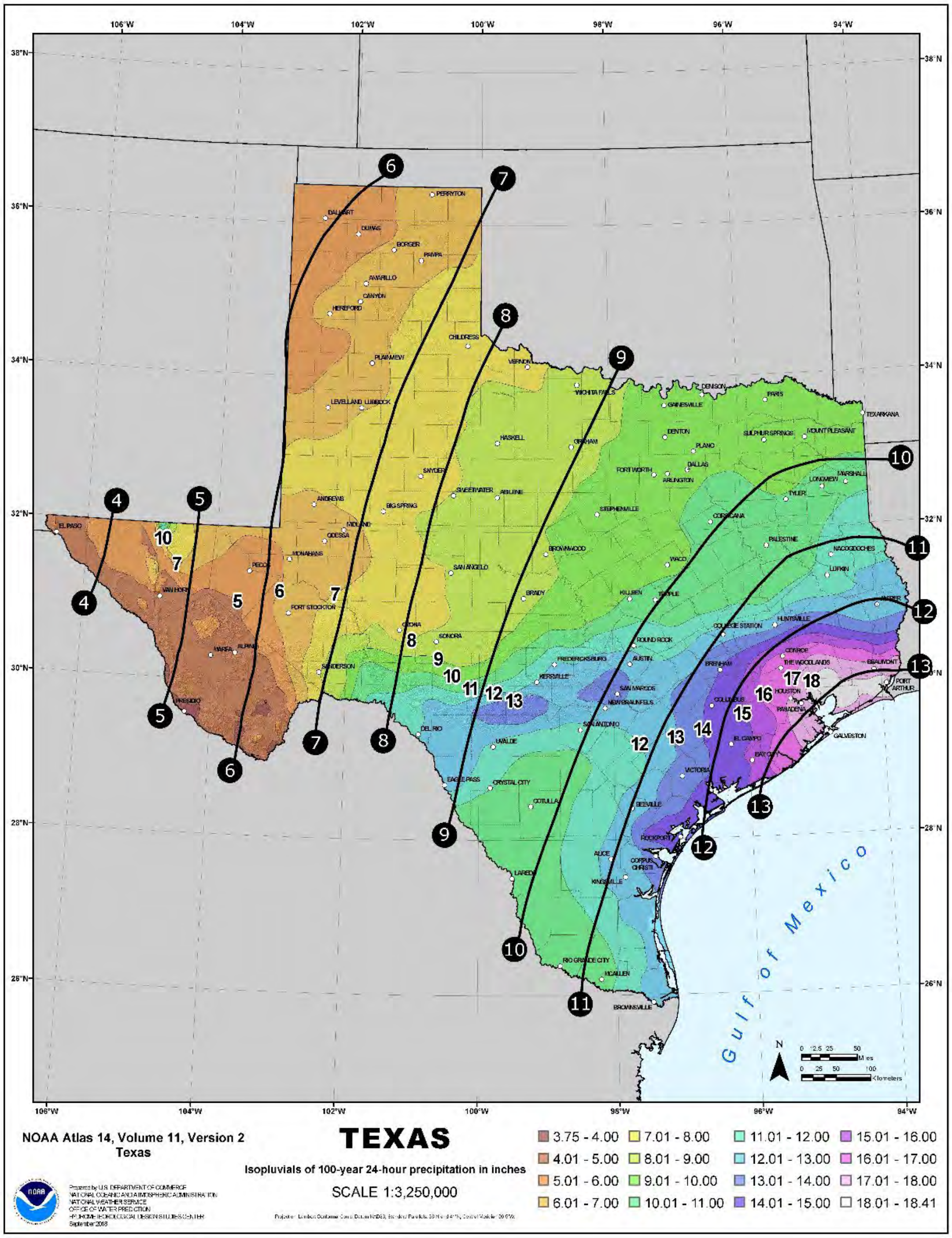
APPENDIX A: TP-40 AND ATLAS 14 COMPARISON

The maps below compare the 25-year and 100-year storm definitions from Atlas 14 and TP-40. Atlas 14 numbers are represented as colored areas with rainfall totals shown as black numbers. The older numbers from TP-40 are shown as black bars with white numbers in black circles.

25-year storm comparison



100-year storm comparison



APPENDIX B: TEXAS COMMISSION ON ENVIRONMENTAL QUALITY RAINFALL REGULATIONS

This appendix includes a plain-language explanation of rainfall regulations in use by the Texas Commission on Environmental Quality.

Chapter 217: Design Criteria for Domestic Wastewater Systems

The design criteria for domestic wastewater systems uses TP-40 to define "twenty-five year, 24-hour rainfall event."[65] This definition is used three times:

- A lift station site must be accessible by truck during all weather conditions, including a 25-year, 24-hour rainfall event.[66]
- A wastewater treatment facility must be accessible by truck during all weather conditions, including a 25-year, 24-hour rainfall event.[67]
- An evaporative lagoon system must be sized to account for the influent flows and precipitation from a 25-year frequency, one-year rainfall event.[68]

Chapter 218: Brine Evaporation Pits

Storm water retention ponds must be capable of containing the volume of storm water runoff from brine product handling areas generated from a 24-hour, 25-year storm.[69] Within the 100-year floodplain, facilities must be equipped with stormwater diversion structures capable of accommodating the 24-hour, 25-year storm.[70]

Chapter 309: Domestic Wastewater Effluent Limitation and Plant Siting

In a chapter regulating land application of sewage effluent, the design criteria for irrigation application systems include a requirement for effluent storage. The code gives detailed instructions for determining storage requirements:

[65] 30 TAC § 217.2(75).
[66] 30 TAC § 217.59(a)(2)
[67] 30 TAC § 217.328(c)
[68] 30 TAC § 217.208(c)(3)(C)
[69] 30 TAC § 218.20(b)(3)(B).
[70] 30 TAC § 218.20(b)(4).

The storage requirements shall be based on a design rainfall year with a return frequency of at least 25 years (the expected 25 year-one year rainfall, alternately the highest annual rainfall during the last 25 years of record may be used) and a normal monthly distribution, the application rate and cycle, the effluent available on a monthly basis, and evaporation losses.[71]

Chapter 311: Watershed Protection, Subchapter H: Regulation of Quarries in the John Graves Scenic Waterway

A "25-year, 24-hour rainfall event" is defined with reference to TP-40.[72] This definition is used twice:

- There is an exemption from effluent limitations for discharges from quarries resulting from a rainfall event greater than the 25-year, 24-hour rainfall event.[73]
- The final control structure for wastewater and stormwater must be designed to impound the volume of water resulting from a 25-year, 24-hour rainfall event.[74]

Chapter 312: Sludge Use, Disposal, and Transportation

A "25-year, 24-hour rainfall event" is defined with reference to TP-40.[75] The definition is used once: the runoff collection system for an active sludge unit must have the capacity to handle runoff from a 25-year, 24-hour rainfall event.[76]

Chapter 321: Control of Certain Activities by Rule

Chapter 321 of Title 30 of the Texas Administrative Code is an assortment of regulations for operations not found elsewhere in the code. The chapter includes several definitions of rainfall events. Both a "twenty-five-year, 24-hour rainfall event"[77] and a "10-year, 24-hour precipitation event"[78] are defined with reference to TP-40.

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71 30 TAC § 309.20(b)(3)(B).
72 30 TAC § 311.71(1).
73 30 TAC § 311.79(2).
74 30 TAC § 311.80(1)(C).
75 30 TAC § 312.8(1).
76 30 TAC § 312.64(g).
77 30 TAC § 321.32(59).
78 30 TAC § 321.72(19).

As discussed above, Chapter 321 includes regulations for Concentrated Animal Feeding Operations and the only two references to Technical Paper 49 in state code. These references are in the definition of "twenty-five-year, ten-day rainfall event"[79] and the definition of "design rainfall event."[80]
The following operations are controlled by Chapter 321.

Concentrated Animal Feeding Operations

The operator of the CAFO shall design, construct, operate, and maintain retention control structures to contain all wastewater including the runoff and direct precipitation from the 25-year, 24-hour rainfall event for the location of the facility.[81] The control facility design requirements for CAFOs contain numerous references to the "design rainfall event" and the "25-year, 24-hour rainfall event."[82]

Meat Processing

Any holding facility shall be designed and operated to retain all rainwater which would enter the holding facilities as a result of a 25-year, 24-hour rainfall.[83]
Wastewater must be isolated from outside surface drainage by diversion structures designed to be effective during peak flows of a 25-year, 24-hour rainfall event.[84]

Surfacing Coal Mining

Any retention pond or series of ponds shall be designed to treat at least the volume of water caused by a 10-year, 24-hour precipitation event.[85]

Any discharge or increase in volume of a discharge caused by precipitation of greater than the 10-year, 24-hour precipitation event or series of events shall, at a minimum, comply with the following limitations instead of the otherwise

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[79] 30 TAC § 321.32(58).
[80] 30 TAC § 321.32(20) (The "design rainfall event" is either the 24-hour or 10-day 25-year rainfall event, depending on the regulatory provision within the subchapter.).
[81] 30 TAC § 321.37(d)(1).
[82] *See generally* 30 TAC §321.38.
[83] 30 TAC § 321.54(1) (defining "25-year, 24-hour rainfall event" with reference to TP-40).
[84] 30 TAC § 321.54(4).
[85] 30 TAC § 321.78(b)(1).

applicable limitations: pH within the range of 6.0 to 9.0 standard units at all times.[86]

Chapter 324: Used Oil Standards

Used oil handling facilities must be equipped with secondary containment facilities with sufficient freeboard to contain the precipitation from a 25-year, 24-hour rainfall event.[87]

Chapter 326: Medical Waste Management

The owner or operator of a medical waste facility must complete a surface water drainage report that certifies that the facility will be constructed to manage "run-on and run-off during the peak discharge of a 25-year rainfall event."[88] The facility must also either be located outside the 100-year floodplain or be able to prevent washout of waste during a 100-year storm event.[89]

Chapter 330: Municipal Solid Waste

Contaminated water and leachate may be collected and stored in a collection unit other than a storage tank. These units must include one foot of freeboard to accommodate a 25-year, 24-hour rainfall event.[90]

Storage and transfer units and surface impoundments must be designed to withstand a 25-year, 24-hour rainfall event.[91]

Chapter 331: Underground Injection Control

Injection wells located in flood-prone areas include certain additional completion requirements. A "flood-prone area" is defined with reference to FEMA Flood Hazard Maps of the 100-year and 50-year flood plains.[92]

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[86] 30 TAC § 321.78(b)(2).
[87] 30 TAC § 324.22(d)(3)(B)(ii).
[88] 30 TAC §326.71(f)(1).
[89] 30 TAC §326.71(f)(4).
[90] 30 TAC §330.207(b).
[91] 30 TAC §330.63(d)(1)(B),(3)(B).
[92] 30 TAC §331.132(f).

Chapter 332: Composting

Composting facilities must be constructed to protect surface water. Construction, maintenance, and operations must manage run-on and run-off from a 25-year, 24-hour rainfall event.[93]

Chapter 335: Industrial Solid Waste and Municipal Hazardous Waste

Certain standards apply when the leachate or run-off from a waste pile is a hazardous waste. A run-on control system must prevent flow on the active portion of the waste pile during a 100-year storm. A run-off management system must collect and control the water from a 24-hour, 100-year storm.[94]

Storage or processing facilities, land treatment facilities, and waste piles may not be located in the 100-year floodplain unless they are designed to prevent the physical transport of hazardous waste during a 100-year flood event.[95]

Chapter 336: Radioactive Substance Rules

Low-level radioactive waste may not occur in the 100-year flood plain.[96] The disposal site for near-surface land disposal of low-level radioactive waste may not be in a county in which the average annual rainfall is greater than 20 inches.[97]

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93 30 TAC §332.37(1).
94 30 TAC §335.120(1).
95 30 TAC §335.204(a)(1), (b)(1), (c)(1).
96 30 TAC §336.728(d).
97 30 TAC §336.728(n).

APPENDIX C: TEXAS ADMINISTRATIVE CODE REFERENCES TO RAINFALL EVENTS

Agency	Code Citation	Code Summary	Precipitation Size/ Event	Reference
RRC	16 TAC §§ 4.219(b)(1), 4.240(b), 4.256(b)(1), 4.272(b)(1)	Solid Oil and Gas Waste Recycling No facility within 100-year flood plain.	100-year flood plain	
RRC	16 TAC §§ 4.232(7), 4.248(7), 4.264(7), 4.280(7)	Solid Oil and Gas Waste Recycling Facility map must include location of 100-year flood plain.	100-year flood plain	
RRC	16 TAC §§4.214, .234, .250, .266, .282	Solid/Liquid Oil and Gas Waste Recycling Stormwater runoff plan for 25-year-24-hour event.	25-year, 24-hour	
RRC	16 TAC §12.341(b)(3), (c)(3)	Surface Mining: Hydrologic Balance Diversion stream design adequate for peak stormwater runoff for 10-year (or 100-year) 6-hour event.	10-year, 6-hour (temporary diversion); 100-year, 6-hour (permanent diversion)	
RRC	16 TAC §12.364(e)	Surface Mining: Disposal of Excess Spoil - Valley Fills Diversion channels designed for surface runoff from 100-year 24-hour event.	100-year, 24-hour	"Specified by the [Railroad Commission of Texas]"
	16 TAC §12.395(c)(2), (3)	Surface Mining: Revegetation Responsibility period for revegetation based on an area's rainfall of more or less than 26.0 inches annually.	26" annual average precipitation	
RRC	16 TAC §3.8(a)(46)	Oil and Gas Division - Water Protection "100-year flood plain" definition.	100-year flood plain	FEMA, or USDA soil maps
RRC	16 TAC §3.8(d)(4)(H)(iv)(I)	Oil and Gas Division - Water Protection Pits must be located outside 100-year floodplain.	100-year flood plain	FEMA, or USDA soil maps

RRC	16 TAC §4.204	Commercial Recycling "100-year flood plain" definition.	100-year flood plain	
RRC	16 TAC §8.206(e)(4)	Pipeline Safety - Natural Gas Consider pipeline leak increase due to "significant amounts or extended periods of rainfall."	"Significant amounts or extended periods of rainfall"	
TCEQ	30 TAC §217.2(75); (76)	Design Criteria for Domestic Wastewater Systems "25-year, 24-hour event" definition by TP-40.	25-year, 24-hour; 2-year, 24-hour	TP-40
TCEQ	30 TAC §217.2(75); (76)	Design Criteria for Domestic Wastewater Systems "2-year, 24-hour event" definition by TP-40.	25-year, 24-hour; 2-year, 24-hour	TP-40
TCEQ	30 TAC §217.208	Design Criteria for Domestic Wastewater Systems Evaporative lagoon system design for 25-year, 1-year event.	25-year, 1-year	30 TAC §309.20(b)(3)(B)
TCEQ	30 TAC §217.250(e)(2)(A)(ii)	Design Criteria for Sludge Processing Sludge drying area design in areas with "less than 45 inches annual rainfall."	"less than 45 inches annual rainfall"	NOAA
TCEQ	30 TAC §217.35	Wastewater Treatment Facility Design Requirements "100-year flood plain" definition by FEMA.	100-year flood plain	FEMA
TCEQ	30 TAC §218.20(a)(1)	Brine Evaporation Pits Brine evaporation pit location in 100-year flood plain.	100-year flood plain	
	30 TAC §218.20(b)(3)(B)	Brine Evaporation Pits Stormwater retention design for 24-hour, 25 year event.	25-year, 24-hour event	
TCEQ	30 TAC §218.20(b)(4)	Brine Evaporation Pits Stormwater diversion structures for siting in 100-year flood plain; requirement to withstand 24-hour-25 year event.	100-year flood plain; 24-hour, 25-year storm	
TCEQ	30 TAC §285.33(b)(1)(A)(ii)	Effluent Disposal Systems Excavation depth five feet maximum in areas with less than 16 inches annual precipitation.	<26"/year annual precipitation	Climate Atlas of Texas, 1983

TCEQ	30 TAC §285.33(b)(2)	Effluent Disposal Systems Evapotranspirative systems "where the annual average evaporation exceeds the annual rainfall."	"where the annual average evaporation exceeds the annual rainfall."	[see 30 TAC 285.91(7)]
TCEQ	30 TAC §285.91(7)	On-site sewage facilities Location criteria based on "yearly net evaporation."	Yearly Average Net Evaporation	
TCEQ	30 TAC §309.11(7)	Wastewater Treatment Plants "100-year flood plain" definition.	100-year flood plain	
TCEQ	30 TAC §309.13(a)	Wastewater Treatment Plants Siting in 100-year flood plain.	100-year flood plain	[see 30 TAC 309.11]
TCEQ	30 TAC §309.20(b)(3)(B)	Wastewater Treatment Plants Study of effluent storage requirements based on 25-year, 1-year event.	25 year-one year event	
TCEQ	30 TAC §311.74(b)(2)	Quarries in the John Graves Scenic Riverway Permit in 100-year flood plain.	100-year flood plain	
TCEQ	30 TAC §311.79	Quarries in the John Graves Scenic Riverway "25-year, 24-hour rainfall event" definition by TP-40.	25-year, 24-hour event	TP-40
TCEQ	30 TAC §311.80(1)(C)	Quarries in the John Graves Scenic Riverway Control structure design for 25-year, 24-hour event.	25-year, 24-hour event	TP-40 [See 30 TAC 311.71]
TCEQ	30 TAC §312.64(b)	Sludge Use, Disposal, and Transportation Active sludge unit shall be not located within the 100-year floodway.	100-year floodway	
TCEQ	30 TAC §312.64(g)	Sludge Use, Disposal, and Transportation Runoff collection system capacity for 25-year, 24-hour event.	25-year, 24-hour event	TP-40 [see 30 TAC 312.8(1)]
TCEQ	30 TAC §312.8(1)	Sludge Use, Disposal, and Transportation "25-year, 24-hour rainfall event" definition by TP-40	25-year, 24-hour rainfall event	TP-40
TCEQ	30 TAC §317.2(c)(5)(C)	Sewage Collection Systems (design criteria prior to 2008) Manhole cover design in 100-year floodplain.	100-year flood plain	

TCEQ	30 TAC §317.4(a)(2)	Wastewater Treatment Facilities (design criteria prior to 2008) Treatment plant design for "wet weather, maximum 30-day average flow."	"wet weather, maximum 30-day average flow"	
TCEQ	30 TAC §317.4(a)(4)	Wastewater Treatment Facilities (design criteria prior to 2008) Treatment unit design for 2-year, 24-hour event.	2-year, 24-hour rainfall event	Figure: 30 TAC §317.9
TCEQ	30 TAC §317.9 Appendix A	Wastewater Treatment Facilities (design criteria prior to 2008) Map defining 2-year, 24-hour rainfall event.	24-hour rainfall at a two-year frequency	[map defining rainfall frequency]
TCEQ	30 TAC §321.255(f)	Livestock Trailer Cleaning Facilities Waste pond design for 10-year, 24-hour event.	10-year, 24-hour rainfall event	
TCEQ	30 TAC §321.32(20)	Concentrated Animal Feeding Operations "Design rainfall event" definition by TP-40 or TP-49.	"Design rainfall event"	TP-40 or -49
TCEQ	30 TAC §321.32(39)	Concentrated Animal Feeding Operations "100-year flood plain" definition.	100-year flood plain	
TCEQ	30 TAC §321.32(58)	Concentrated Animal Feeding Operations "25-year, 10-day event" definition by TP-49 "or equivalent regional or state rainfall information."	25-year, 10-day rainfall event	TP-49; USDA, Two-to-Ten Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States (1964)
TCEQ	30 TAC §321.32(59)	Concentrated Animal Feeding Operations "25-year, 24-hour event" definition by TP-40 "or equivalent regional or state rainfall information."	25-year, 24-hour rainfall event	TP-40
TCEQ	30 TAC §321.37(d)(1)	Concentrated Animal Feeding Operations Retention Control Structure design to 25-year, 24-hour event.	25-year, 24-hour event	
TCEQ	30 TAC §321.38(e)(7)(A)	Concentrated Animal Feeding Operations Retention Control Structure designed for 25-year, 24-hour event.	25-year, 24-hour rainfall event; design rainfall event	
TCEQ	30 TAC §321.38(d)	Concentrated Animal Feeding Operations Control facility location in 100-year flood plain.	100-year flood plain	[see 30 TAC 321.32(39)]
TCEQ	30 TAC §321.39(e)	Concentrated Animal Feeding Operations Manure and sludge storage in 100-year flood plain.	100-year flood plain	[see 30 TAC 321.32(39)]

TCEQ	30 TAC §321.54	Meat Processing Wastewater holding facility design for 25-year, 24-hour event.	25-year, 24-hour event	TP-40, or the latest revision thereof
TCEQ	30 TAC §321.72(19)	Surface Coal Mining "10-year, 24-hour precipitation event" definition by TP-40.	10-year, 24-hour rainfall event	TP-40
TCEQ	30 TAC §324.22(d)(3)(B)(ii)	Used Oil Recycling Used oil handling facility must design secondary containment for 25-year, 24-hour event.	25-year, 24-hour rainfall event	
TCEQ	30 TAC §326.71(f)(1),(4)	Medical Waste Management Facility Medical waste facility runoff design for 25-year event and location in 100-year floodplain.	25-year rainfall event; 100-year floodplain	
TCEQ	30 TAC §330.207(b)	Municipal Solid Waste Contaminated water and leachate containment design for 25-year, 24-hour event.	25-year, 24-hour rainfall event	
TCEQ	30 TAC §330.63(d)(1)(B),(3)(B)	Municipal Solid Waste Storage and transfer unit design for 25-year, 24-hour event.	25-year, 24-hour rainfall event	
TCEQ	30 TAC §331.132(f)	Aquifer Storage and Recovery Injection Well placement in 100-year or 50-year floodplain.	100-year flood plain; 50-year flood plain	FEMA
TCEQ	30 TAC §332.37(1)	Composting Facilities Facility design for 25-year, 24-hour event.	25-year, 24-hour rainfall event	
TCEQ	30 TAC §335.120	Hazardous Waste Runoff management design for 100-year, 24-hour event.	100-year; 24-hour, 100-year storm	
TCEQ	30 TAC §335.204(a)(1), (b)(1), (c)(1)	Hazardous Waste Hazardous waste facility location in 100-year floodplain and design for 100-year event.	100-year floodplain; 100-year flood event	
TCEQ	30 TAC §336.728(d)	Low-level Radioactive Waste Disposal No waste disposal in 100-year flood plain.	100-year flood plain	FEMA
TCEQ	30 TAC §336.728(n)	Low-level Radioactive Waste Disposal No siting where average annual rainfall is greater than 20 inches.	>20 inches annual rainfall	

Coastal Coordination Advisory Committee	31 TAC §501.19(a)	Coastal Management Program - Solid Waste Facilities Hazardous waste landfill/facility design for 100-year flood event.	100-year flood event	Flood Hazard Boundary Map or Flood Insurance Rate Map (FEMA?)
Texas Department of Agriculture	4 TAC §30.60	Disaster Relief Funds No FEMA buyout if property was purchased after being mapped in flood plain.	flood plain	FEMA

www.citizen.org

Exhibit 18

WASTE CONNECTIONS

Connect with the Future®

2022

SUSTAINABILITY REPORT

IN THIS REPORT

ABOUT WASTE CONNECTIONS

Waste Connections is an integrated solid waste services company that provides non-hazardous waste collection, transfer and disposal services, along with resource recovery primarily through recycling and renewable fuels generation. The Company serves more than eight million residential, commercial and industrial customers in mostly exclusive and secondary markets across 43 states in the U.S. and six provinces in Canada. Waste Connections also provides non-hazardous oilfield waste treatment, recovery and disposal services in several basins across the U.S., as well as intermodal services for the movement of cargo and solid waste containers in the Pacific Northwest. For more information, visit Waste Connections at www.wasteconnections.com.

FORWARD-LOOKING STATEMENT

We make statements in this report that are forward-looking in nature. These include:

- Statements regarding our sustainability initiatives, including reduction in greenhouse gas emissions, biogas recovery, recycling, throughput of on-site leachate processing, fleet emissions and efficiency, material recovery, biodiversity and site closures;
- Discussion of safety, voluntary turnover rates, employee engagement, diversity and inclusion, employee development and training and Servant Leadership scores;
- Targets for improvements and investments;
- Statements regarding our Governance and Ethics, including the Board of Director's role in risk oversight, shareholder outreach and communications, integration of ESG metrics into management compensation, data security and privacy, environmental policies and environmental justice; and
- Other statements on a variety of topics such as the coronavirus disease 2019 ("COVID-19") pandemic.

Important factors that could cause actual results to differ, possibly materially, from those indicated by the forward-looking statements include, but are not limited to, risk factors detailed from time to time in the Company's filings with the SEC and the securities commissions or similar regulatory authorities in Canada. There may be additional risks of which we are not presently aware or that we currently believe are immaterial that could have an adverse impact on our business. You should not place undue reliance on forward-looking statements, which speak only as of the date of this report. Waste Connections undertakes no obligation to update the forward-looking statements set forth in this press release, whether as a result of new information, future events, or otherwise, unless required by applicable securities laws.

LETTER FROM THE CHIEF EXECUTIVE OFFICER

Thank you for your interest in sustainability at Waste Connections. As an environmental services company with a culture built on Servant Leadership and a focus on safety, Waste Connections is committed to environmental stewardship in a safe and inclusive environment for engaged and empowered employees.

We have backed up our commitment with the establishment of long-term, aspirational sustainability targets, including the recent addition of an emissions reduction goal. We have a demonstrated track record of progress toward achievement of these targets, along with continued refinement and expansion of the disclosure we provide for our stakeholders.

We are proud of our progress in 2021, a year of outsized growth for the Company, with revenues expanding by 13% from the prior year, including 4% contribution from acquisitions. Despite that outsized growth and expanded footprint, we achieved further reductions in absolute Scope 1 and 2 emissions, driving emissions intensity down 12% in 2021 and *resulting in a two-year reduction in emissions intensity of over 18%*. We enhanced our "net zero" status and increased our net climate benefit to 3.4x, the ratio that our operational offsets exceed our emissions. This increase was possible through the combination of lower emissions and higher operational offsets, primarily due to increases in renewable fuel generation and recyclables processing.

In 2021, we increased renewable gas beneficially reused for energy, expanded the use of robotics at our recycling facilities, completed an over $10 million multi-year upgrade to safety-related camera systems across our fleet, and substantially completed construction of two leachate treatment facilities, which will further enhance our capabilities for on-site treatment. In 2021, we also improved upon our already better than industry average safety statistics and saw record levels of employee engagement, following the challenges of the global pandemic and its impact on the health and well-being of our employees, which we continue to address through an investment of over $50 million since early 2020.

Moreover, our efforts and progress toward achievement of our long-term aspirational targets are continuing in 2022 through the expected investment of over $100 million for the construction of additional facilities — two "next generation" recycling facilities and two renewable natural gas facilities at our landfills, all of which are scheduled to be operational by 2024.

> ***Sustainability efforts are integral to our business, driven by an intentional focus and investments that are consistent with our objective of long-term value creation and part of who we are as Waste Connections.***

We also provided expanded disclosure to include Environmental Justice considerations, supplemented our diversity metrics with EE0-1 data, and aligned our sustainability report content with the reporting recommendations outlined by the Task Force on Climate-related Financial Disclosures (TCFD). Looking ahead, we are broadening our commitment to the environment by adding a new target to reduce Scope 1 and 2 emissions by 15%. Additionally, we are adding a target seeking continuous improvement in emissions intensity — a critical goal for a growth-oriented company. Further, we recognize that ESG-related disclosure and stakeholder needs are constantly evolving and therefore we are committing to work toward the adoption of a Science-Based Target Initiative (SBTi) emissions reduction target.

At Waste Connections, our vision of sustainability starts with our people. We are excited to be back together again following the pandemic, particularly in our 25th anniversary year, with a record amount of *in-person* training and opportunities for celebration and collaboration; expanded efforts directed toward recruiting and retention; and a continued focus on giving back to our communities. At Waste Connections, we believe that relationships matter. We will rely on our relationships and Servant Leadership-driven culture to support our employees and communities, including those that have recently been negatively impacted by Hurricane Ian.

Through this report, we invite you to meet the Waste Connections team and see their visions of sustainability, from empowered local team members making a difference in their communities to our sustainability leadership team working toward achievement of our goals. Thank you again for your interest in sustainability at Waste Connections.

Worthing F. Jackman
President and Chief Executive Officer

25 YEAR ANNIVERSARY

2021 Highlights

↑13%
Revenue growth

↓12%
Reduction in Scope 1 and 2 emissions intensity

~$400M
Acquired annualized revenue

~20%
Adjusted Free Cash Flow growth

18
Consecutive years of positive Total Shareholder Return

Summary of Performance Statistics

	2019	2020	2021
HEALTH AND SAFETY			
Employee Hours	44,637,413	46,279,544	48,702,130
Reportable Incident Rate[2]	17.4	15.4	15.4
Total Recordable Injury Rate (TRIR)	2.9	2.9	3.3
Experience Modifier Rate	0.54	0.62	0.63
PEOPLE			
Total Employees as of Year End	18,204	18,933	19,998
Voluntary Turnover	17.8%	14.6%	21.1%
% of Employees That Are Women[3]	16.0%	16.0%	16.0%
% of Employees That Are Ethnic Minorities[3]	40.0%	38.0%	39.0%
% of Employees from Armed Services[3]	8.0%	8.0%	8.0%
TRAINING / LEADERSHIP DEVELOPMENT			
# of Sessions	168	231	274
Employees in Virtual or In-Person Training Sessions	5,215	12,474	12,572
% of Total Employees	28.6%	65.9%	62.9%
FINANCIAL STATISTICS ($000 USD)			
Revenue	$5,388,679	$5,445,990	$6,151,361
Net Cash Provided by Operating Activities	$1,540,547	$1,408,521	$1,698,229
FACILITIES			
Hauling Operations	300	311	334
Landfills	96	91	97
Transfer Stations	175	185	195
Intermodal Facilities	6	6	6
Recycling Facilities	66	68	71
E&P Liquid Waste Injection Wells	23	23	23
E&P Waste Treatment and Oil Recovery Facilities	19	19	19
TOTAL	**685**	**703**	**745**

	2019	2020	2021
FLEET			
Total Routed Collection Vehicles	8,089	8,912	9,162
Total Routed CNG Collection Vehicles	1,119	1,166	1,090
Routed CNG Trucks as % of Routed Trucks	13.8%	13.1%	11.9%
LANDFILL TONS (TONS PER YEAR)			
Municipal Solid Waste	28,922,292	27,831,800	28,929,584
Special Waste	11,943,036	10,773,600	11,734,314
C&D	7,098,672	6,284,600	6,548,102
TOTAL	**47,964,000**	**44,890,000**	**47,212,000**
RECYCLED COMMODITIES (TONS PER YEAR)			
Old Corrugated Cardboard	452,668	524,787	662,193
Old Newspaper	39,939	39,368	50,855
Mixed/Other Paper	395,511	316,445	276,779
Glass	108,034	108,629	123,283
Metal	64,459	84,247	105,737
Aluminum	5,726	5,922	24,317
Plastics	95,134	90,119	54,053
Commingled / Other	538,046	611,289	547,410
TOTAL	**1,699,517**	**1,780,806**	**1,844,627**
LANDFILL GAS RECOVERY SYSTEMS			
# of Landfill Gas Recovery Systems	53	53	53
# of Power Generation Systems	25	28	27
Annual Standard Cubic Feet Collected for Energy (billions)	26.6	28.5	29.2
LFG Sales as % of Revenue	1.0%	1.1%	1.5%

1. All data provided here has been subject to internal review and is believed to be correct at the time of reporting.
2. 12-month rolling incident rate defined as the number of all reportable incidents per 200,000 employee hours worked, both preventable and non-preventable.
3. % of calculation excludes individuals that did not disclose; 2020 % decreased due to impact from more employees self-disclosing.

ESG HIGHLIGHTS

At Waste Connections our ESG objectives are integral to our strategy to drive value creation for all stakeholders.

ENVIRONMENTAL

>3.4x **Beyond Net Zero:** Our offsets from operations exceed our emissions

18% **2-year reduction** in Scope 1 and 2 emissions intensity

Lowest emissions intensity among national solid waste peers

$500M commitment to achieve aspirational targets

$100M expected capital expenditures in 2022 for two recycling facilities and two Renewable Natural Gas plants

SOCIAL

Servant Leadership Culture a differentiator

OSHA "TRIR" record better than industry average

$50M in frontline support since pandemic

Diversity and Inclusion scores included in annual Servant Leadership surveys

GOVERNANCE

Board of Directors oversight of ESG

ESG targets incorporated into management compensation

Robust environmental policy

OUR JOURNEY

2018
- Initial Sustainability Report
- GRI framework with Scope 1, 2 and 3 data

2019
- Added Diversity Policy
- Added SASB framework

2020
- Introduced ESG targets with Board oversight
- Committed $500M to achievement of targets
- Appointed VP of Engineering and Sustainability

2021
- Incorporated ESG targets into management compensation
- Expanded disclosure of Environmental, Human Rights and Cybersecurity policies

2022
- Added new emissions targets seeking an absolute reduction and further improvement in emissions intensity
- Added TCFD framework
- Disclosed EE0-1 data
- Introduced ESG hub

OUR SUSTAINABILITY TARGETS

The following metrics represent our fifteen-year, aspirational targets, with 2018 as the baseline year. We have been pursuing many of these initiatives since our inception in 1997 and began incorporating them into long-term incentive compensation in 2021. In addition, in 2022 we are expanding our commitment to the environment by introducing a target to reduce absolute Scope 1 and 2 emissions by 15%. Additionally, we are adding a target seeking continuous improvement in emissions intensity.

RECYCLING

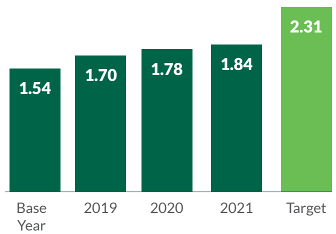
50%

Increase resources recovered by at least 50%

☑ ON TRACK

RECYCLING

MEASURED IN TONS (MIL)



BIOGAS RECOVERY

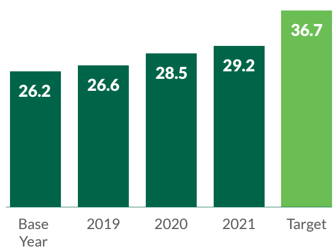
40%

Increase biogas recovery by at least 40%

☑ ON TRACK

BIOGAS RECOVERY

MEASURED IN STANDARD CUBIC FEET (BIL)



LEACHATE

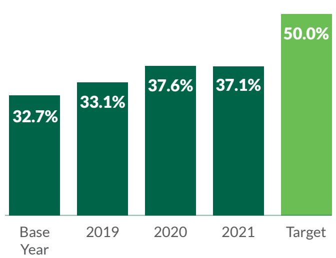
50%

Process at least 50% of leachate on-site

☑ ON TRACK

LEACHATE PROCESSED ON-SITE

MEASURED BY PERCENTAGE



INCIDENT RATE

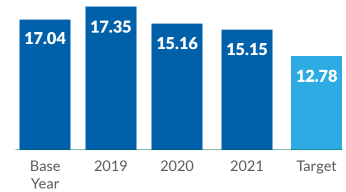
25%

Reduction in Incident Rate

☑ ON TRACK

INCIDENT RATE

INCIDENTS PER 200,000 WORK HOURS

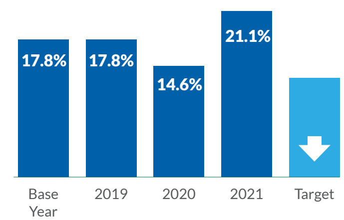


VOLUNTARY TURNOVER

Continuous Improvement

VOLUNTARY TURNOVER

MEASURED BY PERCENTAGE



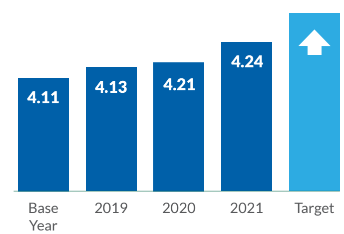
SERVANT LEADERSHIP

Continuous Improvement in Servant Leadership Scores

☑ ON TRACK

SERVANT LEADERSHIP

ON A SCALE 1-5



Target Progress

Waste Connections' sustainability efforts are ongoing and consistent with our strategic focus on value creation. That said, we recognize the importance of demonstrating our commitment to advance ESG efforts through the identification of priorities, establishment of targets and communication of our related progress.

As part of our commitment to provide increased transparency, we introduced fifteen-year aspirational sustainability targets in 2020 and backed up those efforts with a $500 million commitment toward their achievement. Our Vice President of Engineering and Sustainability has responsibility for oversight of our Environmental Management System and management of many of our sustainability efforts.

Senior management reviews targets annually and discusses current and future progress, as well as potential additions to existing targets. In 2022, we expanded our targets by introducing a goal to reduce absolute Scope 1 and 2 emissions, as well as a target to achieve continuous improvement in emissions intensity. Progress toward achievement of our fifteen-year aspirational targets is incorporated into management compensation and reviewed by our Board of Directors.

Our 2021 results reflect continuous improvement toward many of our targets, including lower emissions despite the outsized growth we achieved during the period, as well as higher operational offsets or avoided emissions through our operations. In fact, our emissions intensity measured as a percentage of revenue declined by 12% in 2021, driving a two-year reduction of 18%.

Our carbon footprint, already net negative or "climate positive," improved by another 6% in 2021 to 3.4 times. ***For every metric ton of carbon generated through the management of our customers' waste and recyclables, we eliminated 3.4 metric tons of carbon through our operations, primarily through recycling, energy production, and carbon sequestration.***

We also saw continued improvement in our already elevated levels of employee engagement, as measured by Servant Leadership scores, and our safety incident rate, despite the realities of a challenging labor environment. And finally, in 2021, we made investments to position ourselves for continued improvement and progress toward furthering our efforts.

"We are uniquely positioned as an industry to benefit the environment through increased Renewable Natural Gas generation at our landfill assets as we deploy technologies to minimize fugitive emissions and maximize gas capture"

Kurt Shaner
Vice President – Engineering & Sustainability

ENVIRONMENTAL STEWARDSHIP

ENVIRONMENTAL STEWARDSHIP

As an environmental services company, Waste Connections is committed to environmental stewardship. As we manage and responsibly grow our business, we recognize the importance of minimizing our impact on the environment and the communities we are privileged to serve. As such, our objectives emphasize environmental compliance, resource efficiency, the incorporation of biodiversity into site closure plans, as well as communication and collaboration with our stakeholders.

With a net negative carbon footprint by a factor of over three times and an 18% reduction in Scope 1 and Scope 2 emissions intensity over the past two years, our results demonstrate the effectiveness of our efforts and reflect progress toward achieving our environmental offset targets. In addition to our Environmental Policy that effectively serves as a guidepost for our standards, we emphasize training, employee engagement, accountability and oversight to achieve our environmental objectives.

Looking ahead, we anticipate further improvements through continued expansions of our resource recovery capacity and beneficial reuse of landfill gas resulting from 2022 capital expenditure commitments of approximately $100 million for new facilities. These include two greenfield "next generation" recycling facilities in existing markets and new Renewable Natural Gas (RNG) production facilities at two of our landfills, all of which are scheduled for completion by 2024. In addition to these post-collection initiatives, we continue to evaluate the potential for the utilization of new technologies, including the introduction of fully electric, zero emission collection trucks, in the future.

WE ACHIEVED
18%
REDUCTION
Scope 1 & 2 emissions intensity over the last two years

"NET ZERO" CARBON FOOTPRINT — GOING BEYOND

The collection and responsible handling of our customers' solid waste, along with the biodegradation process for certain waste streams within a landfill, result in the generation of carbon emissions. Recognizing the impact of emissions on climate change, we focus on both their mitigation and the expansion of operational offsets, through recycling and beneficial use of landfill gas.

The largest source of emissions at our operations result from our landfills, where our customers' putrescible waste breaks down over time and produces landfill gas, which we actively work to recover and beneficially reuse. To that end, we install gas collection and control systems, often in advance of regulatory requirements. In order to mitigate fugitive emissions, we deploy drones at several of our landfills to detect potential breaches, utilize temporary cover systems to encapsulate the gas for beneficial reuse and modernize and expand gas collection systems. Where feasible, we beneficially convert the gas to electricity or Renewable Natural Gas (RNG) that can be injected into a gas transmission pipeline.

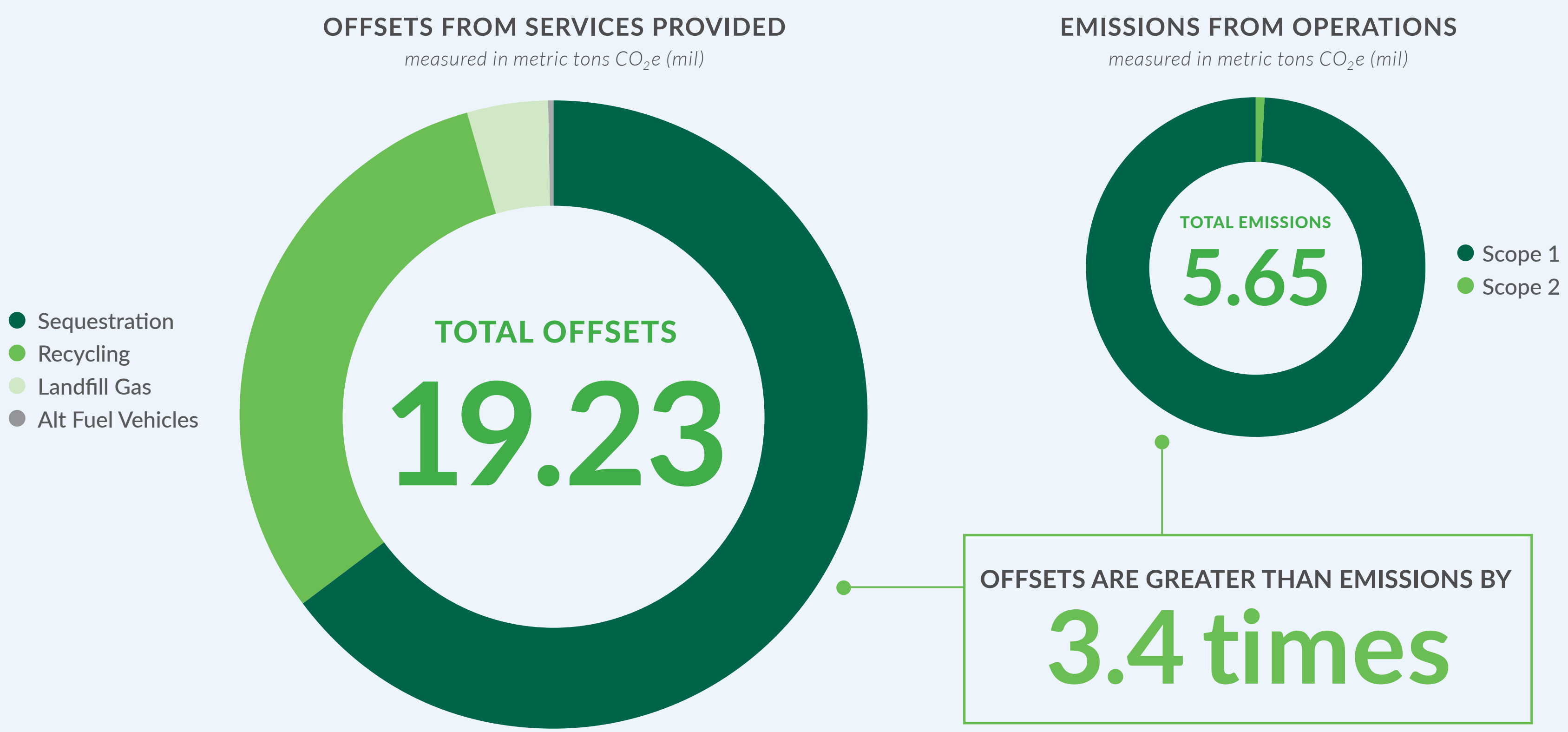
Along with carbon that is permanently sequestered in our landfills, our recycling services and beneficial reuse of landfill gas avoided 19.2 million metric tons of CO_2e in 2021. These offsets or avoided emissions exceeded absolute emissions generated from operations by 3.4 times, putting us in a net negative or climate positive carbon footprint position. These results reflect the benefit of reductions in Scope 1 and 2 emissions in both 2020 and 2021, with two-year improvement of 7%, as well as 6% growth in operational offsets during that period.

Consistent with our Environmental Policy, we actively promote the efficient use of resources and in many instances beneficially reuse or divert materials from landfill disposal. For instance, in 2021, we were able to reclaim over three million gallons of petroleum from our E&P waste operations for beneficial reuse in other applications. In addition to processing recyclables at our material recovery facilities (MRFs), we also segregate additional materials at many landfills, and over the last two years we beneficially reused over 220,000 tons of tires, concrete, asphalt and dimensional lumber, and diverted over 190,000 tons of additional material from landfills.

Beyond "Net Zero": Our Carbon Offsets from Services Provided

ACHIEVING OUR TARGETS

Waste Connections offset carbon emissions through the services that we provide, including recycling and biogas recovery. Therefore, our fifteen-year target to increase carbon offsets by 50% is linked to achievement of our recycling and biogas recovery targets. Given our progress to date and a growing pipeline of these projects under development, we remain well positioned for achievement of our recycling, biogas recovery and carbon offset targets.



TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURE (TCFD)

ASSESSING CLIMATE-RELATED RISKS AND OPPORTUNITIES

Part of our commitment to advancing our sustainability objectives is the continued expansion of disclosure related to our approach to environmental risks and opportunities. Therefore, in 2022, we provided disclosures in alignment with recommendations outlined by the TCFD.

To that end, we established an additional risk assessment in 2022 that focuses solely on climate impacts with input from corporate and regional engineering staff, as well as finance, legal and other regional and senior leadership team members. This multi-disciplinary approach was used to assess and prioritize the management of the risks and opportunities associated with climate change.

AS MORE FULLY DESCRIBED IN OUR TCFD REPORTING this framework was used to assess our climate-related targets and sustainability-related governance structure. In addition, it was incorporated into scenario analysis to consider estimated potential climate-related impacts looking at a number of variables and outcomes.

WE IDENTIFIED CLIMATE CHANGE AS BOTH A RISK AND OPPORTUNITY FOR OUR BUSINESS. As an organization we have taken several steps to evaluate and mitigate the associated risks of climate change, best evidenced by our climate-related risk assessment processes and sustainability-linked governance with oversight from our Board of Directors. In addition, we continued to show improvement in our climate-related metrics such as an absolute reduction in our Scope 1 and 2 emissions and an 18% improvement in emissions intensity over the last two years.

THE CLIMATE-RELATED OPPORTUNITIES are extensive and currently integrated into our business strategy and associated management compensation plans. As an environmental services company, we recognize that we should be well-positioned to benefit from increased adoption of the circular economy. Moreover, our investments in recycling and renewable natural gas infrastructure provide visibility toward achieving our fifteen-year aspirational targets that call for their increase. Growth in both recycling and renewable natural gas not only align with our financial objectives, but also are key components of our vision for the circular economy.

OUR VISION OF THE CIRCULAR ECONOMY

RECYCLING

RESOURCE RECOVERY: RECYCLING

At Waste Connections, resource recovery is a key element of sustainability and includes recycling through our material recovery facilities (MRFs). An integral part of our service offerings, we recycle or divert over 50% of our collected waste volumes in many markets, in some cases over 70%. We continue to expand these efforts through the acquisition of state-of-the-art facilities, the development of new "next generation" facilities and the enhancement of operating capabilities at our existing MRFs through technology additions, including robotics and optical sorters.

71

Recycling facilities that process post-consumer materials, supporting our customers' diversion goals

2M

Tons of fiber, metals and plastics processed in 2021

~50

Recycling robots deployed across our footprint, the largest in the industry

RECYCLING: ACHIEVING OUR TARGETS

The quality of recycled commodities is largely dependent on front-end source separation efforts, which can vary widely and impact MRF processing costs. Source separation education includes local training efforts, coupled with our WasteConnect app that helps customers confirm whether a waste stream is recyclable.

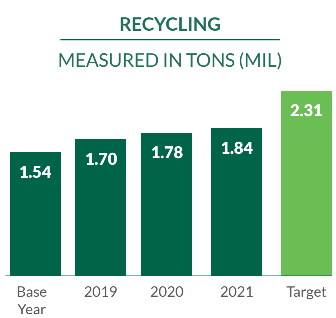
At the plant level, we are investing in additional optical sorters and robotics to manage labor requirements at MRFs, increase productivity and improve the quality and value of recycled commodities through reduced contamination rates. Beyond these enhancements at our existing facilities, we are positioned to achieve our targeted 50% expansion of resource recovery through increased recycling capacity from a combination of opportunistic acquisitions of stand-alone facilities or facilities in conjunction with integrated solid waste operations and construction of greenfield recycling facilities within our existing footprint.

RECYCLING

50%

Increase resources recovered by at least 50%

ON TRACK



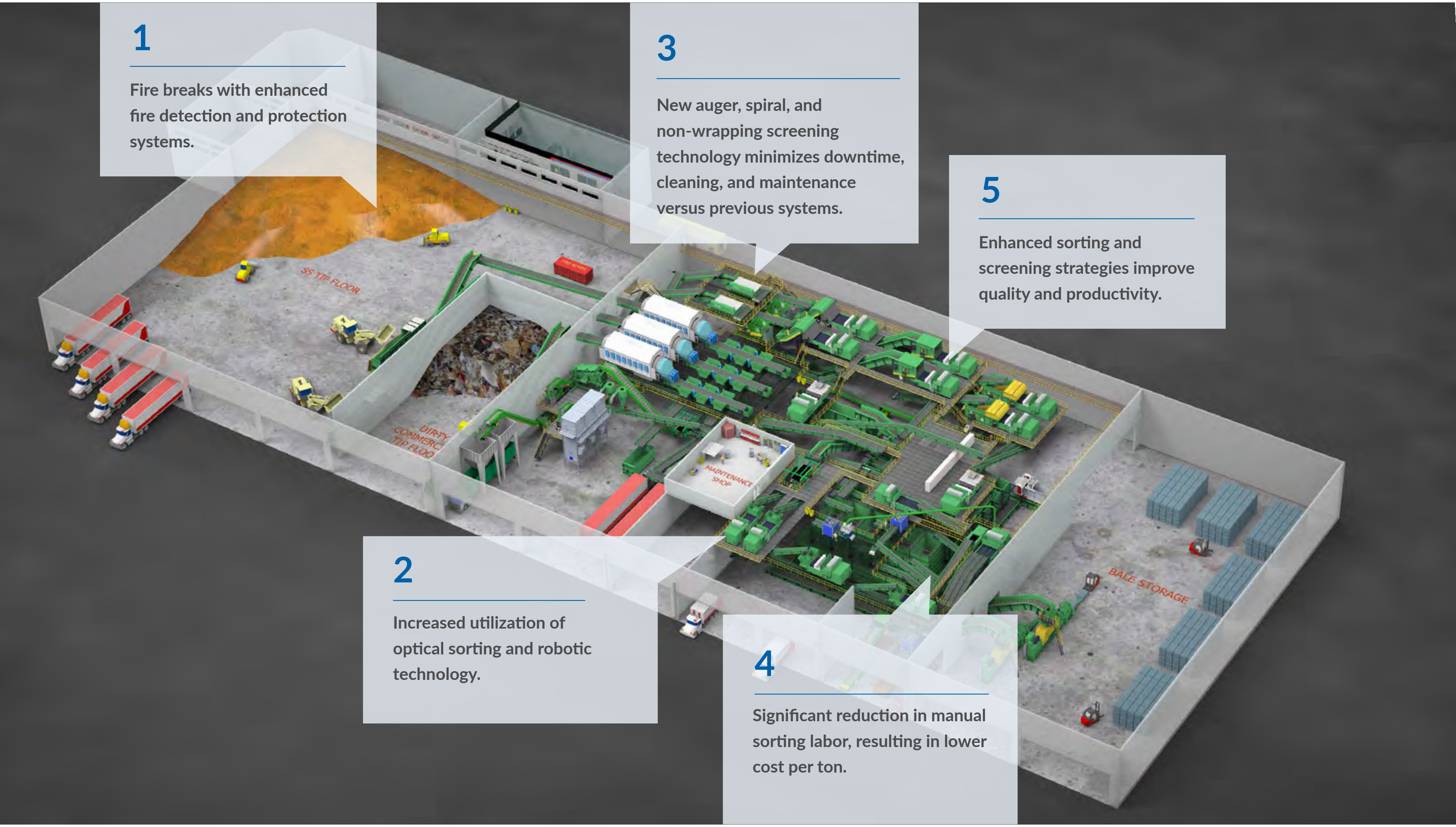
KEY ACCOMPLISHMENTS

In 2021, we continued to increase our processing capabilities and expanded the use of robotics across our network of recycling facilities. Our recycling tons processed in 2021 increased by 4% versus the prior year.

LOOKING AHEAD: 2022 & BEYOND

In 2022, we commenced construction on two recycling facilities in markets where we already collect recyclables, optimizing and vertically integrating our operations. These facilities will feature the newest MRF technology through the expanded use of optical sorters and robotics for enhanced productivity and product quality. When operational by 2024, these two facilities are projected to expand our annual recycling capacity by over 10% from 2021 levels. Given the growth already achieved since 2018 and the additional recycling capacity currently in development, we are well positioned to achieve our long-term targeted increase of 50%.

Our Vision for the Next Generation MRF



1

Fire breaks with enhanced fire detection and protection systems.

2

Increased utilization of optical sorting and robotic technology.

3

New auger, spiral, and non-wrapping screening technology minimizes downtime, cleaning, and maintenance versus previous systems.

4

Significant reduction in manual sorting labor, resulting in lower cost per ton.

5

Enhanced sorting and screening strategies improve quality and productivity.

LANDFILL GAS

RESOURCE RECOVERY: LANDFILL GAS

Resource recovery also extends to our landfills, where we deploy gas recovery systems and provide renewable energy to many of the communities we serve. We have installed gas collection systems for the capture of landfill gas generated at over 53 of our solid waste landfills, often in advance or exceeding regulatory requirements. Our gas recovery systems create the opportunity to convert landfill gas to a renewable energy source and mitigate the environmental impact. At 27 of these landfills, we have beneficial reuse facilities, either through electric generation or Renewable Natural Gas (RNG) recovery. These facilities generate electricity for local households, fuel local industrial facilities, and/or create RNG that can power alternative fuel vehicles. These projects create marketable environmental attributes such as carbon emission credits, Renewable Energy Credits (RECs) or Renewable Identification Numbers (RINs).

Our nine RNG facilities, including one of the largest in North America, provide pipeline-grade methane for use by the transportation industry and represent an area of future growth. We estimate that there are opportunities for new RNG systems or conversions to RNG at 15 to 20 of our landfills.

53
of our solid waste landfills have gas collection systems installed

27
Landfills have beneficial reuse facilities, either Renewable Natural Gas (RNG) or electric generation

~300K
Homes our landfills provide enough energy to power annually

LANDFILL GAS RECOVERY: ACHIEVING OUR TARGETS

The environmental benefits of utilizing landfill gas to generate electricity or produce pipeline-grade RNG is compelling, with the economic benefit dependent on several factors, including landfill size, age, gas generation rates, and infrastructure costs, as well as the value of the energy produced. At our existing landfill gas recovery systems, we annually process approximately 29.2 billion Standard Cubic Feet (SCF) of gas for conversion to energy, or the equivalent needed to power approximately 300,000 homes.

BIOGAS RECOVERY

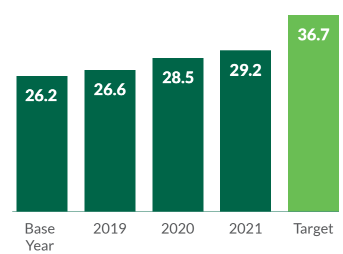
40%

Increase biogas recovery by at least 40%

ON TRACK

BIOGAS RECOVERY

MEASURED IN STANDARD CUBIC FEET (BIL)



KEY ACCOMPLISHMENTS

In 2021, we increased biogas recovery and conversion to energy to 29.2 billion standard cubic feet or approximately 3%, bringing our two-year increase over 2020 and 2021 to 10%.

LOOKING AHEAD: 2022 & BEYOND

In 2022, we commenced construction on two RNG facilities, which should expand our annual beneficial gas generation by approximately 15% when operational. In addition, we have another eight facilities in late stages of development. Given this outlook and increases to date, we believe we are well-positioned for achievement of our fifteen-year aspirational target to expand biogas recovery by 40% from 2018 levels.

LEACHATE

LEACHATE MANAGEMENT

When it rains or snows, water infiltrates the buried materials within uncovered sections of landfills and mixes with the liquids and soluble substances contained in municipal solid waste, resulting in leachate. At our landfills, leachate is contained by an impervious liner system and is collected through a network of perforated drains. Subsequently, leachate is collected and either sent to a third-party disposal facility, such as a municipal or industrial wastewater treatment plant, or treated on-site through wastewater treatment facilities or evaporation.

10%

Increase in leachate gallons processed on site over the last two year period

2

New leachate treatment plants to commence operations in 2022

$5M

investment into independent research for new leachate treatment methods

LEACHATE MANAGEMENT: ACHIEVING OUR TARGETS

Through our current operations, we generate over 650 million gallons of leachate per year, over two-thirds of which has historically been transported off-site for treatment. Our fifteen-year aspirational target is to mitigate the environmental impact of transporting and disposing of leachate by enhancing our ability to treat leachate using our own facilities to over 50% of leachate generated. Reducing reliance on third parties allows us to more effectively manage the costs and mitigate the impacts associated with the transportation and off-site treatment and disposal of leachate.

In order to further increase our leachate self-sufficiency, we will expand utilization of evaporator technology at some landfills and pursue other landfill best practices such as reducing working face size or installation of temporary cover to minimize infiltration of rain or snow. We also will install on-site treatment plants where feasible.

Always looking for a more cost effective and environmentally conscious way to treat and/or dispose of leachate and other waste, we are independently funding research into new leachate treatment methods with an annual commitment of $1 million over a five-year period.

LEACHATE

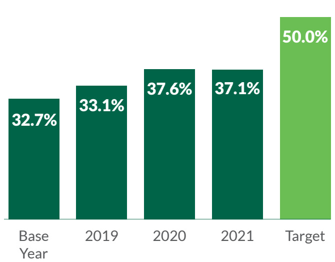
50%

Process at least 50% of leachate on-site

ON TRACK

LEACHATE PROCESSED ON-SITE

MEASURED BY PERCENTAGE



KEY ACCOMPLISHMENTS

During 2021, we added evaporating units at facilities that generated excess leachate and finalized construction on two additional leachate treatment facilities, completed in 2022.

LOOKING AHEAD: 2022 & BEYOND

In 2022, we will commence operations at the two new treatment facilities with combined capacity to process over 100 million gallons of leachate annually, significantly expanding our internal capabilities and positioning us for further progress toward our target.

CASE STUDY

Meadowbranch Landfill, Athens, TN

2021 Leachate processed on site

+2.9M

gallons or +49% YoY

Gas used for energy

+11.2%

2022

well positioned to benefit from investment in temporary cover

Nestled in the foothills of the Great Smokey Mountains, the Meadowbranch Landfill is a critical post-collection asset that serves the markets around Knoxville and Chattanooga, Tennessee. On an annual basis, the landfill receives nearly one million tons of municipal solid waste. With rainfall of approximately 80 inches per year, the site was generating around 30 million gallons of leachate annually and utilizing third parties for treatment and disposal. Beginning in 2021, the site installed evaporation technology that allowed it to treat a larger portion of its leachate on site, reducing the number of trucks needed to transport leachate to treatment plants. In 2021, the site began installation of temporary cover on the landfill in order to further reduce the penetration of liquids into the landfill and minimize fugitive emissions.

Meadowbranch Landfill temporary cover and evaporators

FLEET EMISSIONS AND EFFICIENCY

As a route-based business, a portion of our carbon footprint is linked to our fleet, and therefore we look to selectively utilize alternative fuel vehicles as part of our efforts to reduce fleet emissions.

In addition to utilizing Compressed Natural Gas (CNG) trucks, we have been running a hybrid electric truck in one market and look forward to testing fully electric collection trucks beginning in 2022.

Further, we focus our efforts on reducing consumption of fuel and petroleum-based products through replacement of older trucks with newer, more efficient trucks, utilizing transfer station networks to consolidate waste onto fewer trucks, installing controls to minimize idling time, and switching to synthetic motor oils with longer replacement intervals.

We also reduce emissions by installing more advanced engine filters. In addition, we utilize technology, including on-board tablets and route optimization software, to minimize driving time, and engine diagnostics software to anticipate issues to avoid downtime.

12%

ALTERNATIVE FUELED VEHICLES IN FLEET

INNOVATION

With the expected payload and route capacity of electric collection trucks comparable to diesel trucks, we look forward to beta testing fully electric vehicles, particularly given our encouraging experience from utilization of a hybrid unit since 2021. The fully electric trucks operate quietly, generate zero emissions and are expected to provide considerable operating cost savings relative to comparable diesel trucks, although at an initial cost premium. We look forward to expanding the use of alternative fuel vehicles in Waste Connections' fleet.

Pictured L-R: Compost operation in Quebec; coal ash beneficial reuse project in Florida; compost operation; and anaerobic digester in California.

ZERO WASTE

We believe our sustainability initiatives align with and support the efforts of our customers and the communities we serve.

We regularly work with customers to increase resource recovery and facilitate their pursuit of zero waste goals. Whether providing services like composting of yard waste and food waste or supporting the introduction of new technologies, such as anaerobic digesters, we partner with communities and industrial customers to advance their objectives to reduce their reliance on landfills, decrease waste disposal costs and reduce emissions.

CASE STUDY

Exploration and Production (E&P) Waste

With over thirty exploration and production waste treatment and disposal facilities across the United States, Waste Connections is one of the largest providers of non-hazardous E&P waste disposal. Through our E&P subsidiary R360 Environmental Solutions, we help customers responsibly treat, recycle or dispose of drill cuttings, drilling fluids, produced water and other non-hazardous E&P waste, representing an attractive and safe alternative to disposal at the drilling site. Our processes and technology can recover and transform many of our customers' waste streams into reclaimed oil, recycled produced water and reusable drilling fluids.

> In fact, since 2018, our E&P waste operations have collectively reclaimed nearly 18 million gallons of base oil, and tons sequestered in landfills and injected into deep formations give R360 a net negative carbon footprint.

Pictured is a night view of our state-of-the-art thermal processing facility near Stanton, Texas, that diverts hydrocarbons from landfills — another example of how we promote the circular economy.

18M gallons of reclaimed base oil since 2018

Biodiversity and Site Closure

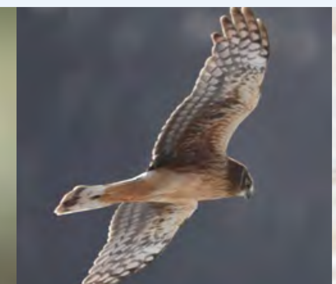
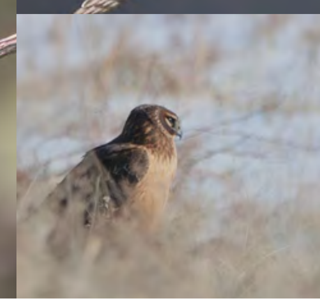
We approach our relationships with the communities we serve as long-term partnerships with an eye toward the future and respect for the environment. From the permitting process to operating protocols and eventual site closure, we consider the environmental impact that our businesses have on local habitats and the surrounding communities. At many of our larger landfills, we establish buffer property that utilizes local plants and vegetation to encourage and promote local wildlife and aesthetically blend with other local vegetation. As a part of the permitting process, we engage with local communities to establish a closure plan. As we anticipate that facilities will ultimately transition into closure, we ensure that closure plans are effective at restoring the land to a condition that is consistent with the biodiversity of the surrounding environment.

CASE STUDY

Blue Ridge Landfill Chambersburg, Pennsylvania

Each year, the grasslands near and surrounding property of the Blue Ridge Landfill are home to numerous species, providing a stopping point for migration or a local breeding ground. Pictured below are several species of birds found within the grasslands of our Blue Ridge Landfill in Pennsylvania, highlighting the local ecology and balance between human activity and nature.




Pictured L-R: Blue Ridge Landfill; Ruby-Throated Hummingbird; Northern Harriers and Green-Winged Teal.
Photos taken by J. Ferguson, administrative assistant, Blue Ridge Landfill.

Environmental Management System

As detailed in our Environmental Policy, we maintain a robust Environmental Management System (EMS) as part of our operating practices and risk mitigation strategy. Our EMS is an all-encompassing approach to environmental protection and regulatory compliance with oversight by our Executive Vice President – Engineering and Disposal as well as our Vice President – Engineering and Sustainability, and Vice President, Deputy General Counsel – Compliance and Government Affairs. It is managed by our Corporate Environmental Manager and utilized by more than 1,800 trained professionals in the field. Our EMS is designed to prioritize environmental protection and promote the rapid flow of information from the field to those overseeing the EMS.

In order to ensure and track regulatory compliance, we utilize a proprietary compliance-tracking tool called the Cube to provide notifications, tracking and reporting of regulatory and permit-related tasks. The Cube notifies facility managers of upcoming tasks, documents their completion and uploads to each respective site's operating record. Monthly progress reports are provided to corporate environmental managers, resulting in follow-up at multiple levels of management.

Annually, one or more of our environmental professionals audits each disposal site, reviewing operating records, infrastructure and the physical conditions, with potential risks of non-compliance tracked in the Cube for remediation and documentation. Our EMS also regulates the day-to-day handling and documentation of waste streams generated from operations, with all wastes disposed or recycled by third party customers inventoried and tracked through our audit function to demonstrate proper handling.

All sites incorporate emergency response planning, which, depending on geography, may incorporate contingencies for responding to various natural disasters or addressing other regional or local needs. We provide emergency action plan training in order to enhance response plans.

"Our EMS ensures regulatory compliance at our sites while at the same time allowing us to effectively manage the day-to-day documentation of waste streams."

Jim Little
Executive Vice President – Engineering and Disposal

SOCIAL ENGAGEMENT

EMPLOYEE ENGAGEMENT

CULTURE MATTERS

At Waste Connections, we believe employee engagement, culture and differentiated results are all related — it is why investing in our people, our greatest asset, has always been a top priority.

As a result, we doubled down on employee support during the COVID-19 pandemic, understanding that employee health and financial well-being was paramount, and that caring for our 20,000-plus employees and their families would translate into happier, more engaged employees, better positioned to serve our customers during a time of need.

As life begins to normalize with the restoration of corporate travel, training and other social and work gatherings, we reflect on our aforementioned investments, our future employee-centric initiatives as well as our Servant Leadership principles and emphasis on safety that has guided us for years. Our reflection leads us to believe that Waste Connections is a closer, stronger organization because of the steps we have taken and we are well positioned for future growth and differentiation — no different from our journey over the last 25 years.

SUPPORTING OUR FRONTLINE

$50M

Discretionary COVID-19 expenses incurred since the pandemic, primarily to support our frontline employees

#1

Operating value is safety

"Our employees' preferences and needs are constantly evolving. By listening to our employees, leveraging the principles of Servant Leadership and utilizing technology, we are able to emphasize our employees' well-being and expand personal development."

Sue Netherton, Senior Vice President – People, Training and Development

Our team has responded and recognized Waste Connections externally, resulting in a series of employee-nominated awards, including Glassdoor's Employee Choice Awards — Top CEOs as well as Comparably's Best Leadership Team, Best CEO for Women, Best HR Team, Best Sales Team and Happiest Employees.

Benefits introduced or expanded since the onset of the COVID-19 pandemic are supportive of our employee engagement efforts:

SUPPLEMENTAL WAGES
deployed over $50 million during the pandemic, largely to support our frontline employees through supplemental wages;

INTRODUCED A FORMAL $15 PER HOUR TARGET
for minimum wage in the United States and $16 per hour in Canada with continued growth in wages;

INTRODUCTION OF A SCHOLARSHIP PROGRAM
to support the educational goals of our employees' children;

EXPANDED TRAINING and development efforts;

INTRODUCTION OF SEVERAL AFFINITY AND NETWORK GROUPS
supporting **diversity and inclusion;**

DEPLOYED NEW MOBILE- AND DESKTOP-BASED TECHNOLOGY
to celebrate individual and local successes and increase employee connectivity;

DISCOUNTED STOCK PURCHASE PROGRAM FOR EMPLOYEES; and

EXPANDED BENEFIT PROGRAMS
including paid time off, parental leave, short- and long-term disability and continued to offer gold plated benefits with included optionality for Health Spending Accounts, Flexible Spending Accounts, counseling services, and life insurance.

SERVANT LEADERSHIP

A DIFFERENT APPROACH

In 2006, we adopted the management concept known as Servant Leadership — a philosophy that has defined and differentiated our organization.

The Servant Leadership concept inverts the traditional management hierarchy, positioning leaders to serve their employees both professionally and personally. The philosophy empowers employees by prioritizing their needs, sharing responsibility and driving personal development.

Our leadership development efforts include multi-day Servant Leadership training sessions, district management training, dozens of varying leadership webinar topics, and other safety, sales, maintenance, operations and financial training courses engaging every employee level throughout the Company.

As an organization, we look to continually raise the level of accountability through our annual Servant Leadership survey, which provides employees the opportunity to grade their managers on an anonymous basis. The score, along with several other metrics such as talent development, are incorporated into the leader's compensation plan. We also view the scores as indicative of employee engagement and therefore incorporate Servant Leadership scores into our aspirational ESG targets with a goal of continuous improvement. With over 85% participation, our 2021 Servant Leadership survey demonstrated continued improvement to record 2021 levels, with the largest gains coming from our frontline drivers and operators.

"In our early years, amid elevated employee turnover and a high frequency of safety-related incidents, we realized a need for change. Initially the concept of Servant Leadership was optional, but with notable success in turnover and safety, we mandated the philosophy and have embraced its principles ever since."

Ron Mittelstaedt
Founder and Executive Chairman

Voluntary Turnover and Engagement

ACHIEVING OUR TARGETS

At Waste Connections, we are intentional about employee training and development, relationship building and accountability across the organization — all factors that affect culture and employee engagement. Over time, we believe being intentional in these areas will result in better retention metrics and higher Servant Leadership scores — our reflection of engagement.

Intentional Retention

In 2021, we redesigned and formalized employee onboarding, relationship building, and other retention best practices. We also expanded training for interview skills in order to hire candidates that are a best fit, more effectively communicate job expectations, and increase awareness of unconscious biases in order to broaden the candidate pool and hire more effectively. We have seen the positive effect of our efforts within new employee retention and anticipate more progress as the broader labor market-related turnover begins to normalize.

KEY 2021 ACCOMPLISHMENTS

Following several years of strong Servant Leadership scores, we demonstrated improvement in our annual survey again in 2021, with the largest improvement coming from frontline employees. Additionally, we are encouraged by recent progress on new employee retention and believe we are positioned for future improvement.

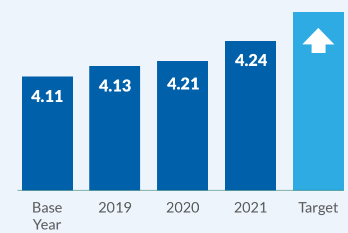
SERVANT LEADERSHIP

Continuous Improvement in Servant Leadership Scores

ON TRACK

SERVANT LEADERSHIP

ON A SCALE 1-5

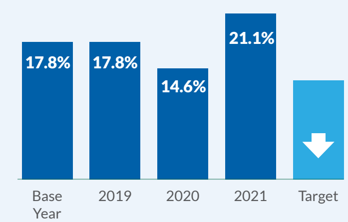


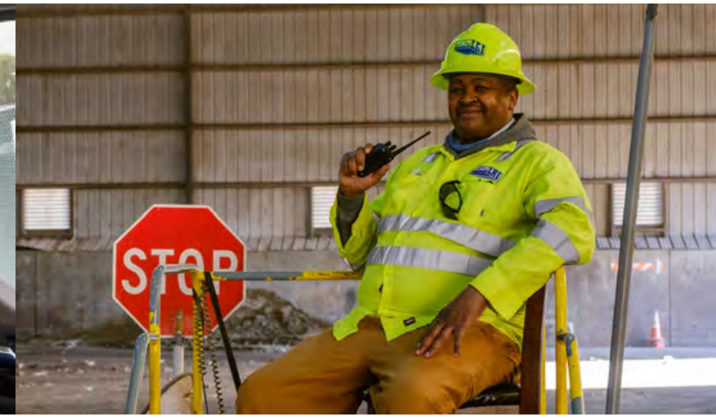
VOLUNTARY TURNOVER

Continuous Improvement

VOLUNTARY TURNOVER

MEASURED BY PERCENTAGE





Diversity and Inclusion

At Waste Connections, we are committed to building and developing diverse teams that function in an environment of mutual respect, where employees feel empowered to contribute. Operating across hundreds of markets in the United States and Canada, we recognize the benefits of diversity and the importance of ensuring that employees feel respected and included, encouraged to bring their unique perspectives, ideas and best skills to work each day.

In keeping with our efforts to support and encourage diversity and inclusion, we have undertaken several initiatives. Those efforts include the introduction of a formal Diversity Policy for our Board of Directors and Senior Management with aspirational targets for female Board representation, and additional disclosure on workforce composition such as our Equal Employment Opportunity report (EEO-1) that we are providing in conjunction with our 2022 Sustainability Report.

We also incorporated diversity and inclusion topics into Servant Leadership training and annual manager assessments in order to ensure that all employees are valued, feel empowered to contribute and are positioned for advancement opportunities. Additionally, we enhanced recruiting practices to ensure the broadest candidate pools, offered monthly diversity and inclusion training modules, and established financial commitments to organizations that focus on racial inequities and that support women and children at risk. We also supported the development of resource groups including our Women's Network and Veterans' S.E.R.V.E. group. We anticipate expanding the resource groups in 2023.

To further expand our efforts, in 2022 we established and filled a new role, Director of Employee Experience, Inclusion, and Diversity. This new role will be responsible for strengthening our diversity and inclusion priorities and improving our practices in key areas of the employee life cycle, including brand attraction, onboarding, orientation, retention, recognition, engagement, and employee development.

Waste Connections is a signatory to the CEO Action for Diversity & Inclusion, the largest CEO-driven business commitment to advance diversity and inclusion within the workplace. We are also supporting members of Women in Trucking and Women in Cleantech & Sustainability.

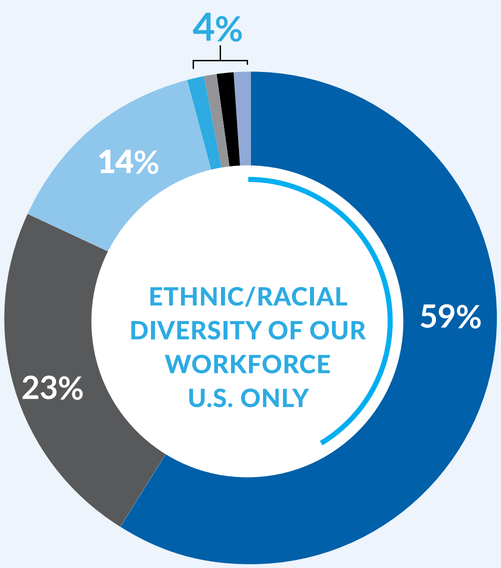
CEO ACT!ON FOR DIVERSITY & INCLUSION

WOMEN IN TRUCKING

WOMEN IN CLEANTECH & SUSTAINABILITY

Diversity Statistics

WORKFORCE DIVERSITY *EEO-1 Report*

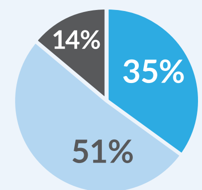


41%

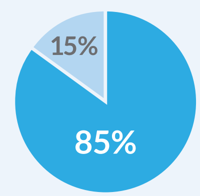
ETHNIC/RACIAL DIVERSITY

As of 2021 and U.S. only data

- 59% Caucasian
- 23% Hispanic
- 14% Black
- 1% Multiracial
- 1% American Indian / Alaska Native
- 1% Asian
- 1% Native Hawaiian / Pacific Islander



- 50 and over
- 30 to 49
- 29 years and under



- Paid hourly
- Salaried

		GENDER		ETHNICITY	
WORKFORCE COMPOSITION (U.S. AND CANADA)	UNIT	FEMALE	MALE	CAUCASIAN	ETHNIC MINORITY
Board of Directors	Percentage (%)	25%	75%	88%	13%*
Top Management Positions	Percentage (%)	17%	83%	90%	10%
Total Workforce	Percentage (%)	16%	84%	61%	39%

*Board of Directors Ethnicity and Workforce Ethnic Composition does not equal 100% due to rounding

ENTERPRISE RESOURCE GROUPS

Women's Network and Veterans Network (S.E.R.V.E.)

>1,000

MEMBERS

FROM THE EXECUTIVE SPONSOR

"The rapid growth of our Women's Network is a direct reflection of our people and culture. The network fosters relationships across all roles at Waste Connections and at the same time empowers our members by providing opportunities for both personal development and community support."

Mary Anne Whitney
Executive Vice President
and Chief Financial Officer

HIGHLIGHTS

- Mentorship opportunities
- Industry interviews
- Monthly themes to inform, empower and connect
- Charitable events and fundraising
- Social gatherings

APPROACHING

500

MEMBERS

FROM THE EXECUTIVE SPONSOR

"Just like the majority of my fellow veterans, my time in the military was a formidable experience, in part shaping me into the employee I am today at Waste Connections. I am excited to help build a network of veterans across the Company to both acknowledge their military experience and support their career development."

Jason Craft
Senior Vice President – Operations

HIGHLIGHTS

- Guest speakers
- Understanding VA benefits and opportunities
- Mentorship opportunities
- Fundraising and events for veterans in need

EMPLOYEE TRAINING AND DEVELOPMENT

Continual learning opportunities benefit our workforce both personally and professionally and have been a cornerstone of our organization's culture for years.

It is why we have been pleased to invest in a new Learning Management System (LMS) that offers mobile, tablet or desktop-based access to a robust library of learning and development resources. In addition to required training sessions with topics such as safety, code of conduct and ethics, antitrust basics, harassment prevention, discrimination education, diversity and inclusion, consumer privacy and cybersecurity in 2021, we introduced additional learning content and significantly expanded the sessions and topics offered to our employees interested in self-directed learning opportunities.

In addition to online trainings, 2021 marked the return of classroom-based educational sessions, including our Servant Leadership series, detailed below. We look forward to further expanding educational content through our LMS system and at the same time welcoming more employees back into the classroom, which not only fosters employee development, but also builds relationships and spreads culture.

+19%

Increase to training sessions offered in 2021

D&I

Ongoing monthly training sessions, with topic now included in annual manager survey

New or Notable Training Programs for 2021

DIVERSITY AND INCLUSION MINI SERIES

Following a leadership summit in 2020 that sought to reduce unconscious biases and enhance diversity and inclusion, this series was introduced and continues after 20+ months. Our leaders utilize the mini courses and underlying discussion guides to have a deeper conversation on the topic with their teams. Topics have included unconscious bias, how to practice inclusiveness, breaking down stereotypes, creating psychological safety for employees and teams, allyship, and fostering belonging.

CULTURE MATTERS

Given significant organic and acquisition-related growth, we introduced the Culture Matters course and encourage this educational session during the onboarding process. Curriculum includes Waste Connections history, our five Operating Values, our approach to safety and Servant Leadership key principles.

TRAINING THE TRAINER

The Driver Trainer Certification Course focuses on how we can best serve our trainees beginning their Waste Connections driving career. The driver trainers learn next-level skills to enhance current training strategies. Routing, documentation, distractions, normalization of deviance, Target 4 (safety) and conversation styles highlight the learning content delivered virtually or in-person.

BUSINESS ACUMEN

Business Acumen financial training links expertise in certain roles to Waste Connections' strategic priorities. The six-hour online workshop or three day in-person session aligns operations to corporate strategy and focuses on the development of the five business drivers — Cash, Profit, Assets, Growth and People.

CODE OF CONDUCT TRAINING

All directors, officers, managers, and supervisor, sales and general/administrative employees receive training on our Code of Conduct and Ethics upon hire and at least once again every three years. We provide more frequent and additional training on our Code of Conduct and Ethics upon material changes to the code or as needed to address applicable rules, regulations or potential patterns of unethical behavior.

CYBERSECURITY TRAINING

We require a five-part training course designed to improve employee cybersecurity awareness and educate users on today's threats. We also provide digital courses that focus on phishing awareness and common cybersecurity attacks.

TAKING SAFETY TO THE NEXT LEVEL

As our First Operating Value, Safety is paramount in all we do. We recognize the responsibility we have to our employees, our customers and the communities in which we operate to minimize incident frequency and protect all from accidents.

We believe that safety is the responsibility of every employee and deploy a behavioral-based approach that is ingrained in our commitment-based, Servant Leadership culture. Our unique approach rewards success and at the same time demands accountability by holding employees and leaders accountable when exhibiting or tolerating unsafe behavior.

We have relied on our Servant Leadership-led philosophy, combined with technology-based tools, to develop employee risk-profile rankings. These rankings encourage effective communication and behavior-based coaching opportunities that are tracked and scored. We believe this approach is what allows us to report better-than-average safety metrics relative to the solid waste industry. This approach also explains how we have historically been able to reduce the number of safety incidents at acquired companies often by over 50% within the first year of operations.

"At Waste Connections we believe that accidents and injuries are not a part of or cost of doing business in our industry. The cost of failure in safety is too great, which is why we rely upon our culture to emphasize communication, drive behavior and positively impact safety within the organization."

Shawn Mandel
Vice President – Safety and Risk Management

50% Typical year-one reduction of safety incidents at acquired companies

SAFETY

Key Initiatives

While we attribute our successful safety record to our culture and behavioral-based approach, we acknowledge that technology can be an important tool in identifying risky behaviors and providing coaching opportunities to address them.

Beginning in 2020, we launched a $10 million fleet-wide upgrade of our onboard camera systems, which are the foundation for establishing our risk-based scoring. In contrast to existing systems, which largely track inertial movements in vehicles, the next-generation systems utilize artificial intelligence and "Machine Vision" to identify additional risks both inside and outside of the cab. Such risk factors inside the cab include unbelted drivers, as well as distracted driving from handheld devices, food and beverages and smoking. Outside of the cab, the units can detect lane departures, rolling stops, unsafe following distances and other critical distances. We continued to install next-generation camera telematics in 2021 and reached full deployment across the legacy Waste Connections fleet in early 2022.

We also continued to deploy Freightliner EconicSD trucks across our fleet. These units feature an overhauled cab design that incorporates many of the safety features already included in passenger vehicles, as well as an integrated collision mitigation system, enhanced visibility, and several ergonomic improvements.

KEY 2021 ACCOMPLISHMENTS

Next-generation camera telematics, combined with our behavioral-based approach, helped drive continued improvement in our incident rate, in spite of increased traffic levels stemming from post-pandemic reopening activity.

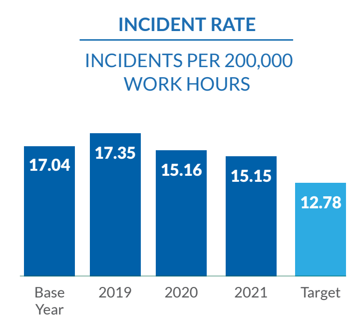
> In total, our behavioral-based approach to safety resulted in over 55% of our operating locations either posting zero safety-related incidents or reducing incident frequency versus the prior year.

INCIDENT RATE

25% ↓

Reduction in Incident Rate

☑ ON TRACK



2021 Driver, Mechanic and Operator of the Year Awards

CANADA | CENTRAL REGION | EASTERN REGION | SOUTHERN REGION | WESTERN REGION

Drivers
OF THE YEAR

Mechanics
OF THE YEAR

Operators
OF THE YEAR

COMMUNITY IMPACT

GIVING BACK AND MAKING AN IMPACT

At Waste Connections, we also attribute our success to the support we receive from communities we serve, where our employees also live and work.

75K Bicycles donated

$8M Cumulative donations from Waste Connections Golf Classic for Kids

We provide opportunities for our employees to get involved in their communities and consider it a privilege for Waste Connections to also give back through charitable donations or sponsoring community events.

GIVING LOCALLY

Waste Connections and our employees support more than a thousand organizations through direct contributions, volunteering and/or fundraising at a local level. Each year, we donate millions of dollars to various charities, including an increasing number of organizations identified by our frontline employees that focus on racial inequities at a local or national level and that support women and children at risk in disadvantaged communities.

OUR COMPANY-WIDE CULTURE OF GIVING

In addition to our local efforts, we are proud of our Company-wide traditions. In 2021, our employees assembled and contributed over 6,000 bicycles to deserving children, bringing our program total since inception to over 75,000 bicycles. In addition, our 13th Annual Waste Connections Golf Classic for Kids in 2021 raised over $1.2 million for charities that support at-risk youth and their families, bringing our total raised to over $8 million.

SUSTAINABILITY AND GIVING

Waste Connections aligns its major financial contributions with its goal to further advance environmental sustainability. For example, our first major grant helped establish the Global Waste Research Institute (GWRI), developed in conjunction with California Polytechnic State University, San Luis Obispo.

THE GWRI'S MISSION

The GWRI's mission is to advance state-of-the-art research and development of sustainable technologies and practices to more effectively manage existing and emerging wastes and byproducts. We also regularly contribute to the Environmental Research Education Foundation and fund over $1 million per year in research related to the environmental industry.

SELECT ORGANIZATIONS WE SUPPORT

100 Black Men of Knoxville
Alzheimer's Resource of Alaska
American Cancer Society
American Heart Association
American Red Cross
Angel Reach
Beyond Batten Disease
Big Brothers Big Sisters
Boys and Girls Clubs
Bridge the Gap
Bridge to Home
Canadian Club of Toronto
CASA Child Advocates
Cayuga Seneca Community Center
Centre for Young Black Professionals
Charleston Area Justice Ministry
Children's Home Society
Chippewas of the Thames First Nation
Circles of Mercy
City Care Inc.
Columbia River Mental Health Foundation
Community Assistance Center
Concern for Animals
Eloy Food Bank
Emergency Food Network
Empire Club of Canada
Empower Tehama
Equal Justice Initiative
Fondation — CSSS Du Sud De Lanaudiere
Food Backpacks 4 Kids
Glove House Inc.
Habitat for Humanity
Homeless Youth Connections
Homes4Families
Hope Ministries
Inner City Outreach
Inspiration Ranch
Interfaith of The Woodlands
Juvenile Diabetes Research Foundation
Kids Meals
Kids 'n Kinship
Leukemia & Lymphoma Society
Lighthouse for Grieving Children
Loaves and Fishes Family Kitchen
Lotus House
Love Fosters Hope
Low County Food Bank
Make-a-Wish Foundation
March of Dimes
Meals on Wheels
Mission of Hope
Montgomery County Food Bank
Montgomery County Women's Center
National Women's Hall Of Fame
Northwest Association for Blind Athletes
Oklahoma Children's Hospital
Oregon Zoo
Pink Lemonade Project
Redeemed Ministries
Roger Clemens Foundation
Seneca Falls Fire Department
Special Olympics
St. Jude Heroes
Step by Step
Tent Mission STL
The Black Coalition for AIDS Prevention
The Children's Hospital Volunteers Inc.
The Nature Conservancy
The Salvation Army
The Wishing Well Foundation
Toby Keith Foundation
UNCF
United Way
Veterans Emergency Relief Fund
Volunteer Prince William
Waterloo Fire Department
Westborough Police Foundation
Winter Center for Autism
Women's Institute for Leadership and Learning
Wounded Warriors in Action Foundation
YES to Youth
Young Men's Educational Network (YMEN) Chicago
Youth Alliance
Youth First

WASTE CONNECTIONS CARES

Giving Back to Employees

EMPLOYEE RELIEF FUND (ERF)

The Waste Connections Employee Relief Fund was established to help employees and their immediate families who have experienced significant financial hardship following a natural disaster or other catastrophic event. In 2020, we expanded its applicability to address unexpected hardships experienced during COVID-19. Through contributions from Waste Connections, our employees and vendors, we assist impacted employees by helping to pay for essential living expenses, such as food, clothing, utilities, temporary housing, property repairs, and other basic necessities. Since its inception in 2017, the Employee Relief Fund has helped approximately 250 Waste Connections employees.

SCHOLARSHIP PROGRAM

We introduced the Waste Connections scholarship program in 2020 as a way to help our employees' children achieve their vocational, technical and university education goals. The scholarship program awards renewable scholarships to children of Waste Connections' employees based on academic record, demonstrated leadership, participation in school activities, work experience, career goals and family circumstances. Determined by an impartial third party, award recipients receive $2,500 each per academic year for up to four years. Now on its third year, the program has 125 recipients with financial contributions from Waste Connections that exceed $300,000 and a total commitment of up to $1.25 million.

Emily Hickel

Majoring in Mechanical Engineering at
Washington State University Vancouver

Daughter of **Kelly Hickel, Lead Equipment Operator**, (32+ years of service)

Region: Western | Vancouver, Washington

"I am beyond grateful and humbled to earn this award, and for your support of my continued education."

Russel Acosta

Majoring in Art & Art History at
Columbia University

Son of **Roussel Acosta, Driver**, (17+ years of service)

Region: Central | El Paso, Texas

Thank you!

WE ARE PROUD TO HAVE SUPPORTED

125
Award Recipients

$1.25M
in scholarship commitments

"At Waste Connections, we are stewards of local resources and trusted advisors to our customers. Our priority is obtaining expertise on emerging recycling efforts and offering those services in ways that work in the communities we serve."

Aaron Donley
2021 Bob Davis Award Recipient for Sustainability

Community Engagement

Now more than ever it is critical to increase engagement within our communities and connectivity with our customers. Through our WasteConnect app, customers can confirm their collection dates, search our Waste Wizard database to confirm if a waste stream is recyclable, pay their bills, and communicate with their local service provider.

We partner with our communities and in many instances deploy recycling coordinators to schools, community events and residences to provide educational sessions about the benefits of recycling and proper waste management. In 2019, we launched the Bob Davis Award for Leadership in Sustainability to recognize employees who demonstrate exemplary leadership in advancing sustainability through implementing or serving on community projects, programs, outreach, education initiatives or services that benefit their community, customers, coworkers or Waste Connections.

2021

BOB DAVIS AWARD RECIPIENT AARON DONLEY

Aaron's specific areas of contribution have been numerous, whether rolling out recycling programs at the University of Oregon athletic facilities, supporting recycling at the US Olympic Trials, developing recycling literature, growing recycling participation, or teaching members of the community how the recycling system works. Aaron takes a very hands-on approach to sharing his sustainability passion. He volunteers at local events and has spent countless hours speaking to community groups about recycling.

Natural Disaster Relief Efforts

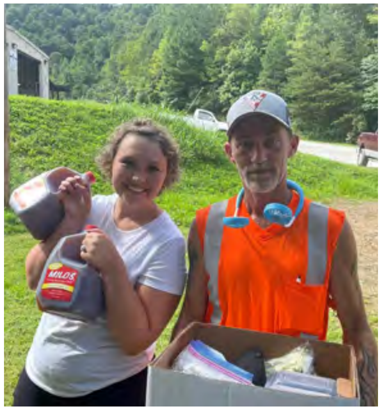
With essential operations across 43 states in the U.S. and six provinces in Canada, Waste Connections provides relief to communities that are negatively impacted by natural disasters, including forest fires, hurricanes, tornadoes and flooding. These events can negatively affect our employees, our customers and the communities in which we serve.

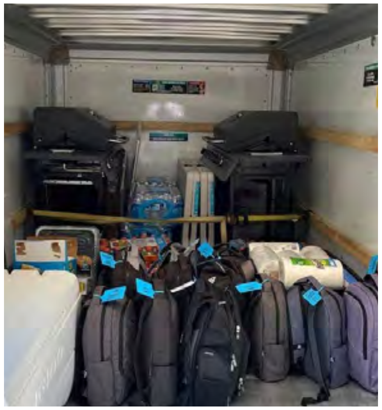
Our large network and Servant Leadership-focused culture provides a response roadmap. We recognize that local employees are likely to be the most impacted, and we immediately ensure their welfare by providing food, water and shelter in many instances. We deploy additional support teams to back up local employees that may be unavailable, providing trash and recycling collection services. We deliver construction containers and extend business hours at our disposal facilities in order to aid the cleanup efforts. For some of our most impacted employees, we utilize our Employee Relief Fund to help provide financial stability. As an essential service provider, this is how we help restore normalcy to our communities.

OPERATING IN

43

States and Six Canadian Provinces





ENVIRONMENTAL JUSTICE

INTRODUCTION TO ENVIRONMENTAL JUSTICE

The EPA defines Environmental Justice (EJ) as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. At Waste Connections, our approach to community engagement and support is consistent with EJ and integral to our operating philosophy and environmental stewardship at our over 550 collection and post-collection facilities in 43 states in the U.S. and six provinces in Canada.

OUR APPROACH TO ENVIRONMENTAL JUSTICE

In addition to benefiting the health and well-being of the communities we are privileged to serve, our operations are frequently major employers in our communities, where many of our local leaders and frontline employees live and make local concerns a priority. Additionally, EJ consideration for us begins with facility siting and development, which requires regulatory reviews and includes opportunities for local input and consideration, and continues throughout the life of each site. We work with communities to address concerns through the siting and design process, and we remain engaged after that process is completed. We also have vigorous internal processes in place to ensure compliance with regulations and work to minimize community impacts.

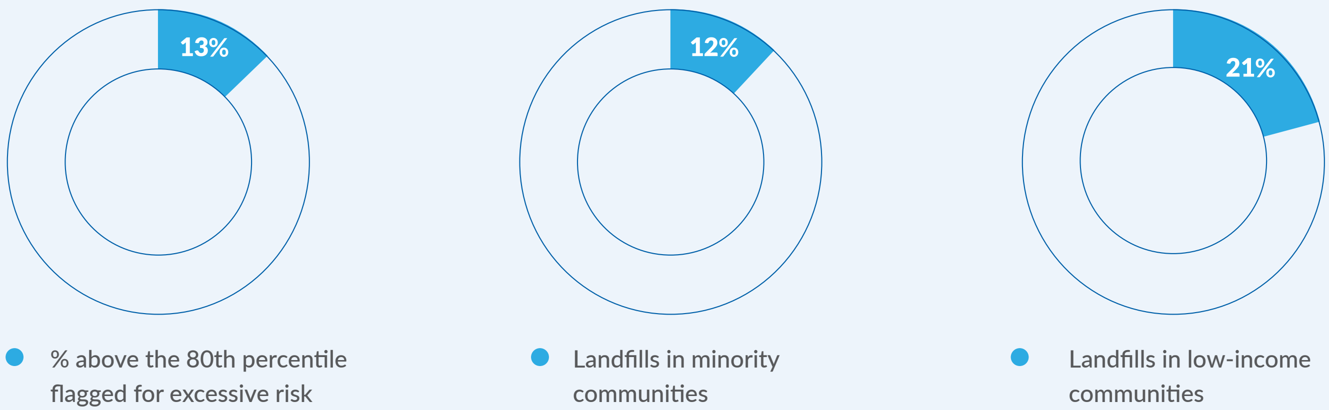
BOARD OVERSIGHT

Our Board of Directors has oversight of our efforts related to EJ and receives periodic updates from our Executive Vice President – Engineering and Disposal and Vice President – Engineering and Sustainability. Those updates include discussion of our analysis regarding EJ impacted areas and the steps we are taking to address local concerns.

METHODOLOGY AND FINDINGS

We utilize several methods to assess our company assets — informing our understanding of our impacts on local communities as well as potential regulatory risk to permitting and ongoing operations. As part of our assessment, we utilize the EPA's EJScreen to evaluate the socioeconomic attributes of our operating locations in the U.S. First, we utilize the EJScreen's "Demographic Index" or "DI" that incorporates both race and income statistics throughout each census tract. We focus our analysis to the 80th percentile of the DI, above which census blocks are flagged for excessive EJ risk. In addition, we analyze the racial and low-income percentages of households within one-kilometer of our facilities. As depicted below, when focusing on our landfill assets, only 13% of our landfills exceed the 80th percentile of the DI index and only 12% and 21% are located within communities with above average minority and low-income household representation, respectively. For additional details on our EJ strategy, including the same analysis for our other operating sites, please see our EJ Analysis.

PERCENTAGE OF U.S. SITES THAT EXCEED THE DI 80TH PERCENTILE THRESHOLD AND ARE LOCATED IN AT RISK COMMUNITIES



GOVERNANCE & ETHICS

CORPORATE GOVERNANCE

Since our inception, we have been committed to well-defined principles of corporate governance. Our Corporate Governance Guidelines and Board Charter align the Board of Directors and its four distinct committees with management in order to promote the best interests of the Company.

- Directors are elected individually
- Majority voting policy for the election of our Directors
- Separate CEO and Chairman of the Board of Directors, or Board Chairman positions
- Having a strong Lead Independent Director serve on the Board of Directors
- Women account for 33% of independent Board members and 25% of total Board members
- Director retirement policy
- Annual Board of Directors and committee evaluation processes
- Board of Directors' oversight of risk
- Robust Risk management program related to compensation
- Share ownership requirement for Directors and corporate officers
- Diversity Policy including aspirational targets for Board of Directors composition
- Regular executive sessions of only independent directors

The Board of Directors adopted a Diversity Policy for the Board of Directors and senior management, which provides for annual progress reviews by the Board. Similarly, the Board provides oversight of our aspirational ESG targets introduced in 2020, with management compensation tied to progress against our ESG targets beginning in 2021.

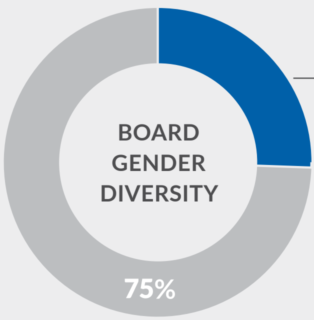
The Board also has oversight of our Environmental Policy and our efforts related to Environmental Justice.

Board Member Diversity and Skills

In addition to seeking diverse policy-making experiences in business and other personal and professional characteristics, we strive to maintain a Board of Directors with a diversity of backgrounds, including gender and ethnicity. The following charts summarize the independence and diversity metrics represented by our Board of Directors.

BOARD DIVERSITY

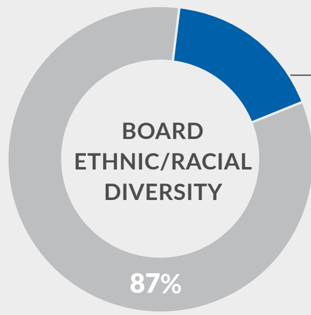
As of 2021



25%

OF OUR BOARD MEMBERS ARE FEMALE

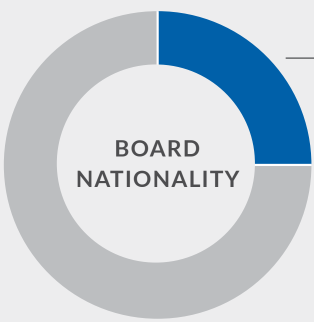
- Female
- Male



13%

IDENTIFY AS AN ETHNIC OR RACIAL MINORITY

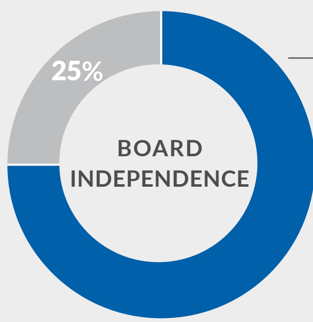
- Ethnic Minority
- Caucasian



25%

OF OUR BOARD MEMBERS ARE CANADIAN

- Canada
- U.S.



75%

OF OUR BOARD MEMBERS ARE INDEPENDENT

BOARD SKILLS

THE BOARD'S ROLE IN RISK OVERSIGHT

The Board of Directors and its committees have an active role in overseeing management of the Company's risks.

OUR BOARD HAS FOUR STANDING COMMITTEES

EXECUTIVE COMMITTEE

AUDIT COMMITTEE

COMPENSATION COMMITTEE

NOMINATING AND CORPORATE GOVERNANCE COMMITTEE

Except for the Executive Committee, the committees are composed entirely of independent, non-employee directors.

PERFORMANCE

Regularly reviews information from members of senior management regarding the Company's safety performance, employee retention, financial performance, financial outlook, balance sheet, credit profile and liquidity, as well as the risks associated with each.

STRATEGIC RISKS

Receives reports from members of senior and regional management on areas of material risk to the Company, including market-specific, operational, legal, information technology (including cybersecurity), regulatory and strategic risks.

SUCCESSION PLAN

With recommendations from the Audit and Compensation Committees, approves and maintains a succession plan for the CEO and other senior management of the Company, including policies and principles for selecting and evaluating a new CEO in the event of an emergency or retirement of the CEO.

AUDIT

The Audit Committee oversees management of financial, financial reporting and internal controls risk. The Compensation Committee assesses and monitors risks relating to the Company's corporate officer compensation policies and practices.

MANAGEMENT RISK

The Nominating and Corporate Governance Committee is responsible for overseeing the management of risks associated with the independence of the Board of Directors and potential conflicts of interest.

SECURITY

Receives reports on information technology risks, including cybersecurity and data security risks. Day-to-day management of data security is the responsibility of our Chief Information Officer, who reports directly to the CEO. The Board periodically reviews cybersecurity and data security risks and mitigation strategies with the Chief Information Officer.

DIVERSITY

The Board of Directors and its committees also play an active role in the Company's efforts to advance sustainability and diversity and inclusion, including the development and approval of targets, monitoring achievement toward such objectives, and evaluating the effectiveness of policies and targets. In addition, the Board added ESG targets as a performance measure in long-term incentive compensation beginning in 2021.

Code of Conduct

We have adopted a Code of Conduct and Ethics that applies to all of our directors, officers and employees. Our Code of Conduct and Ethics details Company principles to guide employee decision-making in many areas, including:

- **CONFLICTS OF INTEREST** No officer, director or employee may be subject to influences, interests or relationships that conflict with the best interests of the Company.

- **FULL, FAIR AND ACCURATE DISCLOSURE** It is the Company's policy that the information in its public communications, including its SEC filings and filings with the Canadian Securities Administrators, be full, fair, accurate, timely and understandable.

- **COMPLIANCE WITH LAWS, RULES AND REGULATIONS** It is the Company's policy to comply with all laws, rules and regulations applicable to the Company and its operations. The Company's strict compliance policy also extends to all other applicable laws and regulations, including the U.S. Foreign Corrupt Practices Act (FCPA), the Canadian Corruption of Foreign Public Officials Act (CFPOA), and other applicable anticorruption laws; antitrust laws; tax laws; environmental and safety regulations; equal opportunity, non-discrimination and fair employment laws; and foreign asset control regulations.

- **PROHIBITED ACCOUNTING PRACTICES** The Company's policy is to make and keep books, records and accounts that accurately and fairly reflect the transactions of the Company.

- **WHISTLEBLOWING — REPORTING ILLEGAL OR UNETHICAL BEHAVIOR** All officers, directors and employees should promptly report to senior management all actual or potential illegal or unethical behavior of Company personnel that they observe. The Company encourages and expects full and open communication with senior management even when it appears that less candor may be desirable to protect the Company or members of management. It is the Company's policy and the responsibility of each officer, director and employee to comply with all whistleblower protection laws, rules and regulations.

- **FAIR DEALING; MORAL AND ETHICAL STANDARDS** Each officer, director and employee must endeavor to deal fairly with the Company's customers, suppliers, competitors and employees and not to take unfair advantage of anyone through manipulation, concealment, abuse of privileged or misappropriated confidential information, misrepresentation of material facts or any other unfair dealing practice. More generally, each officer, director and employee must adhere to and comply with the highest moral and ethical standards of our society in conducting business on behalf of the Company.

- **HUMAN RIGHTS** It is the Company's policy and the responsibility of each officer, director and employee to comply with all laws, rules and regulations related to the protection and advancement of human rights, including, but not limited to, laws, rules and regulations governing the use of child labor, compulsory or forced labor, slavery and human trafficking, and freedom of association and collective bargaining. The Company acknowledges the rights of all employees to bargain collectively through representatives of their own choosing, and to engage in other concerted activities for the purpose of collective bargaining or other mutual aid or protection, as provided for in Section 7 of National Labor Relations Act. The Company also has polices regarding safety, equal opportunity, non-discrimination and fair employment. Potential human rights violations or grievances can be reported to the Company's Senior Vice President – People, Training and Development. Monitoring and reporting human rights performance is overseen by the Human Resources Department, including the Senior Vice President – People, Training and Development.

Code of Conduct Continued

COMPLIANCE AND DISCIPLINE Violations of this Code by officers, directors or employees will result in disciplinary action that may include termination, referral for criminal prosecution and reimbursement to the Company for any losses or damages resulting from the violation.

INSIDER TRADING Buying or selling securities, directly or indirectly through family members or other persons or entities, while possessing material nonpublic information or selectively disclosing such information to others who may trade based on it is prohibited by applicable securities laws.

CONTRIBUTIONS Officers, directors and employees may not (directly or indirectly) contribute Company funds to, or spend Company funds in support of, any kind of political party, political action committee or other committee in the United States or Canada or to any candidate for, or holder of, any office of any national, state or local government in the United States, or any national, provincial or local government in Canada. Exceptions may be permitted for state, provincial and local contributions in jurisdictions that permit corporate political contributions, but only upon approval by the Vice President, Deputy General Counsel — Compliance and Government Affairs and in consultation with the General Counsel. In countries other than the United States or Canada, the policy will be determined in accordance with local law and practice as well as laws applicable to the Company.

No political contribution by any officer, director or employee may be made, or even appear to be made, with the Company's funds, or be reimbursed from the Company's funds; nor should the selection of a candidate or a party be, or seem to be, coerced by the Company. Officers, directors and employees are prohibited from using their positions to induce, coerce or in any way influence any person, including subordinates, to support or contribute time or money to any political party, to the campaign of any candidate for office or to any charitable activity.

The Nominating and Corporate Governance Committee is responsible for, among other matters, the development and implementation of the Company's corporate governance principles, including the review of and compliance with our Corporate Governance Guidelines and Board Charter and our Code of Conduct and Ethics. The Nominating and Corporate Governance Committee is responsible for monitoring the implementation of the Company's diversity policy on a periodic basis, and at least annually, to assess its effectiveness, monitoring and reviewing the Company's progress in achieving its aspirational targets and reporting the results to the Board, and making recommendations to the Board regarding any revisions to this policy that may be necessary or appropriate.

The Board is responsible for reviewing strategy, policies and performance related to the Company's management of environmental, social and governance (ESG) issues, including reviewing any reports on the Company's performance against ESG targets, any ESG programs, products and disclosures, and any corporate responsibility policies and programs, in coordination with other committees of the Board, as appropriate.

Copies of our Corporate Governance Guidelines and Board Charter and our Code of Conduct and Ethics are available on our website at http://investors.wasteconnections.com. A copy of the Corporate Governance Guidelines and Board Charter and our Code of Conduct and Ethics may also be obtained, free of charge, by writing to our Secretary or Investor Relations at our principal administrative offices located at:

Waste Connections, Inc.
3 Waterway Square Place, Suite 110
The Woodlands, Texas 77380

Integration of ESG Metrics into Management Compensation

In October 2020, the Company adopted long-term, aspirational sustainability targets and committed over $500 million for investments to meet or exceed such targets.

These targets primarily focus on reducing emissions, increasing resource recovery of both recyclable commodities and clean energy fuels, reducing reliance on off-site disposal for landfill leachate, increasing employee engagement, and further improving our industry-leading safety performance. In 2022, we are broadening our commitment to the environment by adding a new target to reduce Scope 1 and 2 emissions by 15%. Additionally, we are adding a target seeking continuous improvement in emissions intensity — a critical goal for a growth-oriented company.

The Company views its ESG/Sustainability initiatives to be consistent with its objective of long-term value creation. As such, the Compensation Committee introduced continuous improvement toward the Company's sustainability targets as an additional performance measure of long-term incentive compensation beginning in 2021.

RECYCLING

50% ↑

Increase resources recovered by at least 50%

INCIDENT RATE

25% ↓

Reduction in Incident Rate

BIOGAS RECOVERY

40% ↑

Increase biogas recovery by at least 40%

VOLUNTARY TURNOVER

↓ Continuous improvement in Voluntary Turnover scores

LEACHATE

50% ↑

Process at least 50% of leachate on-site

SERVANT LEADERSHIP

↑ Continuous improvement in Servant Leadership scores

Shareholder Engagement

COMMUNICATIONS WITH THE BOARD

Shareholders and other interested parties may communicate with the Board of Directors generally, with the non-employee directors as a group or with a specific director at any time by writing to the Board of Directors, the non-employee directors or a specific director, care of the Company's Secretary, at our principal administrative offices located at:

Waste Connections, Inc.
3 Waterway Square Place, Suite 110
The Woodlands, Texas 77380

SHAREHOLDER OUTREACH

We believe that our relationship with and accountability to shareholders are critical to our success. Engaging with our shareholders helps us to understand how they view us, to set goals and expectations for our performance, and to identify emerging issues that may affect our strategies, sustainability initiatives, corporate governance, compensation practices or other aspects of our operations. Our shareholder and investor outreach includes investor road shows, analyst meetings, investor meetings and investor conferences, either virtually or in person. We also communicate with shareholders and other interested parties through various media, including our annual and quarterly reports, sustainability reports, proxy statements and other SEC and Canadian securities filings, press releases and our website. Our conference calls for quarterly earnings releases and major corporate developments are open to all. These calls are available in real time and are also archived as webcasts on our website. Our President and CEO, Chief Financial Officer and other senior management also regularly engage with investors to discuss our strategy, financial and business performance, and ESG efforts and to update investors on key developments.

DATA SECURITY AND PRIVACY

We maintain, log and monitor all information and technology assets — data, systems, and applications — that are critical to the operations and success of Waste Connections. We have incorporated a defensive and offensive security strategy built on people, process and technology with a focus on threat intelligence and security operations.

Waste Connections continues to maintain a robust security posture in response to today's ever-evolving threat landscape. The prime directive of this initiative is the safety and security of our customers', employees' and company's information. Our security model refers to an information security approach in which security mechanisms and controls are strategically layered throughout our infrastructure to secure our data's confidentiality, integrity and availability.

> We have the same expectations for our information technology service providers and all third parties that support the business.

MANAGING DATA SECURITY RISK

We employ the widely recognized National Institute of Standards & Technology Framework for Improving Critical Infrastructure Cybersecurity (The NIST Cybersecurity Framework) to manage cybersecurity risk. This voluntary guidance was developed with private sector input in 2014 and provides a framework for organizations to manage cybersecurity risk. We regularly assess our technologies and monitor our systems and other technical security controls, maintain information security policies and procedures, including an incident response plan, ensure maintenance of backup and valuable systems, and have a team of security personnel managing our efforts and initiatives.

Policies have been put in place to protect our customers and employees from fraudulent activity by building processes that require continuous education, phishing simulations, real-time threat monitoring, and detection. We use vulnerability scanning tools to regularly assess potential data security risks across our businesses. We correlate the results and prioritize any actions based on threat modeling analysis and monitor any actions in progress with the system owners based on assigned timelines for remediation. In addition, we actively monitor the web for any suspicious domain registrations, social media disinformation, and fraudulent campaigns being initiated against our customers and/or employees.

UPHOLDING DATA PRIVACY

We strive to protect personal data through reasonable technical and organizational security measures, including technical security tools, restrictions on access to data and physical security measures to help prevent unauthorized or unlawful access, disclosure, loss, destruction or damage. We access and use personal data for legitimate business purposes and maintain appropriate access controls and use limitations.

Our employees are required to follow all applicable privacy, information security and data protection laws, including the California Consumer Privacy Act. Our Data Privacy Policy sets forth the principles that govern our treatment of personal data, while our Policy on the Acceptable Use of Systems and Data governs the use and protection of information about our company and information that is stored on our computers and mobile devices. Our policies restrict individuals' access to personal data to those that need access to accomplish a business objective and allow access only for so long as it is necessary. We endeavor to follow data privacy best practices and have established specific governance structures to regularly review and improve upon our data privacy processes.

ENVIRONMENTAL POLICY

Waste Connections is committed to environmental protection and compliance. In order to realize and communicate these commitments across our workforce, Waste Connections has developed an Environmental Policy that applies to all of our subsidiaries, operating divisions and affiliates, and their respective officers, directors and employees. Waste Connections' management, including our Vice President – Engineering and Sustainability, is responsible for communicating, implementing and reviewing this policy annually. A full copy of our Environmental Policy can be found on our website. Below are highlights of our policy.

ENVIRONMENTAL COMPLIANCE

Comply with or exceed all local, state and federal environmental laws and regulations in order to manage and mitigate air-, water- and land-based pollution.

ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

Utilize and continually improve our EMS (The Cube, the Environmental Compliance Audit Center and/or other future systems) in order to track, audit and promote environmental compliance on a site-by-site basis.

BIODIVERSITY AND SITE REHABILITATION

As facilities are transitioned into closure, ensure that site construction and closure plans are effective at restoring the land to a condition that is consistent with the biodiversity of the surrounding environment.

EMERGENCY PREPAREDNESS

Establish emergency response action plans on a site-by-site basis, including processes to guide site personnel and local community service providers during emergency events.

RESOURCE EFFICIENCY

Minimize internal waste generation and incorporate new technologies where applicable to mitigate our environmental impact.

EXTERNAL COMMUNICATION

Promote the benefits of proper waste management, including resource recovery, to local stakeholders and customers.

STAKEHOLDER ENGAGEMENT

Partner with and engage the public as part of our environmental decision-making processes in order to promote the fair treatment and the opportunity for meaningful involvement of all people within the communities we serve.

ENVIRONMENTAL PERFORMANCE MEASUREMENT

Report our environmental progress through our annual Sustainability Report and as required with regulatory agencies.

EMPLOYEE TRAINING

Provide adequate training, oversight and resources to our employees to promote awareness and successful implementation of this Policy.

ESG FRAMEWORKS

GRI EMISSIONS DISCLOSURE

Waste Connections' emissions disclosure was developed using the Global Reporting Initiative (GRI) G4 Sustainability Reporting Guidelines. Waste Connections' GHG Inventories were prepared by a third-party, independent environmental services firm with the conclusions audited and verified by a separate third-party. The data was prepared in a manner consistent with The Climate Registry (TCR) General Reporting Protocol (GRP) Version 3.0 dated May 2019 and its associated updates and clarifications.

The affirmation of carbon sequestration in our landfills is well documented in scientific literature. Due to anaerobic conditions that exist within landfills, lignins and hemicellulosic materials remain undecomposed. They represent approximately 50% of biogenic carbon in the waste stream. Waste Connections disposed of 34,116,400 and 35,477,686 tons of Municipal Solid Waste and Construction & Demolition debris in 2020 and 2021, respectively. In total, our landfills sequestered 11,790,884 and 12,542,647 MT CO_2e in 2020 and 2021, respectively.

G4-EN15
DIRECT (SCOPE 1) GREENHOUSE GAS (GHG) EMISSIONS

MT CO_2e		
2019	2020	2021
6,006,643	5,609,964	5,600,178

G4-EN16
ENERGY INDIRECT (SCOPE 2) GHG EMISSIONS

MT CO_2e		
2019	2020	2021
55,442	51,506	50,694

G4-EN17
OTHER INDIRECT (SCOPE 3) GHG EMISSIONS

Emission Source	MT CO_2e		
	2019	2020	2021
Purchased goods and services	861,763	744,323	786,072
Capital goods	292,218	233,961	300,439
Waste generated in operations	151,342	77,359	77,143
Upstream transportation and distribution	503,351	498,960	555,497
Business travel (air and vehicle)	51,142	49,977	63,522
Use of sold products	84,119	48,436	33,653
TOTAL	**1,943,936**	**1,653,017**	**1,816,327**

G4-EN18
GHG EMISSION INTENSITY

	UNIT	2019	2020	2021
Gross revenue	$US Dollars Millions	$ 5,389	$ 5,446	$ 6,151
Scope 1 emissions	MT CO_2e	6,006,643	5,609,964	5,600,178
MT CO_2e/$M revenue		1,115	1,030	910
Scope 2 emissions MT CO_2e	MT CO_2e	55,442	51,506	50,694
MT CO_2e/$M revenue		10	9	8
Scope 1 & 2 emissions	MT CO_2e	6,062,085	5,661,470	5,650,872
MT CO_2e/$M revenue		1,125	1,040	919

G4-EN19: Reduction of GHG emissions

Waste Connections has undertaken several initiatives to reduce GHG emissions. The Company collected landfill gas for use at landfill gas-to-energy facilities at 27 landfills in 2021. The beneficial reuse of landfill gas at these facilities resulted in annual avoided GHG emissions estimated at 746,092 and 763,569 MTCO_2e in 2020 and 2021, respectively. The estimate of avoided emissions assumed that natural gas was the fuel replaced by the use of landfill gas. The avoided emissions were calculated using default methodologies from TCR and included CO_2, CH_4 and N_2O emissions.

Waste Connections diverts over 50% of collected waste volumes in certain markets, in some cases over 70%. The estimated avoided GHG emissions in 2020 and 2021 from recycling was 5,645,326 and 5,922,543 MT CO_2e, respectively. These values were calculated using the USEPA Waste Reduction Model (WARM).

Over the past several years, Waste Connections has deployed vehicles using alternative fuels such as compressed natural gas (CNG) and biodiesel as a means of reducing its GHG footprint. Waste Connections currently deploys approximately 1,100 CNG vehicles. The estimated annual reduction in GHG emissions from CNG vehicles was 21,824 and 20,544 MT CO_2e in 2020 and 2021, respectively. The calculation uses an equivalent diesel vehicle as a baseline.

G4-EN22: Water discharge by quality and destination

In 2020, Waste Connections collected 696,531,341 gallons of leachate with 434,295,795 gallons being sent to third parties for treatment. In 2020, Waste Connections also collected 582,364,767 gallons of E&P produced water for on-site treatment. A total of 21,201,290 gallons of E&P produced water was sent to third parties for treatment in 2020. In 2021, Waste Connections collected 679,892,559 gallons of leachate with 424,275,425 gallons being sent to third parties for treatment. In 2021, Waste Connections also collected 544,976,403 gallons of E&P produced water for on-site treatment. A total of 19,045,809 gallons of E&P produced water was sent to third parties for treatment in 2021.

Our E&P waste water treatment technologies allow us to process and dispose of 100% of drilling-related waters without discharging to surface waters. The majority of waste fluids are injected into brine formations via deep wells.

SASB APPENDIX

GREENHOUSE GAS EMISSIONS	UNITS	2019	2020	2021
Gross global Scope 1 emissions	MT CO2e	6,006,643	5,609,964	5,600,178
Scope 1 coverage under emissions-limiting regulations	Percentage (%)	85%	78%	83%
Scope 1 coverage under emissions-reporting regulations	Percentage (%)	85%	78%	83%
Total landfill gas recovered	Millions British Thermal Units (MMBtu)	21,547,648	22,939,938	23,600,222
Landfill gas flared	Percentage (%)	39%	40%	39%
Landfill gas used for energy	Percentage (%)	61%	60%	61%

FLEET FUEL MANAGEMENT	UNITS	2019	2020	2021
Fleet fuel consumed	Gigajoules (GJ)	10,501,924	10,743,000	11,426,299
Natural gas as % of fuel consumed	Percentage (%)	8.0%	7.8%	8.4%
Renewable as % of fuel consumed	Percentage (%)	N/A	N/A	N/A
Alternative fuel vehicles as % of fleet	Percentage (%)	13.8%	13.1%	11.9%

AIR QUALITY	UNITS	2019	2020	2021
NOx (Excluding N2O)	Metric Tons (t)	265	285	258
SOx	Metric Tons (t)	62	67	60
Volatile organic compounds (VOC)	Metric Tons (t)	N/A	7.7	7.2
Hazardous air pollutants (HAP)	Metric Tons (t)	N/A	10.9	9.9
Number of facilities in or near dense population centers	Number	7	7	7
Non-compliant air emissions issues	Number	2	2	6

MANAGEMENT OF LEACHATE & HAZARDOUS WASTE	UNITS	2019	2020	2021
Total leachate collected	Gallons (000)	703,342	696,531	679,893
Total leachate treated by third parties	Gallons (000)	470,251	434,296	424,275
Corrective actions implemented for landfill releases	Number	0	0	0
Incidents of non-compliance associated with environmental impacts	Number	0	0	0

SASB APPENDIX CONTINUED

LABOR PRACTICES	UNITS	2019	2020	2021
Active workforce covered under collective bargaining agreements	Number	3,159	3,172	2,934
Work stoppages	Number	0	1	0
Impacted employees as a percent of total workforce	Percentage (%)	0.00%	0.76%	0.00%
Total days idle	Days	0	6	0

WORKFORCE HEALTH AND SAFETY	UNITS	2019	2020	2021
Total recordable incident rate (TRIR)[1]	Rate	2.91	2.90	3.25
Incident rate (I-Rate)[1]	Rate	17.4	15.4	15.4
Fatality rate	Rate	0.00%	0.02%	0.00%

1. BASIC score definitions are unclear and can be inconsistent; we prefer to use TRIR and Incident Rate as a better barometer of safety.

RECYCLING & RESOURCE RECOVERY	UNITS	2019	2020	2021
Waste incinerated	Metric Tons (t)	0	0	0
Hazardous waste incinerated as percent of waste incinerated	Percentage (%)	0%	0%	0%
Energy recovery from waste incinerated	Percentage (%)	0%	0%	0%
Customers receiving recycling	Percentage (%)	50%	50%	50%
Customers receiving composting	Percentage (%)	27%	25%	25%
Amount of material recycled	Metric Tons (t)	1,541,792	1,615,536	1,673,435
Amount of material composted	Metric Tons (t)	210,757	201,991	121,348
Amount of material processed as waste-to-energy	Metric Tons (t)	N/M	N/M	N/M
Amount of electronic waste collected	Metric Tons (t)	N/M	N/M	N/M
Percentage of electronic waste recovered through recycling	Percentage (%)	N/M	N/M	N/M

SASB APPENDIX CONTINUED

ACTIVITY METRICS	UNITS	2019	2020	2021
Customers - municipal	Number	2,000	2,100	2,230
Customers - commercial	Number	600,000	720,000	745,000
Customers - industrial	Number	100,000	135,000	145,000
Customers - residential	Number	6,500,000	7,425,000	7,875,000
Customers - other	Number	200,000	220,000	230,000
Vehicle fleet size[2]	Number	8,089	8,912	9,162
Landfills	Number	97	92	97
Transfer stations	Number	175	185	195
Recycling centers	Number	66	68	71
Composting centers	Number	6	7	7
Incinerators	Number	0	0	0
All other facilities	Number	342	352	334

2. Represents total routed collection vehicles.

TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURE (TCFD)

Since our first Sustainability Report in 2018, we have rapidly expanded our ESG-related disclosure in order to incorporate feedback from our stakeholders and provide transparency around the integration of ESG into our long-term business objectives. This year, we are responding again to stakeholder feedback and are providing greater disclosure related to our approach to environmental risks and opportunities by detailing recommendations outlined by the Task Force on Climate-related Financial Disclosure (TCFD). Related to our TCFD disclosure and risk assessment, we are furthering our commitment to fighting climate change by adding two emissions-related targets and pledging to work towards the adoption of a Science-Based Target Initiative (SBTi) emissions reduction target.

Our high-level approach to TCFD was no different from our traditional risk assessment process, incorporating feedback from various disciplines and weighing both risks and opportunities. While not without some level of climate-based risk, our conclusion from the process and associated risk assessment is that our company and industry are well-positioned to leverage opportunities within the circular economy. To this point, we look forward to expanding our beneficial recovery of landfill gas and converting into lower carbon intensity renewable fuel, increasing our recycling efforts, and deploying fully electric vehicles when they become commercially available.

"The TCFD process and risk assessment has created a formal process to frame potential impacts and opportunities associated with physical and transitional risks of climate change. We will remain vigilant of future risks and opportunities with fundamental oversight and are well-positioned to benefit from future regulations supporting a transition to low carbon based fuels."

Kurt Shaner
Vice President – Engineering & Sustainability

WASTE CONNECTIONS
Connect with the Future®

Principal Executive Offices
6220 Hwy 7, Suite 600
Woodbridge, Ontario L4H 4G3 Canada

Principal Administrative Offices
3 Waterway Square Place, Suite 110
The Woodlands, Texas 77380 USA

832.442.2200
www.wasteconnections.com
www.wasteconnections.com/sustainability

Exhibit 19

Waste Connections to Buy Oil Field Waste Company for $1.3 Billion

Allan Gerlat | Sep 17, 2012

Save

Allan Gerlat | Sep 17, 2012

Waste Connections Inc. has agreed to buy oil field waste treatment and disposal company R360 Environmental Solutions Inc. for approximately $1.3 billion in cash.

R360 provides non-hazardous oilfield waste treatment, recovery and disposal services for natural resource producing areas in the United States with annual revenue of about $300 million. It operates 26 facilities in Louisiana, New Mexico, North Dakota, Oklahoma, Texas and Wyoming, the Woodland, Texas-based Waste Connections said in a news release.

Waste Connections expects the transaction to close in the fourth quarter of this year, subject to certain closing conditions.

“This acquisition represents a natural extension of our existing E&P [exploration and production] disposal activities," said Ron Mittelstaedt, Chairman and CEO of Waste Connections. "While a tepid economy has impacted MSW [municipal solid waste] volumes, increased drilling activity in unconventional areas is fueling impressive organic growth within the E&P waste sector.”

He added that R360 is actively permitting several new sites to further expand its operations.

R360 has about 11 landfills with about two-thirds of its business in solids and the rest liquids, according to a newsletter published by Michael Hoffman, managing director of Wunderlich Securities Inc.

Springfield, Mo. Teaches Kids About Recycling with “Trash or Treat” Event

Wavebreak Media ltd / Alamy Stock Photo

Exhibit 20

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UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-K

(Mark One)

☑ **ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the fiscal year ended December 31, 2022

OR

☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the transition period from ___________ to ___________

Commission File No. 1-34370

WASTE CONNECTIONS, INC.
(Exact name of registrant as specified in its charter)

Ontario, Canada
(State or other jurisdiction of incorporation or organization)
98-1202763
(I.R.S. Employer Identification No.)
6220 Hwy 7, Suite 600
Woodbridge
Ontario L4H 4G3
Canada
(Address of principal executive offices)

(905) 532-7510
(Registrant's telephone number, including area code)
Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common Shares, no par value	WCN	New York Stock Exchange ("NYSE") Toronto Stock Exchange ("TSX")

Securities registered pursuant to Section 12(g) of the Act: None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act.
Yes ☑ No ☐

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act.
Yes ☐ No ☑

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days.
Yes ☑ No ☐

Indicate by check mark whether the registrant has submitted electronically every Interactive Data File required to be submitted pursuant to Rule 405 of Regulation S-T during the preceding 12 months (or for such shorter period that the registrant was required to submit such files).
Yes ☑ No ☐

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company, or an emerging growth company. See the definitions of "large accelerated filer," "accelerated filer," "smaller reporting company" and "emerging growth company" in Rule 12b-2 of the Exchange Act. (Check one):

☑ Large accelerated filer	☐ Accelerated filer	☐ Non-accelerated filer	☐ Smaller reporting company	☐ Emerging growth company

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Indicate by check mark whether the registrant has filed a report on and attestation to its management's assessment of the effectiveness of its internal control over financial reporting under Section 404(b) of the Sarbanes-Oxley Act (15 U.S.C. 7262(b)) by the registered public accounting firm that prepared or issued its audit report. ☑

If securities are registered pursuant to Section 12(b) of the Act, indicate by check mark whether the financial statements of the registrant included in the filing reflect the correction of an error to previously issued financial statements. ☐

Indicate by check mark whether any of those error corrections are restatements that required a recovery analysis of incentive-based compensation received by any of the registrant's executive officers during the relevant recovery period pursuant to §240.10D-1(b). ☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act).
Yes ☐ No ☑

As of June 30, 2022, the aggregate market value of shares held by non-affiliates of the registrant, based on the closing sales price for the registrant's common shares, as reported on the New York Stock Exchange, was $31,785,271,082.

Number of common shares outstanding as of February 3, 2023: 257,220,344

DOCUMENTS INCORPORATED BY REFERENCE

Portions of the registrant's definitive Management Information Circular and Proxy Statement for the 2023 Annual Meeting of Shareholders (which will be filed with the SEC pursuant to Regulation 14A of the Securities Exchange Act of 1934, as amended, or the Exchange Act, and with the securities commissions or similar regulatory authorities in Canada within 120 days after the end of our 2022 fiscal year) are incorporated by reference into Part III hereof.

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WASTE SERVICES

Collection Services

We provide collection services to residential, commercial, municipal, industrial and E&P customers. Our services are generally provided under one of the following arrangements: (1) governmental certificates; (2) exclusive franchise agreements; (3) exclusive municipal contracts; (4) residential subscriptions; (5) residential contracts; or (6) commercial, industrial and E&P service agreements.

Governmental certificates, exclusive franchise agreements and exclusive municipal contracts grant us rights to provide MSW services within specified areas at established rates and are long-term in nature. Governmental certificates, or G Certificates, are unique to the State of Washington and are awarded by the Washington Utilities and Transportation Commission, or WUTC, to solid waste collection service providers in unincorporated areas and electing municipalities. These certificates typically grant the holder the exclusive and perpetual right to provide specific residential, commercial and/or industrial waste services in a defined territory at specified rates, subject to divestiture and/or overlap or cancellation by the WUTC on specified, limited grounds. Franchise agreements typically provide an exclusive period of seven years or longer for a specified territory; they specify a broad range of services to be provided, establish rates for the services and can give the service provider a right of first refusal to extend the term of the agreement. Municipal contracts typically provide a shorter service period and a more limited scope of services than franchise agreements and generally require competitive bidding at the end of the contract term. In markets where exclusive arrangements are not available, we may enter into residential contracts with homeowners' associations, apartment owners and mobile home park operators, or work on a subscription basis with individual households. In such markets, we may also provide commercial and industrial services under customer service agreements generally ranging from one to five years in duration. Finally, in certain E&P markets with "no pit" rules or other regulations that limit on-site storage or treatment of waste, we offer containers and collection services to provide a closed loop system for the collection of drilling wastes at customers' well sites and subsequent transportation of the waste to our facilities for treatment and disposal.

Landfill Disposal Services

As of December 31, 2022, we owned or operated 75 MSW landfills, nine E&P waste landfills, which only accept E&P waste and 16 non-MSW landfills, which only accept construction and demolition, industrial and other non-putrescible waste. Eight of our MSW landfills also received E&P waste during 2022. We generally own landfills to achieve vertical integration in markets where the economic and regulatory environments make landfill ownership attractive. We also own landfills in certain markets where it is not necessary to provide collection services because we believe that we are able to attract volume to our landfills, given our location or other market dynamics.

For landfills we operate but do not own, the owner of the property, generally a municipality, usually holds the permit and we operate the landfill pursuant to a landfill operating agreement for a contracted term, which may be the life of the landfill. Where the contracted term is not the life of the landfill, the property owner is generally responsible for final capping, closure and post-closure obligations. We are responsible for all final capping, closure and post-closure obligations at our operated landfills for which we have life-of-site agreements.

Based on remaining permitted capacity as of December 31, 2022, and projected annual disposal volumes, the average remaining landfill life for our owned and operated landfills and landfills operated, but not owned, under life-of-site agreements, is estimated to be approximately 31 years. Many of our existing landfills have the potential for expanded disposal capacity beyond the amount currently permitted. We regularly consider whether it is advisable, in light of changing market conditions and/or regulatory requirements, to seek to expand or change the permitted waste streams or to seek other permit modifications. We also monitor the available permitted in-place disposal capacity of our landfills on an ongoing basis and evaluate whether to seek capacity expansion using a variety of factors.

We are currently seeking to expand permitted capacity at 10 of our landfills, for which we consider expansions to be probable. Although we cannot be certain that all future expansions will be permitted as designed, the average remaining landfill life for our owned and operated landfills and landfills operated, but not owned, under life-of-site agreements is

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	Three Months Ended								
	March 31, 2021		June 30, 2021		September 30, 2021		December 31, 2021		Twelve Months Ended
	Number of Sites	Total Tons	Number of Sites	Total Tons	Number of Sites	Total Tons	Number of Sites	Total Tons	December 31, 2021
Owned operational landfills and landfills operated under life-of-site agreements	87	10,189	87	12,433	89	12,545	92	11,465	46,632
Operated landfills	4	127	4	147	5	147	5	159	580
	91	10,316	91	12,580	94	12,692	97	11,624	47,212

The expiration dates for the seven operated landfills range from 2023 to 2042. We are seeking or intend to seek renewal of all seven contracts prior to, or upon, their expiration.

Transfer Station Services

We own or operate MSW transfer stations and E&P waste transfer stations with marine access. Transfer stations receive, compact and/or load waste to be transported to landfills or treatment facilities via truck, rail or barge. They extend our direct-haul reach and link collection operations or waste generators with distant disposal or treatment facilities by concentrating the waste stream from a wider area and thus providing better utilization rates and operating efficiencies.

Recycling Services

We offer residential, commercial, industrial and municipal customers recycling services for a variety of recyclable materials, including compost, cardboard, mixed paper, plastic containers, glass bottles and ferrous and aluminum metals. We own and operate recycling operations and market collected recyclable materials to third parties for processing before resale. The majority of the recyclables we process for sale are paper products and are shipped to customers in the United States and Canada, as well as other markets, including Asia. Changes in end market demand as well as other factors can cause fluctuations in the prices for such commodities, which can affect revenue, operating income and cash flows. We believe that recycling will continue to be an important component of local and state solid waste management plans due to the public's increasing environmental awareness and expanding regulations that mandate or encourage recycling. We also believe that the costs of processing recyclables, including the costs of contamination, which have historically been subsidized by the sale of recycled commodities, need to be fully recognized. To that end, we have increased the fees that we charge for the collection of recyclables and for processing at our recycling facilities to more fully reflect the processing costs associated with the separation of recyclables into marketable commodities. In some instances, we will look to pass the risk associated with the volatility of recycled commodity prices onto our customers.

Beneficial Reuse of Landfill Gas

We develop, own and operate projects for the beneficial reuse of landfill gas through our landfill network. Over time, landfill gas is produced as waste decomposes at landfills, and the methane component is a readily available renewable energy source that can be gathered and converted into a valuable source of clean energy as recognized by the United States Environmental Protection Agency, or the EPA, in the same category as wind, solar, and geothermal resources. As of December 31, 2022 we have gas recovery systems at 55 of our landfills to collect methane, which can then be used to generate electricity for local households, fuel local industrial power plants or power alternative fueled vehicles. For 17 of these beneficial reuse projects, the processed gas is used to fuel electricity generators. The electricity is then sold to public utilities. For 10 of these projects, the landfill gas is processed to pipeline quality natural gas and sold to natural gas companies. In some cases, landfill gas generated at our landfills qualifies as a renewable fuel for which renewable fuel credits may be available.

E&P Waste Treatment, Recovery and Disposal Services

E&P waste is a broad term referring to the by-products resulting from oil and natural gas exploration and production activity. These generally include: waste created throughout the initial drilling and completion of an oil or natural gas well,

Exhibit 21

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UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-K

(Mark One)

☒ **ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the fiscal year ended December 31, 2012

OR

☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the transition period from _________ to _________

Commission File No. 1-31507

WASTE CONNECTIONS, INC.
(Exact name of registrant as specified in its charter)

Delaware (State or other jurisdiction of incorporation or organization)	**94-3283464** (I.R.S. Employer Identification No.)
Waterway Plaza Two **10001 Woodloch Forest Drive, Suite 400** **The Woodlands, Texas** (Address of principal executive offices)	**77380** (Zip Code)

(832) 442-2200
(Registrant's telephone number, including area code)

Securities registered pursuant to Section 12(b) of the Act:

Common Stock, par value $0.01 per share (Title of each class)	**New York Stock Exchange** (Name of each exchange on which registered)

Securities registered pursuant to Section 12(g) of the Act: None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act. Yes ☒ No ☐

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act. Yes ☐ No ☒

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes ☒ No ☐

Indicate by check mark whether the registrant has submitted electronically and posted on its corporate Web site, if any, every Interactive Data File required to be submitted and posted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit and post such files). Yes ☒ No ☐

Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K is not contained herein, and will not be contained, to the best of registrant's knowledge, in definitive proxy or information statements incorporated by reference in Part III of this Form 10-K or any amendment to this Form 10-K. ☒

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, or a smaller reporting company. See the definitions of "large accelerated filer," "accelerated filer" and "smaller reporting company" in Rule 12b-2 of the Exchange Act. (Check one):

Large accelerated filer	☒	Accelerated filer	☐
Non-accelerated filer	☐	Smaller reporting company	☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act). Yes ☐ No ☒

As of June 30, 2012, the aggregate market value of voting and non-voting common stock held by non-affiliates of the registrant, based on the closing sales price for the registrant's common stock, as reported on the New York Stock Exchange, was $3,664,771,905.

Number of shares of common stock outstanding as of February 15, 2013: 123,327,573

DOCUMENTS INCORPORATED BY REFERENCE

Portions of the registrant's definitive Proxy Statement for the 2013 Annual Meeting of Stockholders are incorporated by reference into Part III hereof.

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Transfer Station and Intermodal Services

As of December 31, 2012, we owned or operated 61 MSW transfer stations and seven E&P waste transfer stations with marine access. Transfer stations receive, compact and load waste to be transported to landfills or treatment facilities via truck, rail or barge. They extend our direct-haul reach and link collection operations or waste generators with distant disposal or treatment facilities by concentrating the waste stream from a wider area and thus providing better utilization rates and operating efficiencies.

Intermodal logistics is the movement of containers using two or more modes of transportation, usually including a rail or truck segment. We entered the intermodal services business in the Pacific Northwest through the acquisition of Northwest Container Services, Inc., which provides repositioning, storage, maintenance and repair of cargo containers for international shipping companies. We provide these services for containerized cargo primarily to international shipping companies importing and exporting goods through the Pacific Northwest. We also operate two intermodal facilities primarily for the shipment of waste by rail to distant disposal facilities that we do not own. As of December 31, 2012, we owned or operated seven intermodal operations in Washington and Oregon. Our fleet of double-stack railcars provides dedicated direct-line haul services among terminals in Portland, Tacoma and Seattle. We have contracts with the Burlington Northern Santa Fe and Union Pacific railroads for the movement of containers among our seven intermodal operations. We also provide our customers container and chassis sales and leasing services.

We intend to further expand our intermodal business through cross-selling efforts with our solid waste services operations. We believe that a significant amount of solid waste is transported currently by truck, rail and barge from primarily the Seattle-Tacoma and Metro Portland areas to remote landfills in Eastern Washington and Eastern Oregon. We believe our ability to market both intermodal and disposal services will enable us to more effectively compete for these volumes.

Recycling Services

We offer residential, commercial, industrial and municipal customers recycling services for a variety of recyclable materials, including cardboard, office paper, plastic containers, glass bottles and ferrous and aluminum metals. We own or operate 38 recycling processing operations and sell other collected recyclable materials to third parties for processing before resale. The majority of the recyclables we process for sale are paper products and are shipped to customers in Asia. Changes in end market demand can cause fluctuations in the prices for such commodities, which can affect revenue, operating income and cash flows. To reduce our exposure to commodity price volatility and risk with respect to recycled materials, we have adopted a pricing strategy of charging collection and processing fees for recycling volume collected from third parties. We believe that recycling will continue to be an important component of local and state solid waste management plans due to the public’s increasing environmental awareness and expanding regulations that mandate or encourage recycling.

E&P Waste Treatment, Recovery and Disposal Services

E&P waste is a broad term referring to the by-products resulting from oil and natural gas exploration and production activity. These generally include: waste created throughout the initial drilling and completion of an oil or natural gas well, such as drilling fluids, drill cuttings, completion fluids and flowback water; production wastes and produced water during a well’s operating life; contaminated soils that require treatment during site reclamation; and substances that require clean-up after a spill, reserve pit clean-up or pipeline rupture. E&P customers are principally integrated oil and natural gas exploration and production companies operating in the areas that we serve. E&P revenue is therefore driven by vertical and horizontal drilling, hydraulic fracturing, production and clean-up activity; it is complemented by other services including closed loop collection systems and the sale of recovered products. E&P activity varies across market areas which are tied to the natural resource basins in which the drilling activity occurs and reflects the regulatory environment, pricing and disposal alternatives available in any given market.

Our customers are generally responsible for the delivery of their waste streams to us. We receive flowback water, produced water and other drilling and production wastes at our facilities in vacuum trucks, dump trucks or containers deposited by roll-off trucks. In certain markets we offer bins and rails systems that capture and separate liquid and solid oilfield waste streams at our customers’ well sites and deliver the drilling and production wastes to our facilities. Waste generated by offshore drilling is delivered by supply vessel from the drilling rig to one of our transfer stations, where the waste is then transferred to our network of barges for transport to our treatment facilities.

Exhibit 22

(11) Brine pit--A pit used for storage of brine in connection with the solution mining of brine, the operation of an underground hydrocarbon storage facility, or other activities associated with oil and gas exploration, development, storage or production that involve the creation or use of a salt cavern.

Commented [PD17]: Rule 8(a)(2), modified

(12) Buffer zone--A zone free of oil and gas waste processing and disposal activities within and adjacent to the facility boundary on property owned or controlled by the owner or operator.

Commented [PD18]: New

(13) Cap--A continuous, impervious layer of materials, synthetic or natural, which is placed over an area of waste disposal and that serves to restrict the release or migration of oil field fluids or oil and gas wastes into the subsurface or surface.

Commented [PD19]: New

(14) Capillary barrier--A high porosity layer installed over an area of waste disposal in lieu of a cap to prevent upward migration of waste constituents in areas where the annual evaporation rate is greater than the annual precipitation rate, the annual precipitation rate is 25 inches or less, and the depth to subsurface groundwater is greater than 100 feet below land surface (bls).

Commented [PD20]: New

(15) Carrier--A person who transports oil and gas solid and liquid wastes. A carrier of another person's oil and gas wastes may be a generator of its own oil and gas wastes.

Commented [PD21]: Rule 8(a)(17), modified

(16) Coastal Management Program (CMP) rules--The enforceable rules of the Texas Coastal Management Program codified at 31 Texas Administrative Code, Chapters 501 through 506.

Commented [PD22]: Rule 8(a)(36)

(17) Coastal Natural Resource Area (CNRA)--One of the following areas defined in Texas Natural Resources Code, §33.203: coastal barriers, coastal historic areas, coastal preserves, coastal shore areas, coastal wetlands, critical dune areas, critical erosion areas, gulf beaches, hard substrate reefs, oyster reefs, submerged land, special hazard areas, submerged aquatic vegetation, tidal sand or mud flats, water in the open Gulf of Mexico, and water under tidal influence.

Commented [PD23]: Rule 8(a)(37)

(18) Coastal waters--Waters under tidal influence and waters of the open Gulf of Mexico.

Commented [PD24]: Rule 8(a)(38)

(19) Coastal zone--The area within the boundary established in 31 Texas Administrative Code, §503.1 (relating to Coastal Management Program Boundary).

Commented [PD25]: Rule 8(a)(35)

(20) Commercial facility--A facility whose owner or operator receives compensation from others for the receipt, handling, storage, treatment, reclamation, recycling, or disposal of oil field fluids or oil and gas wastes. See also "Facility" and "Non-commercial facility."

Commented [PD26]: New. Similar to Rule 78(a)(3)

(21) Commission--The Railroad Commission of Texas (RRC).

Commented [PD27]: New

(22) Completion/workover pit--A pit used for storage or disposal of spent completion fluids and solids, workover fluids and solids, and drilling fluids and solids, silt, debris, water, brine, oil scum, paraffin, or other materials which have been cleaned out of the wellbore of a well being completed, or worked over, or plugged.

Commented [PD28]: Rule 8(a)(4), modified

Exhibit 23

Texas Commission on Environmental Quality
Municipal Solid Waste Facility
Geomembrane/Geosynthetic Liner
Evaluation Report

******Read These Instructions Before Completing This Form******

This form is to be completed by a knowledgeable professional engineer experienced in geotechnical engineering and is experienced in geosynthetic clay liner testing, the interpretation of these test results, and the proper methods of constructing impermeable geomembrane/geosynthetic clay liners that meet the requirements of the Texas Commission on Environmental Quality (TCEQ) rules.

The certifying engineer or a member of his or her staff qualified by training and experience shall monitor liner construction, but the final evaluation must be made by the aforementioned engineer.

The purpose of the geomembrane/geosynthetic clay liner evaluation report is to assure that groundwater, as defined in the TCEQ rules, is protected from contamination resulting from the storage, processing, and disposal of municipal solid waste. This liner evaluation report is required to document that the liner was constructed as designed in accordance with the issued registration or permit and meets the TCEQ regulatory requirements prior to unit operation.

This report is to be supplemented with those quality-assurance/quality-control (QA/QC) tests as detailed in the liner quality control plan (LQCP) and shall be the basis of documentation of the quality control and acceptance of the constructed liner.

The term “GCL” as used in this report form refers to geosynthetic clay liner. The term “GCLER” refers to geosynthetic clay liner evaluation report and is synonymous with the term “SLER” as described in the TCEQ rules when GCL is used to replace or supplement a soil liner as part of an alternative liner design.

Attach additional sheets as needed, and on each sheet identify the appropriate Part and Paragraph number for each reference.

If the geosynthetic clay liner is to be covered by a geomembrane, complete Part F and G of this form with the geomembrane liner evaluation report.

Provide an interim status report within six (6) months completion of the protective cover as stated in Part E.3 and each 6 months thereafter until the entire liner system is covered by municipal solid waste. This report should be developed by a qualified independent consultant and submitted to the TCEQ. No formal report form exists for this purpose. The integrity and required thickness of the protective cover must be verified. If erosion of the protective cover has occurred, then it must be replaced and reported as such and verified by the consultant that it meets the thickness requirement. If repairs are necessary on the synthetic liner, then these repairs must be completed in accordance with the approved LQCP and reported to the TCEQ in a supplemental liner evaluation report.

Important: Three **signed, sealed, and dated copies** of this form which includes one original copy and all attachments (drawings, comments, etc.) must be provided to the TCEQ.

(Submit this Report to the TCEQ in Triplicate)

Texas Commission on Environmental Quality
Municipal Solid Waste Facility
Geomembrane/Geosynthetic Liner
Evaluation Report

Part A: Facility Identification

Permittee: ____

Permit No.: ________________ Operational Classification Type: _________________

County: ____

Part B: General Information

1. What type of liner system is required by the permit and is detailed in the site development plan (SDP)? ____

2. Is this the first liner element of a composite liner system? ________________________

3. Does the SDP require a leachate collection system (LCS) for this liner system? ________

4. Date of the current approved LQCP that was used to develop this GLER/GCLER? ______

   a. Was this plan followed? ____

   b. If not followed, why not? ____

Part C: Locations and/or Description of Areas Currently Being Evaluated

1. Attach to this report a copy of the latest approved sectorized fill layout plan showing the areas or sectors of the landfill or waste management unit currently under evaluation and noting areas previously filled. The required grid system must be shown on this drawing.

2. On a sketch(es) or drawing(s) of the area or areas under evaluation, indicate the following:

   a. Boundary lines distinguishing the bottom and sidewall areas of the trenches or fill areas being evaluated and SLER/GCLER/GLER boundary markers.

   b. Geomembrane/GCL panel layout with number designation and location of all repairs.

   c. As-built elevations of subgrade or liner.

3. Are boundary markers in place at the time of this submittal (see rules in title 30 Texas Administrative Code, Chapter 330, Section 330.143.)? ________________

4. Present evaluation location and area of coverage:

   a. Trench, sector, or area identification or number (include SLER/GCLER/GLER boundary coordinates) of this evaluation: ______________________________

b. Excavation depth ______ft.; Actual elevation of trench at: top __________ ft.; bottom _________ ft.; Width of excavation at: top _________ ft.; bottom ________ ft.; and ration of side slopes __________ H: __________V.

c. total square footage of liner construction for the floor ________________ ft.^{2} and for each individual side slope: (1) ________ft.^{2}; (2) __________ ft.^{2}; (3) _______ ft.^{2}; (4) _________ ft.^{2} (if evaluated area has more than four sides, list all others) ____

Part D: Liner Materials

1. Geomembrane Liner

a. Indicate type of geomembrane used on floor and sidewalls _________________

b. Indicate geomembrane roll dimensions _______________________________

c. Does the geomembrane material meet the specifications and the requirements given in the SDP and the LQCP? _____________________. If not, please explain ____ Attach roll delivery documentation, manufacturer's certification, and conformance testing results. Provide information on a geosynthetics inventory table 6 if not provided elsewhere.

2. Geosynthetic Clay Liner

a. Indicate type of GCL used on floor and sidewalls:

___________ Needle-punched geotextile-encased GCL placed with nonwoven side up and woven side down.

___________ Needle-punched geotextile-encased GCL placed with woven side up and non-woven side down.

___________ Needle-punched GCL with nonwoven geotextile on both sides.

___________ Adhesive-bonded GCL with woven geotextile on both sides.

___________ Stitch-bonded GCL with woven geotextile on both sides.

___________ Geomembrane-backed adhesive bonded GCL placed with geomembrane side down.

___________ Geomembrane-backed adhesive-bonded GCL placed with geomembrane side up.

___________ Other (describe) ________________________________

b. GCL roll dimensions ____

c. Does the GCL material meet the specifications and the requirements given in the SDP and LQCP? _________. If not, please explain ______________________

Attach roll delivery documentation and manufacturer's certification and test results. Provide information on geosynthetics inventory form (attached) if not provided elsewhere.

Part E: Installation of the Geomembrane/Geosynthetic Clay Liner

Describe concisely on attached sheets the field and laboratory activities performed by the certifying engineer and/or the engineer's staff to accomplish this evaluation. Please indicate the method used to determine testing locations, testing procedures, testing locations and repairs, and field and laboratory methods that were followed.

1. Dates geomembrane/geosynthetic clay liner was installed. __________________

2. Dates the engineer visited the site. ____________________________________

3. Dates the protective cover was installed. ________________________________

4. Name(s) of the engineer's technician and dates on site. _____________________

____

5. Submit subgrade acceptance certificates.

6. Were all the QA/QC tests and the rate of testing preformed in conformance with the current LQCP? ___________. If not, please explain. ______________________

7. Attach any independent laboratory conformance test results for geomembrane liner or GCL if performed. These data must include copies of all laboratory permeability test data sheets. Also, include any miscellaneous tests such as any required field density tests on subgrade.

8. Submit geomembrane/geosynthetic clay liner panel development summary and geomembrane seam summary.

9. Geomembrane installation.

   a. Types of field seaming used? _____________________________________

   b. Start-Up Testing

      Were peel and shear test seams made by each seamer each day at the start-up of each seaming period and after the mid-day break, for each seaming apparatus he or she used that day? ___________. Did each seamer make at least one test seam each day he or she performed seaming? __________. Submit applicable geomembrane fusion trial seam summary and geomembrane extrusion trial seam summary tables.

   c. Non-Destructive Testing

      1. Was continuous, non-destructive testing performed on all seams? __

      2. Type of non-destructive testing: vacuum box _____, air pressure _____, other (please explain) _____________________________

      3. Submit air pressure test summary table and other non-destructive test documentation on the applicable geomembrane seam summary and geomembrane repair summary table.

   d. Destructive Testing (if performed)

      1. Number of locations where destructive tests were performed. __________ Total length of seaming ______ feet. Attach destructive tests results.

2. Minimum number of peel tests required to be performed by quality control laboratory. ______. Number actually performed? ______ (Dual track welds must be tested independently).

3. Minimum number of shear tests required to be performed by quality control laboratory. ______. Number actually performed? _______

4. Where are samples from each destructive testing archived? _______

5. Submit destructive test summary table and laboratory destructive test data.

e. Repairs

Were all seams which failed destructive or non-destructive testing and other areas requiring repairs repaired in accordance with the LQCP? ____________

Submit geomembrane repair summary table.

10. Geosynthetic Clay Liner Installation

a. How much overlap was provided at the edges of the GCL panels? ___________. Was granular bentonite placed in the overlaps? _______ If so, please describe the placement procedure, the rate of bentonite placement, and the procedure used to verify the amount of bentonite placed. ________________________

b. Were the GCL panels placed by unrolling or by dragging the rolls across the subgrade? ____

c. Did any GCL hydrate prematurely prior to covering with geomembrane or protective cover? _____. If so, were the hydrated areas removed and replaced? ____________. If not, please explain. ____________________________

____

d. How was the GCL tied into existing liner from any adjacent lined areas (attach sketch showing tie-in if necessary)? _______________________________________

____

Part F: Leachate Collection System/Protective Cover

1. Gradient of bottom of evaluated area. ________________________________.

2. Gradient of leachate collection lines. _________________________________.

3. What method of placement was used for the LCS and/or protective cover over the geomembrane liner/GCL? ____

____

____

4. Was the liner system (including LCS/protective cover placement) completed prior to the engineer's final field visit? __________________.

5. Do protective cover soil and leachate collection system materials (trench backfill; leachate collection layer soil; drainage, filter or cushion geosynthetics; collector pipes) meet the required specifications? ______________________________.

6. Attach result of any required permeability, grain size, and calcium carbonate content tests on soil drainage and protective cover materials by suppliers and independent laboratory. For geosynthetic materials; attach roll delivery documentation, suppliers' certifications and test results, and results of any conformance tests required by the LQCP.

7. Attach survey documentation from a registered surveyor for thickness verification of LCS and protective cover. Also attach a sketch showing the liner/LCS/protective cover cross-section.

Part G: Ballast

Does this liner system require any ballast to overcome hydrostatic pressure? _______.

Include a demonstration of stability during construction (or post-construction BER if desired) with this GLER/GCLER. This documentation must include: (1) the seasonal high water table and how it was derived (a table showing the groundwater elevations from monitor wells or piezometers is sufficient); (2) the depth of the excavation (Part C.2.c above); and (3) a narrative explaining why ballasting is required with respect to the depth of excavation and the seasonal high water table elevation.

Part H: Signature of the Professional of Record

I certify that the liner has been constructed as designed in accordance with the issued permit and in general compliance with the regulations.

Affix Professional Engineer's Seal (Date & Sign)

[seal]

____
(typed or printed name)

____
(phone number)

____
(date signed)

____
(fax number)

____
(company or business name)

____
(address, city, zip code)

Note: A professional engineer must be registered in Texas.

Part I: Signature of Permittee

I have read and fully understand the findings of this GLER/GCLER submittal.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

____
(signature)

____
(typed or printed name)

____
(title)

____
(date signed)

____
(phone number)

____
(fax number

____
(company or business name)

____
(*address, city, state, zip code*)

Exhibit 24

Geosynthetic Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Original: December 16, 2013

GRI Test Method GM29*

Standard Practice for

"Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Nondestructive Testing"

This practice was developed by the Geosynthetic Research Institute (GRI) with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new practices on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this practice either at this time or in the future.

1. Scope

1.1 This standard practice provides guidelines to assess the integrity of geomembrane field seams (and sheet) in a progression ranging from fixed interval destructive seam testing eventually to electrical leak location nondestructive testing of both seams and sheet.

1.2 The need for the practice is to acknowledge that the fixed interval destructive seam testing concept of one sample in 150 m (500 ft.) is now over 30-years old and antiquated. Significant improvement in concepts, equipment, personnel, training, and technology have occurred in the interval.

1.3 The practice describes three separate tracks that may be considered when developing a construction quality assurance (CQA) plan.

1.4 This practice is field oriented toward both construction quality control (CQC) and construction quality assurance (CQA) of geomembranes for all applications.

1.5 This standard may involve hazardous operations, equipment and climates. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This practice will be reviewed at least every 5-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

2. Reference Documents

2.1 ASTM Standards:

D4439 Terminology for Geosynthetics

D5820 Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

D6392 Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

D6747 Guide for Selection of Leaks in Geomembranes (see also D7703, D7230, D7852, D7002, and D7007 for specific practices in this regard)

2.2 GRI Standards:

GM1 Practice for Seam Evaluation by the Ultrasonic Shadow Method

GM6 Practice for Pressurized Air Channel Test for Dual Seamed Geomembranes

GM14 Practice for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attribute

GM19 Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

GM20 Practice for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts

2.3 EPA Documents:

EPA/530/SW-91/051, "Inspection Techniques for Fabrication of Geomembrane Field Seams"

EPA/600/R-93/182, "Quality Assurance and Quality Control for Waste Containment Facilities"

EPA/530/SW-91/051, "Inspection Techniques for the Fabrication of Geomembrane Field Seams"

EPA/600/R-93/112, "Proceedings of the Workshop on Geomembrane Seaming, Data Acquisition and Welders," June, 1993, 64 pgs.

2.4 References:

Koerner, R. M. (2012), "Designing With Geosynthetics," 6th Edition, Xlibris Publ. Co., 914 pgs.

GSI White Paper #3, (2003), "Providing Flexibility in Destructive Seam Sampling/Testing," Geosynthetic Institute, Folsom, PA, 14 pgs.

GSI White Paper #26 (2012), "Need For and Justification Of Quality Management Systems for Successful Geosynthetic Performance," Geosynthetic Institute, Folsom, PA, 20 pgs.

Lord, A. E., Koerner, R. M. and Crawford, R. B. (1986), "Nondestructive Testing Techniques to Assess Geomembrane Seam Quality," Proceedings 7th Natl. Conf. on Management of Uncontrolled Hazardous Waste Sites, Washington, DC, pp. 272-276.

Noski, V. and Touze-Foltz, N. (2000), "Geomembrane Liner Failures," Proceedings 2nd European Geosynthetic Conference (GeoEuro 2), Italy, pp. 557-560.

Peggs, I.D., Micelli, G. F., McLearn, M.E., (1994), "Infrared Thermographic Nondestructive Testing of HDPE Geomembranes Seams: A Feasibility Study," 5th International Conference on Geotextiles, Geomembranes and Related Products, Singapore, September 1994, pp. 941-944.

3. Terminology

3.1 Definitions of Generic Terms

3.1.1 *field seams* - The seaming of rolls or panels together in the field thereby making a continuous liner system; also sometimes called *production seams.*

3.1.2 *trial seams* - Trial seams are spare scraps of geomembrane that are field seamed and tested to establish welding machine settings of temperature, pressure and travel rate for a specific device under a specific set of atmospheric conditions as well as establishing procedures to be correctly used by the installation personnel.

3.1.3 *thermal fusion seams* - A seam which involves the temporary, thermally-induced reorganization in the polymer structure at the surface of two opposing geomembranes which, after the application of pressure and the passage of a certain amount of time, results in the two being joined together.

Note 1: The dual track hot wedge seam is considered to be the premier technique for making geomembrane seams. It is always accompanied by using air pressure in the opening between the welded inner and outer tracks, thereby allowing for an air pressure test on both tracks as a nondestructive test method.

3.1.4 *nondestructive test* - Test performed on geomembranes in the field to verify integrity and completeness without taking physical samples and testing them to failure.

3.1.5 *destructive test* - Test performed on geomembrane samples cut from a field installation or test strip to verify specification performance requirements, e.g., shear and peel tests of geomembrane seams are destructive tests in which the specimens are tested to failure.

3.1.6 *seam shear test* - A destructive test in which two seamed sheets or panels on opposite sides of the seam specimen are pulled in tension such that the seam is placed in a shear mode of stress.

3.1.7 *seam peel test* - A destructive test in which two seamed sheets or panels on opposite sides of the seam specimen are pulled in tension such that the seam is placed in a peel mode of stress.

3.1.8 *Construction Quality Control (CQC)* - A planned system of inspections that is used to directly monitor and control the quality of a construction project. Construction quality control is normally performed by the geosynthetics installer and is necessary to achieve quality in the constructed or installed system. Construction quality control (CQC) refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project. (See GSI White Papers #3 and #26)

3.1.9 *Construction Quality Assurance (CQA)* - A planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design. Construction quality assurance includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to determine if the installer or contractor is in compliance with the plans and specifications of the project. (See GSI White Papers #3 and #26)

4. Summary of Practice

The benchmark destructive seam test interval for geomembrane was established pre-1980 at one sample per 150 m (500 ft.) length of seam irrespective of the type of seam and the quality of the seaming crew. This is unfortunate since good seaming results should allow for greater intervals and poor results vice versa. The methods of attributes and control charts allows for these variations. Furthermore, entirely new concepts (certified installers, taped edges, automatic welders and ultrasonic or infrared (US/IR) testing) should allow for the initial interval to be increased, e.g., to one sample per 225 m (750 ft.). Even further, the electrical leak location (ELL) method which evaluates both seams and sheet can be used to investigate and approve a completed geomembrane system. This standard practice explains each of these value-added advances insofar as current practice of developing construction quality assurance (CQA) plans is concerned. Of course, if site-specific regulations call for a particular strategy with no options, it must be followed accordingly.

This entire practice is embodied in the flow chart of Figure 1 which will be described throughout the discussion. In viewing it, one will observe that three separate tracks are possible. All three concepts are mature and can, and should, be implemented immediately.

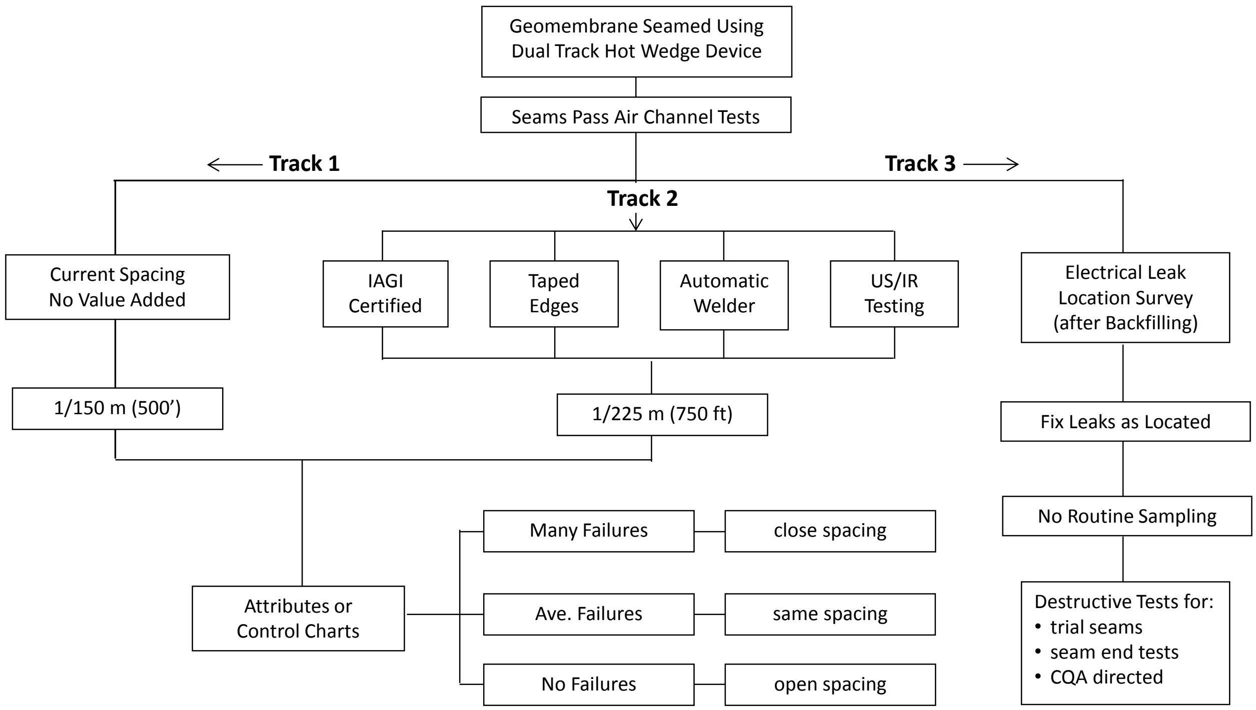


Figure 1. Flow chart of methods and techniques to be described herein in assessing the field integrity of geomembrane seams and sheets.

5. Significance and Use

5.1 Geomembranes are used as liquid and/or gas barriers and, as such, should be leak-free. While field seaming of the edges and ends of the panels has received almost all of the past attention, the sheet itself should also be evaluated. This standard addresses each aspect of the recommended practice so as to have the best possible quality field completed liner system.

Note 2: In this context this standard represents current "best practice" with respect to CQC and CQA.

5.2 Seaming equipment and personnel have improved considerably since pre-1980 when the one destructive seam sample in 150 m (500 ft.) distance was established. This standard practice is focused on increasing this interval (as described) and optimally using the electric leak location (ELL) method which replaces the need for designated destructive tests, but nevertheless provides safeguards as considered necessary.

6. Procedure

Using the flow chart of Figure 1, each item listed thereon will be described in sequence. As seen there are three different tracks that can be taken. Each will be described accordingly. The precursor of all three tracks is that acceptable dual track hot wedge seams have been made and have successfully passed air channel testing, e.g., see GRI-GM6 and ASTM D5820.

The dual track hot wedge seam method consists of an electrically heated element in the shape of a wedge that travels between the two sheets to be seamed. As it melts the surface of the two opposing sheets being seamed, a shear flow occurs across the upper and lower surfaces of the wedge. Roller pressure is applied as the two sheets converge at the tip of the wedge to form the final seam. Hot wedge units are operated as far as temperature, amount of pressure applied, and travel rate. Getting these parameters/variables adjusted to produce a quality weld requires the utmost attention to details and site conditions. A standard hot wedge creates a single uniform-width seam, while a dual (or *split*) hot wedge forms two parallel seams with a uniform unbounded space between them. See Figure 2. This space is used to evaluate seam quality and the continuity of the seam by pressurizing the unbounded space with air and monitoring any drop in pressure that may signify a leak in the seam. *The dual hot wedge seam is considered to be the preferred seaming method for all thermoplastic geomembranes* (ref. Koerner, 2012).

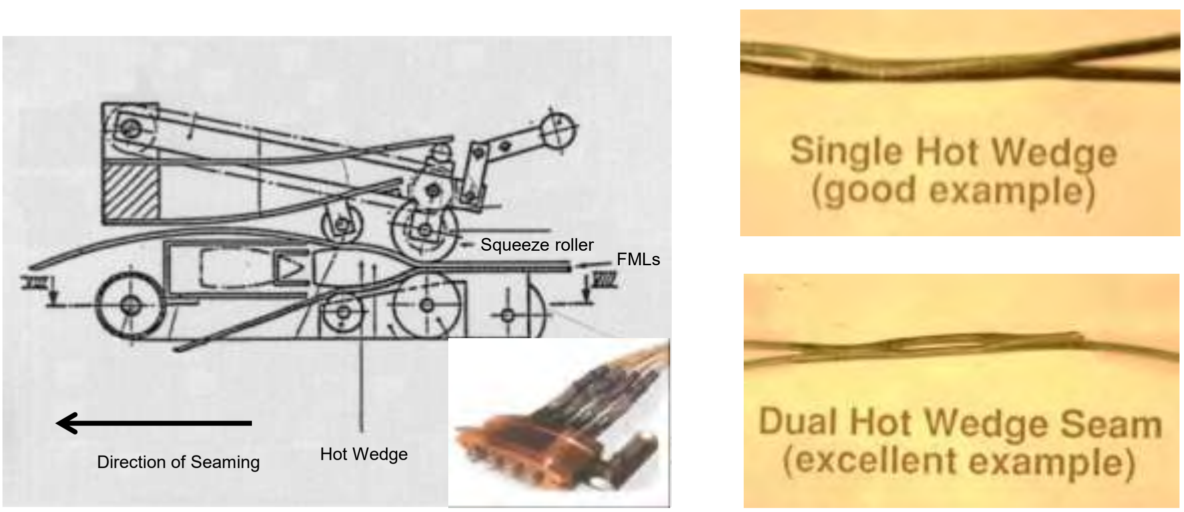


Figure 2. Hot wedge welding device, the wedge itself and resulting single and dual track geomembrane seams, the latter with an open air channel for pressure testing.

The *pressurized dual seam* method uses the air channel that results between the two parallel seams which is inflated using a needle and is pressurized to approximately 200 kPa (30 lb/in^2). If no drop on a pressure gauge occurs over a given time period, the entire seam is acceptable. The test method is standardized as ASTM D5820 and by the Geosynthetic Research Institute as GRI-GM6. If an excessive drop in pressure occurs, a number of actions can be taken: The distance can be systematically halved until the leak is located, the section can be tested by some other detection method, or a cap strip can be seamed over the entire exposed edge. Because there is no limitation in seam length, a single test can extend from one end of a facility to the other. The test is generally performed by the installation contractor, but with the CQA personnel viewing the procedure and assessing the results.

Note 3: For the purposes of the remainder of this practice, it is assumed that a successful air channel test (or one that is suitably repaired) has resulted for the entire seamed geomembrane facility.

6.1 **Track 1:** Initial Historical Spacing, Then Systematically Modified

The historical spacing for taking destructive samples from field fabricated geomembrane seams appears to be initiated (prior to 1980) by Henry Haxo under contract for the U.S. Environmental Protection Agency. The spacing interval was set at one sample per 150 m (500 ft.) of seam length. The removed sample was divided into parts for testing and archiving by the various parties involved, e.g., CQA, CQC, owner, see Figure 2a. Of course, it eventually requires a patch as shown in Figure 2b.

(a) Removal of field seam sample (b) Patch repair of sampled area

Figure 2. Removal, and subsequent patching, of destructive seam sample of field installed geomembranes.

This removal and replacement process is the essence of the issue to which this practice is focused. The following negative points in taking destructive seam samples are relevant in this regard.

- The removed seam sample has already passed the nondestructive air channel test
- There are actually two parallel seams that are properly functioning
- Patching of the geomembrane invariably decreases the local region's original strength and elongation
- Patches result in a discontinuity for the possible transfer of mobilized stresses and strains from panel-to-panel

- The welding of the replacement patch is by the extrusion fillet method (recall Figure 2b) which is clearly an inferior weld to the hot wedge method
- Extrusion fillet welding requires grinding of the sheets in the area to be bonded which is difficult and must be done with great care so as to avoid thinning of the sheets and inducing stress risers
- The two T-seam tie-ins of extrusion welding to the original dual-track weld is very difficult to fabricate and requires excellent workmanship
- The testing of the adequacy of extrusion fillet welds is by the vacuum box method which is quite subjective and qualitative in its usual application

The removed field seam sample is then sent to a laboratory and tested in both tensile shear and tensile peel with results compared to the site-specific CQA plan. Decisions are then made accordingly.

Note 4: There are several available specifications for the acceptable performance of laboratory sheet, shear and peel testing. See ASTM D6392 for the testing protocol and GRI-GM19 for specification values.

The results of these destructive seam tests, aka, the failure rate, has historically not been used to vary the sampling rate. *This standard encourages that the field sampling interval should be increased when seam failure rates are low, and decreased when seam failures rates are high. Thus, good seaming is rewarded, while poor seaming is penalized.*

Note 5: According to recent data of the International Association of Geosynthetic Installers (IAGI) the seam testing failure rates for certified welders is currently about 2%.

Rather than arbitrarily increasing or decreasing the sampling interval there are two standard practices available that are based on statistical methods.

The *Method of Attributes*, see GRI-GM14, gives details of this first procedure and illustrates example situations.

In general, the guide gives the procedure for establishing the initial number of samples needed for a possible modification to the start-up sampling interval. This is called the initial batch. Based upon the number of failed samples in the initial batch, the spacing is either increased (for good seaming), kept the same, or decreased (for poor seaming). A second batch size is then determined and the process is continued. Depending on the project size, i.e., the total length of seaming, a number of decision cycles can occur until the project is finished.

It is seen that the number of samples required for the entire project is either fewer than the start-up frequency (for good seaming); the same as the start-up frequency (for matching the initial anticipated failure percentage); or more than the start-up frequency (for poor seaming).

The *Method of Control Charts*, see GRI-GM20, gives details of this second procedure as well as example situations.

In general, use of the guide requires the establishment of an upper control limit (UCL) and lower control limit (LCL) of seam failure rates. It also requires the establishment of an initial, or start-up, sampling interval. It then proceeds with the calculation of the seam failure rate beginning with the first sample's test result. Thus, it is an ongoing process.

When the failure rate exceeds the UCL, the sampling frequency, or interval, should be decreased. The establishment of this interval is an arbitrary decision. When the failure rate drops beneath the LCL, the sampling frequency, or interval, should be increased. The establishment of this interval is also an arbitrary decision. When the failure rate is between the UCL and the LCL, the sampling frequency, or interval, should remain the same.

Note 6: Since both attributes and control chart methods are statistically based, either can be used. That said, attributes appear to be better suited to large projects, while control charts to smaller ones.

6.2 **Track 2:** Modified Historical Spacing, Then Systematically Modified

As indicated in Figure 1, there should be an initial benefit toward a more open spacing for installation organizations who have invested in people and programs to provide high quality geomembrane seams. In this regard four situations are considered. In providing any of them it is felt that the historical spacing interval for taking destructive tests should be increased. Suggested is one sample per 300 m (1000 ft.). Of course, as the project develops the initial spacing can be increased, remain the same, or decreased as results of the laboratory tests develop over time. Four separate situations will be presented.

6.2.1 Certified Installers – If a geomembrane installer has trained (by means of an independent certified process) for the adequacy of its workforce in fabricating field geomembrane seams, there should be an immediate benefit derived. Such a program is available for both individual and companies.

The International Association of Geosynthetic Installers is an association of geosynthetic professionals created by and for installers. IAGI's mission is to advance installation and construction technologies as well as to provide a central clearinghouse for worldwide industry information. Incorporated in 1995, the association represents organizations that are involved or interested in all aspects of geosynthetic installation. There are three membership categories available.

- Installer Members – Any organization engaged in the installation of geosynthetics is eligible to become an Installer member of IAGI.

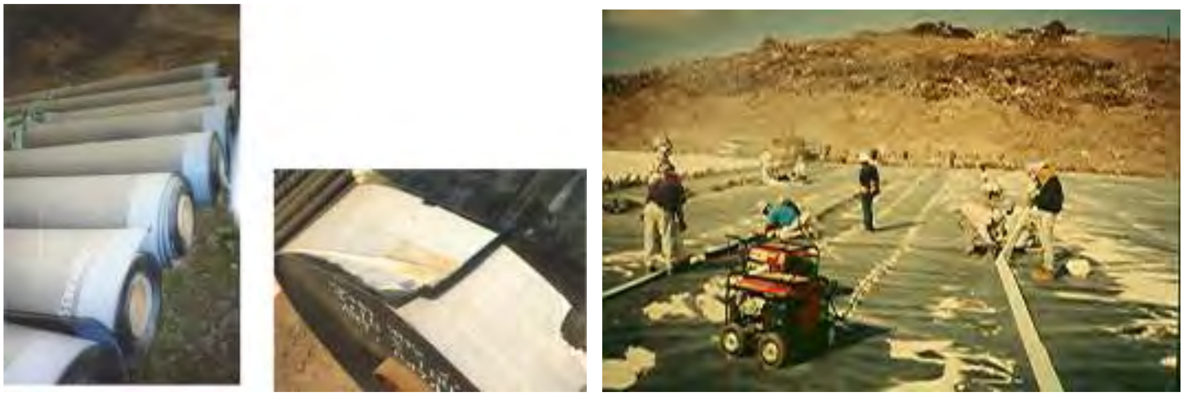
- Associate Members – Any organization not engaged in the installation of geosynthetics but who is otherwise associated with the industry (e.g., resin supplier, extruder, equipment supplier, and consultant) is eligible to become an Associate member of IAGI.
- Affiliate Members – Any organization not engaged in the installation of geosynthetics but interested in being allied with the geosynthetics installation industry is eligible to become an Affiliate member of IAGI. This non-voting category provides informational access to IAGI's activities.

Note 7: As a compliment to certified installers (i.e., CQC) it should be mentioned that a certified inspectors program (i.e., CQA) is also available; see www.geosynthetic-institute.org/certification.htm.

6.2.2 Taped Geomembrane Edges – It is universally agreed that the area to be bonded for a successful geomembrane seam must be clean and dry. In field installation, however, this is oftentimes difficult to achieve. Figure 3a and 3b show unprotected seaming areas being cleaned and dried. One method of safeguarding the sheet to assure dryness and cleanliness in the area to be bonded is to have upper and lower surfaces protected by a thin polyethylene strip, approximately 150 mm (6.0 in.) wide, applied before factory shipment to the site. The strips are electrostatically bonded to the sheet edges and are easily removed, that said the strips are not removed until immediately followed by the wedge welding device doing the product seaming. See Figure 3c showing a geomembrane with taped edges thereby assuring clean and dry surfaces to be seamed.


(a) Cleaning area for seaming


(b) Drying an area for seaming



(c) Geomembranes with taped edges

Figure 3. Photographs illustrating the advantages of geomembranes with taped edges in advance of field seaming.

6.2.3 Automatic Welding Devices – To consistently have successful field welding of geomembranes, the operator of a hot wedge welder must be constantly aware of three machine settings;

- pressure of the nip rollers,
- temperature of the wedge, and
- rate of wedge movement (speed)

Note 8: A common situation is when a cloud appears and cools the sheets to be seamed. The operator must slow the welding device so as to generate additional energy for an adequate seam to result, and then reset the speed when the cloud passes by. Rather than adjust these settings manually there are automatic welders which adjust as conditions change.

An automatic welding device, see Figure 4, senses the geomembrane sheet temperature and then automatically adjusts for the changed condition. Even further, automatic welders have data storage in their on-board computers which monitor and record speed, temperature and pressure so as to have a permeant record of conditions along every station of field seam locations, see EPA/600/R-93/112 for a conference proceedings in this regard.

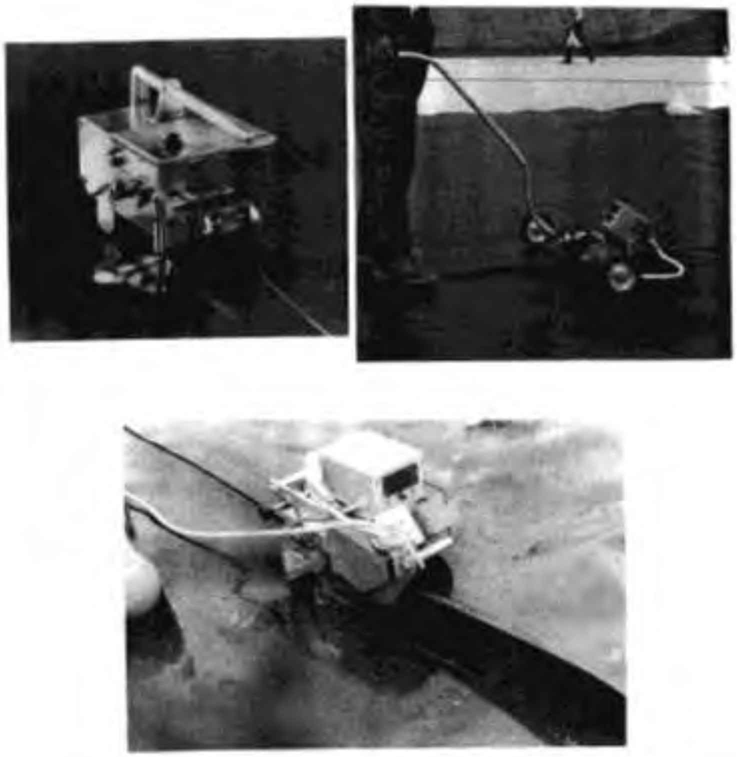


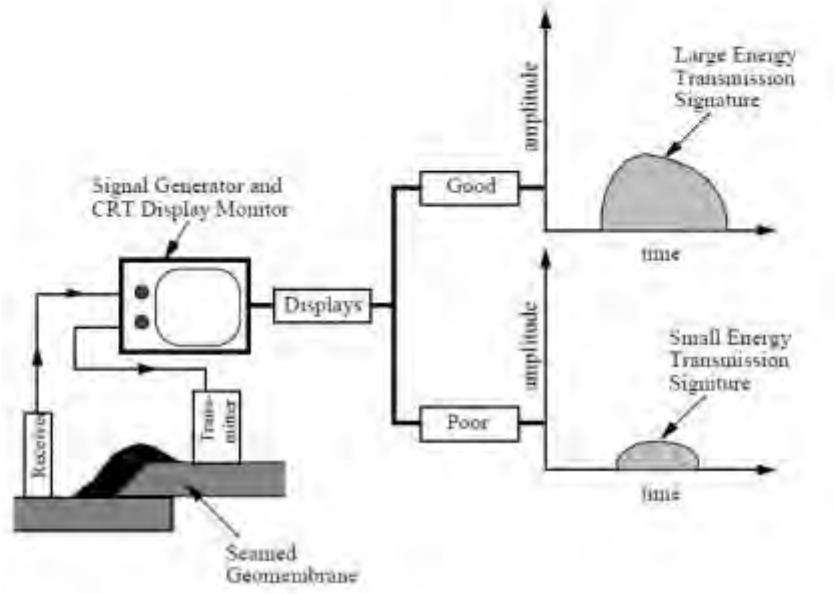
Figure 4. Examples of automatic field welding devices.

6.2.4 Complimentary Nondestructive Testing – There are several nondestructive seam test methods that can be used to supplement the air channel test mentioned previously. They are based on passing ultrasonic (US) or infrared (IR) energy through the seamed area. A good seam will pass the energy very adequately, while a poor seam will intercept the energy and be indicated accordingly. Figure 5 shows the ultrasonic technique. The infrrared method is similar with the exception of the energy type being generated and received.

Note 9: While technical papers have been written on each method (Lord, et al. 1986, and Peggs, et al., 1994) their use in practice has been limited to date as a research activity.

(a) Laboratory calibration

(b) Ultrasonic field monitoring



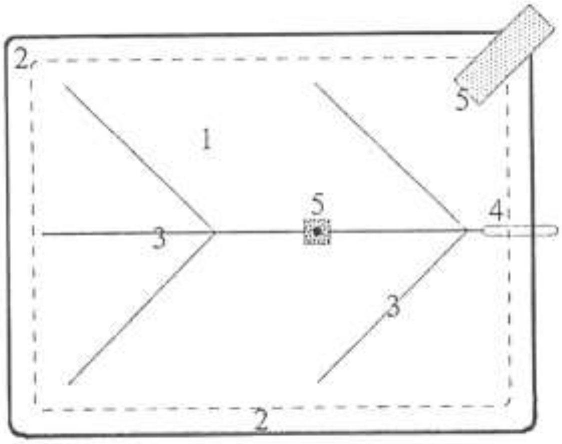
(c) Typical response signals

Figure 5. Ultrasonic nondestructive testing method to evaluate seam quality in the field.

6.3 **Track 3:** Electrical Leak Location (ELL) Survey

Developed by Southwest Texas Research Institute in the 1990's, the electrical leak location (ELL) survey or method progressed rapidly after a set of ASTM practices were developed. ASTM D6747 is a guide as to how these practices are to be used. The fundamental value in the ELL method is that both seams and sheet are evaluated and furthermore they can be assessed either before or after backfilling. The importance of inspection of both seams and sheet is shown in the data of Figure 6, by Noski and Touze-Foltz (2000). Readily seen is that 71% of the holes detected are in the sheet and only 6% are in the seams.

Note 9: The power of this finding cannot be denied. It begs the question as to why complete focus to date has been on the seams and not on the sheets themselves. This is emphasized and illustrated in this section of the standard.



Plan View of Geomembrane Lined Site
Notes:
1 = flat floor
2 = corners and edges
3 = under drainage pipes
4 = pipe penetrations
5 = other (access roads, temporary storage, concrete structures)

Location of Holes

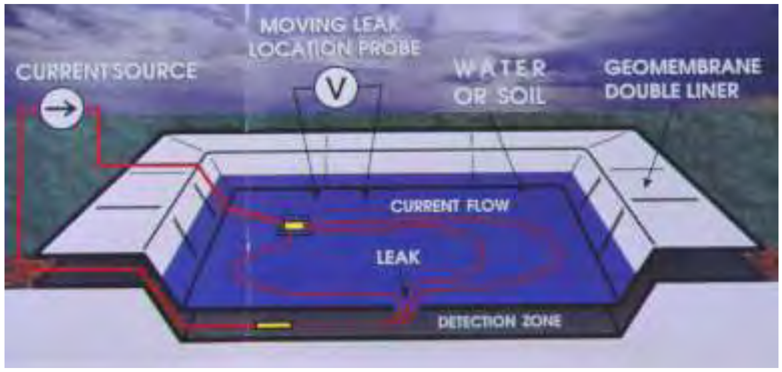
No. of Holes	Flat Floor (1)	Corners and Edges (2)	Under Drainage Pipes (3)	Pipe Penetrations (4)	Other (5)
4194 100%	3261 77.8%	395 9.4%	165 3.9%	84 2.0%	289 6.9%

Cause of Holes vs. Size of Holes

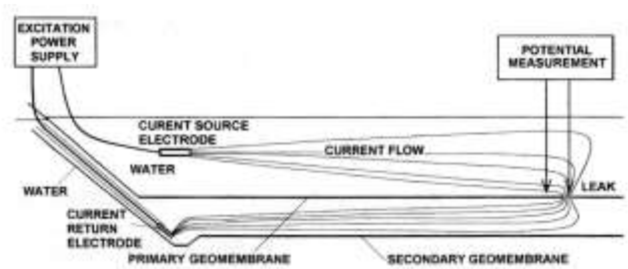
Size of Holes (cm^2)	Stones	%	Heavy Equip.	%	Welds	%	Cuts	%	Worker Directly	%	Total
<0.5	332	11.1	-	-	115	43.4	5	8.5	195	-	452
0.5-2.0	1720	57.6	41	6.3	105	39.6	36	61.0	105	84.4	2097
2.0-10	843	28.2	117	17.9	30	11.3	18	30.5	36	15.6	1044
>10	90	3.0	496	75.8	15	5.7	-	-	-	-	601
Amount	2985		654		265		59		231		4194
Total	71.17%		15.59%		6.32%		1.41%		5.51%		100%

Figure 6 – Results of electrical leak location surveys from 300 sites, ref. Nosko and Touze-Foltz (2000).

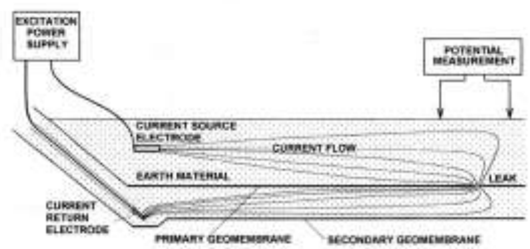
The concept of the ELL method is to use a high voltage (albeit low amplitude) DC power source where the cathode (-) is grounded in moisture beneath the geomembrane (or the lower part of a conductive geomembrane if so provided) and the anode (+) is in water above the geomembrane; see Figure 7a. A technician with an indicator attached to a voltage meter will receive a signal when a hole in the geomembrane is located. As indicated by the various ASTM standards there are several options as to when to use the technique. Figure 7b shows the geomembrane exposed while Figure 7c has the geomembrane backfilled with about 300 mm (12 in.) of soil (in this case leachate collection sand or gravel). Figure 7d is a mosaic of various field surveying projects.



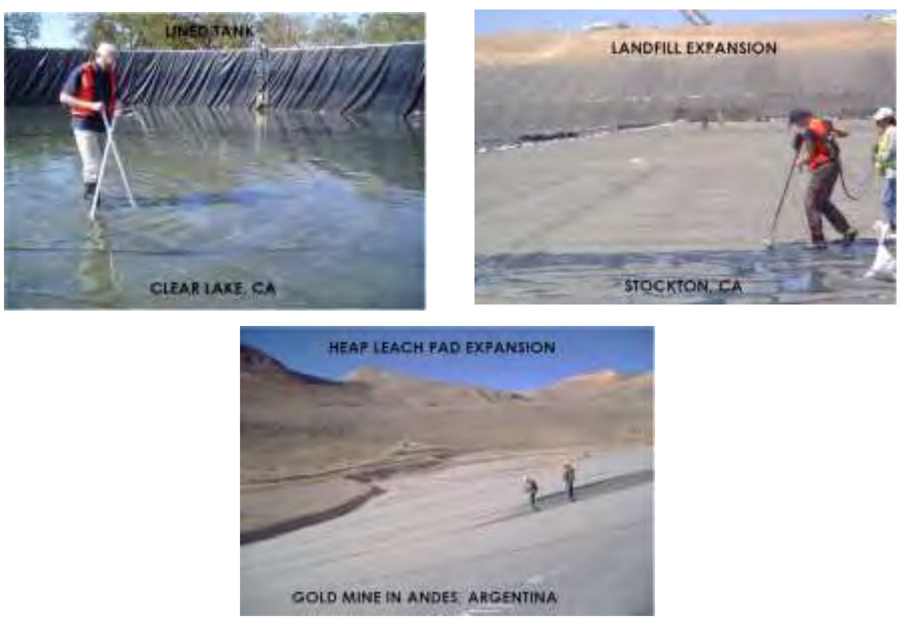
(a) Concept of ELL method



(b) Water covering geomembrane



(c) Soil covering geomembrane



(d) Examples of ELL surveys (Photos. compl. of TRI)

Figure 7. The Electric Leak Location (ELL) Method.

Note 10: There are courses regularly given on the various ELL methods (water covered, soil covered, water puddled and conductive layer sparking) as well as a certification program for personnel performing such surveys. See www.tri-environmental.com in this regard.

Using the ELL survey actual leaks in the installed geomembrane are designated by markers or stations and then repaired accordingly. Repair is invariably by an extrusion welded patch as shown in Figure 2b. Using the ELL method as indicated in Figure 1, there is no routine destructive test sampling recommended. However, there are some destructive samples and testing that should be considered. Situations in this regard are as follows:

- destructive testing of trial, or test, seams
- tests near seam ends, e.g., the anchor trenches
- tests where ever the CQA personnel direct

Note 11: In light of improvements in field seaming (both personnel and equipment) over the decades since the one sample is 150 m (500 ft.) interval was developed **and** the fact that the majority of leaks are in the sheet, this Track 3 of the practice appears to be compelling. While there are obstacles to overcome, e.g., existing state EPA regulations, less reliance on copious amounts of seam shear and peel tests, additional costs over current practices, who pays for such service, etc., it is felt that the ELL method is the way-forward for assessing the field integrity of geomembrane seams and sheet.

7. Summary

This practice focused on assessing the field integrity of geomembrane seams and sheets. It begins with the assumption that the geomembranes have been seamed using the dual track hot wedge method and have successfully passed the prescribed air channel test specification. At that point either destructive and/or nondestructive testing can begin.

Three tracks as illustrated in Figure 1, are described. *First* is to take destructive tests at the historical interval of one sample per 150 m (500 ft.). Rather than keep this interval throughout the project, the interval can be increased or decreased as laboratory testing progresses. There are two such standardized methods: attributes and control charts. In this manner good seaming can be rewarded and poor seaming penalized.

The *second* track is to begin the project at a greater interval, e.g., one sample per 225 m (750 ft.) if some type of "value added" to the seaming aspect of the project is indicated. Such actions as certified welding technicians, taped geomembrane edges, use of automatic welding machines and complimentary nondestructive testing using ultrasonics and infrared were described.

The *third* track described the ELL method which does a post-installation survey investigation for leaks in both seams and sheets. No routine sampling was recommended, however, destructive tests on trial seams, ends of the geomembrane rolls and as CQA directed, should be considered. The method can be deployed after initial backfilling of the seamed geomembrane which directly challenges the care of the backfilling operation.

It is this third track which is felt to be the way-of-the-future. This is rationalized since seam destructive failure rates are low (certainly in comparison to historical data) and it appears that sheet failure holes, tears, and rips are more prone to occur particularly after the geomembrane has been soil covered. These sheet failures come as either a few number of large holes (bulldozer gauges) or many small holes (stones above or below the geomembrane). Since the ELL method is currently performed by many organizations and the technicians performing the survey can be certified, the recommendation for its use is unequivocal.

Exhibit 25

How are process ponds constructed and monitored?

Pregnant and barren ponds are used to store chemical process solutions at a mine facility. The Division requires these ponds to be constructed with two plastic liners to keep the solution from leaking into the environment, and include a leak detection system installed between the liners to alert the operators if any leaks develop in the top liner. The liners are constructed with a tough plastic, such as high-density polyethylene (HDPE) or linear low-density polyethylene (LLDPE), that are typically 60- or 80-mil thick. The bottom liner is referred to as the "secondary" liner and the top liner the "primary" liner. Similar to the installation of heap leach pad liners, each pond liner sheet is welded together and pressure tested at the seams using standardized and internationally accepted testing protocols to ensure there are no gaps, holes, or areas of potential failure. Layered between the two liners is a leak detection system, also referred to as a leak collection and recovery system, consisting of a layer of porous plastic with access ports for determining whether the primary liner is leaking. The pond bottom is sloped to a sump where the leak detection system reports. If the primary liner has a leak, the water will report to the leak detection sump. As with all process components at a mine site, a pond cannot be put into service or operation until the Division has reviewed and approved a detailed "as-built" report prepared by a Nevada licensed professional engineer showing that the pond was constructed properly and has been tested to ensure that it will not leak to the environment when it is filled with process solution. Minimum quarterly and annual leakage limits have been established by the Division and mining facilities are required to monitor their leak detection systems regularly. If the primary liner is found to have a leak, the mine operator is required to repair it. No leakage is allowed through the secondary liner. If the pond will contain toxic chemicals above concentration limits established by the Nevada Department of Wildlife, the top of the pond must be netted, covered with floating "bird balls," hazing devices such as propane cannons, or other measures to keep animals from using the ponds. See Figure 1 for a cross section of a process pond.

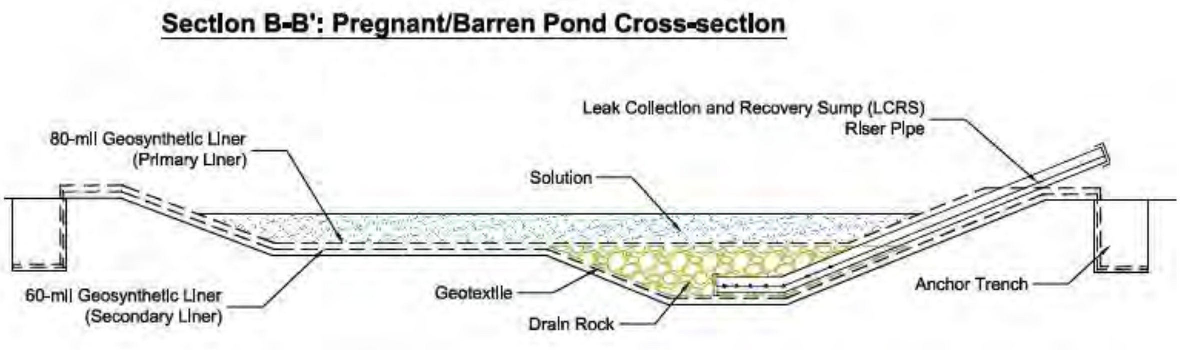


Figure 1: Process ponds are required to be double-lined with a functioning leak detection system.

Exhibit 26

Topic #1: Surface Owner Permission Should be Required for Permanent Disposal Via Reserve Pit.

Suggested Edit: §4.114(g)(2) – Closure Requirements

"The operator shall obtain the written permission of the surface owner of the property on which the waste will be buried. Without surface owner consent, oil and gas waste shall be removed from the property and disposed in an authorized manner.

Rationale:

Landowner consent has been required for onsite burial via landfarming for years – consent should likewise be required for onsite burial via reserve pit. The proposed revision creates consistency across both methods of permanent disposal.

Texas is one of the only states that does not *require* landowner permission prior to any permanent disposal of oil and gas wastes at the wellsite/lease (regardless of the means of disposal).[1] In fact, most other states also require title marking and/or publicly filed document reflecting the location of the pit.[2]

Reserve pits are often large, de facto mini-landfills capable of storing hundreds to thousands of barrels of waste (see Figure 1). Texas landowners should be afforded the right to decide whether their land is used for this purpose because permanent disposal includes potential financial, environmental, and health risks for the landowner. Therefore, obtaining consent prior to permanent burial not only protects the landowner, it also protects the operator, the Railroad Commission, and ultimately Texas taxpayers from bearing the burden of future financial liability and remediation costs.

Figure 1: Onsite Reserve Pits Permian Basin Aerial (1)

[1] Example 1: In Louisiana, 72 hours prior to closure, the operator must give written notification to the Office of Conservation of the operator's intent to dispose via reserve pit. The notification must include a **detailed explanation of the method(s) used to generate the waste material**, including **types and volumes** of the additives used, **amounts of waste material generated**…and **written approval from the surface owner of the property** where the processed material is to be applied, and any other pertinent information required by the Commissioner [La. Admin. Code title 43 § XIX-313(G]

[2] Example 2: New Mexico requires title marking: "when onsite burial occurs on private land, the **operator shall file a deed** notice identifying the **exact location of the onsite burial** with the county clerk in the county where onsite burial occurs." [NMAC 19.15.17.13(E)(4)]

Topic #2: As drafted, Permanent Disposal via Burial in a Reserve Pit Unintentionally Encourages Surface and/or Groundwater Contamination.

<u>Suggested Edit</u>: §4.114(g)(5)(B) – partial, and §4.114(g)(5)(C) – re: Closure requirements for pits if waste will be buried in place pursuant to §4.111 of this title.

(B) The samples shall be analyzed for the constituents and using the methods identified in the Figure in this subsection to determine whether the constituent concentrations are below the limit in the Figure.

Rationale:

In this context, "background concentrations" should mean native soil, in its naturally occurring state. However, as currently drafted, "background concentrations" could also include soil that has been highly contaminated by prior waste disposal (or spills) because there are no prescribed concentration limits associated with "background concentrations" and because there is no definition of "background concentrations". Therefore, an operator could permanently bury new waste at the highly contaminated levels because those highly contaminated levels are the "background concentrations". This would result in an increased likelihood of pollution to groundwater, which is antithetical to the purpose of New Chapter 4, Subchapter A.


Figure 2. Reserve Pit (Permian Basin) with Extensive Chloride Impact


Figure 3. Permian Basin (Odessa) Drilling Density and Reserve Pits

Topic #3: Reserve Pits and Mud Circulation Pits Used for Permanent Disposal Should Not be Exempt from Groundwater Monitoring.

Suggested Edit: §4.114(h)(3)(B):

(B) the authorized pit has a natural liner and an active life of less than one year.

Rationale:

This clarifying edit is required to close an unintentional loophole in §4.114(h)(3)(B), which would allow *any* lined pits – (including those with synthetic liners being utilized for **permanent disposal)** to be exempted from groundwater monitoring requirements.

This clarification is necessary to align with the intent of new Chapter 4 Subchapter A.

For example, the following sections of the revised rule specify pits with only "a **natural liner** shall only be used for authorized pits with an **active life** of **less than one year**.**"**[3,4] If an operator wants to use a pit for **waste disposal**, then the pit must also contain a **synthetic liner**.[5]

In line with the Commission's desire to implement a tiered, risk-based regulatory framework, it is reasonable for **naturally lined pits** (most commonly used for the ***temporary*** storage, processing or handling of oil and gas wastes) to be **exempted** from groundwater monitoring requirements.

However, keeping with the same tiered, risk-based focus for regulations, authorized pits that are for the **permanent disposal** of oil and gas wastes (and, thus, **required** to have a **synthetic liner**) **should not be exempted** from groundwater monitoring requirements.

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[3] §4.114(c)(6)(D)(i)

[4] Note: §4.114(c)(6)(D)(i) is the only place within the revised rule where "active life" is specifically referenced other than §4.114(h)(3)(B). Thus, we believe that the inclusion of use of the word "***natural*** liner" was overlooked and necessary to conform to the intent of the broader rule, as revised.

[5] §4.114(c)(6)(D)(iii)

Topic #4: New Commercial Disposal Facilities Permit Should Submit a Statement of Need.

Suggested Edit: Reinsert the following as §4.140 ("Additional Requirements for Commercial Facilities"):

"An application for a commercial waste facility shall include a statement of need, detailing the necessity for an additional commercial facility in the geographical market where the property and proposed facility are located. The statement of need shall include a map showing, within a 30-mile radius around the proposed facility:

(1) All permitted commercial waste facilities; and

(2) All oil and/or gas wells drilled within the 12-month period prior to the date of the permit application submission."

Rationale: Commercial disposal facilities must be operated by companies with regulatory, operational and safety expertise. The consequences of (i) mismanagement of commercial facilities and/or (ii) the financial instability of some commercial facility operators, negatively impacts the Railroad Commission, landowners and Texas taxpayers. Further, ensuring the sound operation of commercial disposal facilities is critical to deterring federal intervention in the Texas energy industry. Negative, misinformed media attention is no friend of industry (*see*: https://www.texastribune.org/2019/04/17/texas-attorney-general-sues-inland-recylcling-and-remediation/).

Operators known for cutting operational and safety corners to maintain profitability must be discouraged from opening new facilities. A market analysis and an associated statement from the Commercial Facility applicant, detailing the necessity for an additional facility in the market where the proposed facility is to be located, should be *a part* of the Commission's assessment criteria for new commercial facility permits.

To be clear, this is not a requirement for a "Certificate of Need." However, the commercial facility operator seeking a new facility permit must provide a (i) statement outlining their operational experience/background and (ii) a "Statement of Need" providing supportive information related to historical drilling activity in the defined area and other disposal options in the market) for a new facility in the market area for the Commission's consideration.

Exhibit 27

Oklahoma Cooperative Extension Service CR-2272
0114
Current Report
Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
osufacts.okstate.edu

Application of Water-base Drilling Mud to Winter Wheat: Impact of Application Timing on Yield and Soil Properties

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The recent increase in oil and gas exploration has resulted in the production of more water-base mud, (WBM), a by-product from the drilling process. The most common method of disposal for this material is land application to agricultural and grazing lands. Land application companies typically compensate landowners based on the total volume of WBM they are willing to receive. A common rate is $0.50 per barrel. Even though water is the most common component, the water-base mud also contains dissolved solids (i.e. salts) and sodium. There is a small amount of non-dissolved solids that includes drill cuttings (i.e. rock and soil) and also added bentonite, which is a naturally occurring soil mineral with a large cation exchange capacity. A basic introduction on drilling mud can be found in WREC-102 ("An introduction to the land application of drilling mud"). Figure 1 shows a picture of WBM in both an agitated state and after being allowed to settle for several minutes. Notice the thin layer of solids after settling.

The primary risk associated with over-application of WBM is that it can result in a soil becoming saline or sodic. Oklahoma State University defines a "saline" soil as one that has an electrical conductivity (EC) greater than 4 mS/cm, or 2600 ppm soluble salts (PSS-2226). Depending on the degree of salinity and plant tolerance, excessive salinity can decrease the ability of a plant to uptake water due to increased osmotic potential. If conditions become excessively saline for a particular plant, the plant will display drought-like symptoms even if there is plenty of water applied. Some plants are more tolerant of salinity; for example, wheat can tolerate around 7,800 ppm soluble salts, while Bermudagrass can handle 11,700 ppm. Similarly, it is generally accepted that a soil with an exchangeable sodium percentage (ESP) greater than 15 percent and an EC less than 4 mS/cm will be "sodic" (PSS-2226). Note that a sodium adsorption ratio (SAR) of 13 is roughly equivalent to an ESP of 15 percent. A sodic soil is a more serious problem than a saline soil since the soil structure becomes dispersed and can inhibit drainage through it.

Figure 1. Example of water-base mud (WBM) pictured with (left) and without agitation.

There is currently no information regarding the impact of WBM application timing on grain production in wheat. For example, wheat may be more sensitive to WBM applications at certain growth stages. The purpose of this study was to:

- Determine the impact of WBM application rate and timing on soil EC and SAR after application to a wheat crop.
- Monitor changes in soil EC and SAR with time after WBM application.
- Determine the impact of WBM application rate and timing on wheat grain yield.

Approach

A simulated WBM was applied to a growing wheat crop located at Lahoma, OK, on the Oklahoma State University wheat research station. Chemical characteristics of the WBM included an electrical conductivity (EC) of 233 mS/cm and sodium concentration of about 60,000 mg/L.

Two application rates were tested: 6,000 and 4,000 lbs/acre of total dissolved solids (TDS). Background soil samples were taken to determine native soil TDS, which was then subtracted from the target application rates. Note that 6,000 lbs TDS/acre is the highest loading rate for TDS allowed by the Oklahoma Corporation Commission (OCC). In addition,

Figure 2. Application of the simulated water-base mud (WBM) prior to planting.

a control plot which received no amendment was included for comparison. The TDS and cation concentrations were measured using the saturated paste method.

Five different WBM application timings were examined separately: Pre-plant (October 16, 2012) and post-establishment on December 6, 2012; January 14, 2013; February 15, 2013; and March 20, 2013. Wheat was planted on October 18, 2012, and harvested on June 20, 2013. Immediately after application, soil samples were taken at the 0-inch to 3-inch depths and 3-inch to 6-inch depths. Samples were also taken at 30, 60 and 90 days after application in order to monitor salt movement from the root zone. Final soil samples were taken several months after wheat harvest on August 28, 2013.

Time to recovery and salt leaching

Immediately after application, soil EC levels in the 0-inch to 3-inch layer were extremely high, while the 3-inch to 6-inch layer remained the same as the control soil (Figure 3). On average, the 0 to 6-inch layer had an EC level of about 9 mS/cm, which is detrimental to most plants. Similarly, Figure 4 shows that soil SAR levels were often near the threshold value of 13 at the 0-inch to 3-inch layer immediately after application of WBM. However, when averaged over the 0-inch to 6-inch layer, the SAR was only eight to nine. While this elevated SAR at the immediate surface (about 15) is unlikely to negatively impact growing plants, it could possibly impede germination, depending on soil texture and other properties.

Although application of WBM initially increased soil salt content (EC) and SAR in the surface (0 inch to 3 inches), Figures 3 and 4 show that appreciable rainfall received over the next 90 days (Table 1) led to a quick recovery. Although the average 0-inch to 6-inch EC was greater than 4 mS/cm in most of the plots at day 90, most treatments were less than 6 mS/cm, which is considered to be a more specific threshold for wheat. In general, higher amounts of rainfall received during the 90 day period after WBM application (Table 1) generally resulted in a greater reduction in soil EC and SAR. Note that after 90 days, the 0-inch to 3-inch layer greatly decreased in soil EC while the 3- to 6- inch layer increased as indicated by the red and blue bars coming closer together; this is because the salts in the 0-inch to 3-inch layer leached down to the 3- to 6-inch depth. This was less dramatic for soil SAR (Figure 4). By August 2013 (5 to 10 months after application), nearly all plots were less than the 4 mS/cm threshold (Figure 3). Even the 3-inch to 6-inch depth decreased in EC from Day 90 to

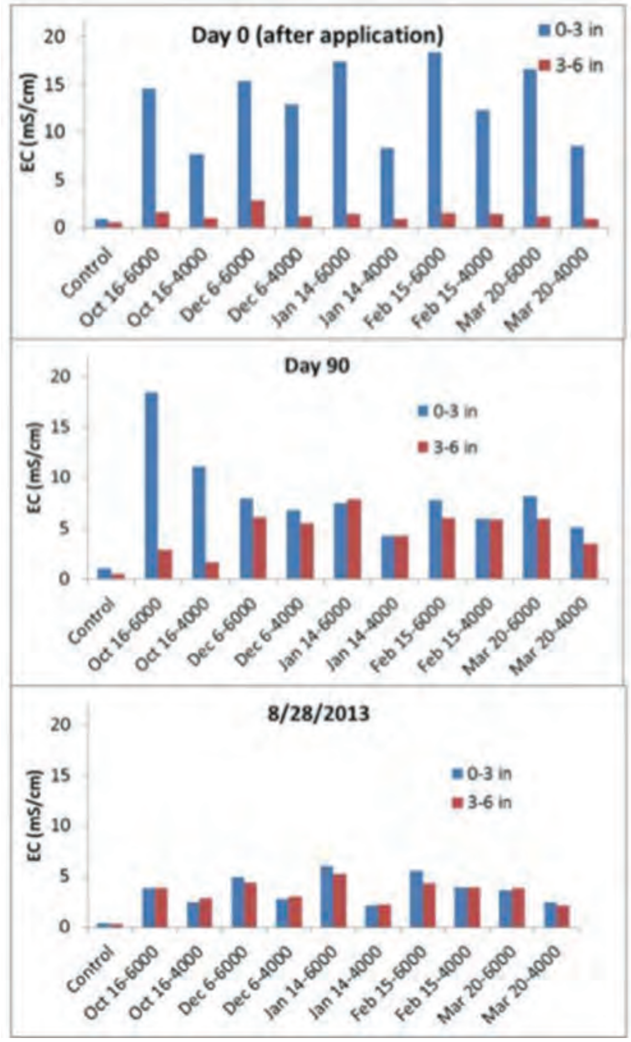

Figure 3. Changes in soil salt content at depth, as indicated by electrical conductivity (EC) from day 0 (initially after application) to 90 days after application, and on 8-28-13 (5 to 10 months after application. The numbers "4,000" and "6,000" indicate the rate of total dissolved salts applied (lbs/acre).

Table 1. Application dates of water-based mud (WBM) to Lahoma wheat plots and the corresponding depth of rainfall received 90 days after application.

WBM application date	*90-day precipitation since application (inches)*
October 16, 2012	0.52
December 6, 2012	4.38
January 14, 2013	6.81
February 15, 2013	8.75
March 20, 2013	9.45

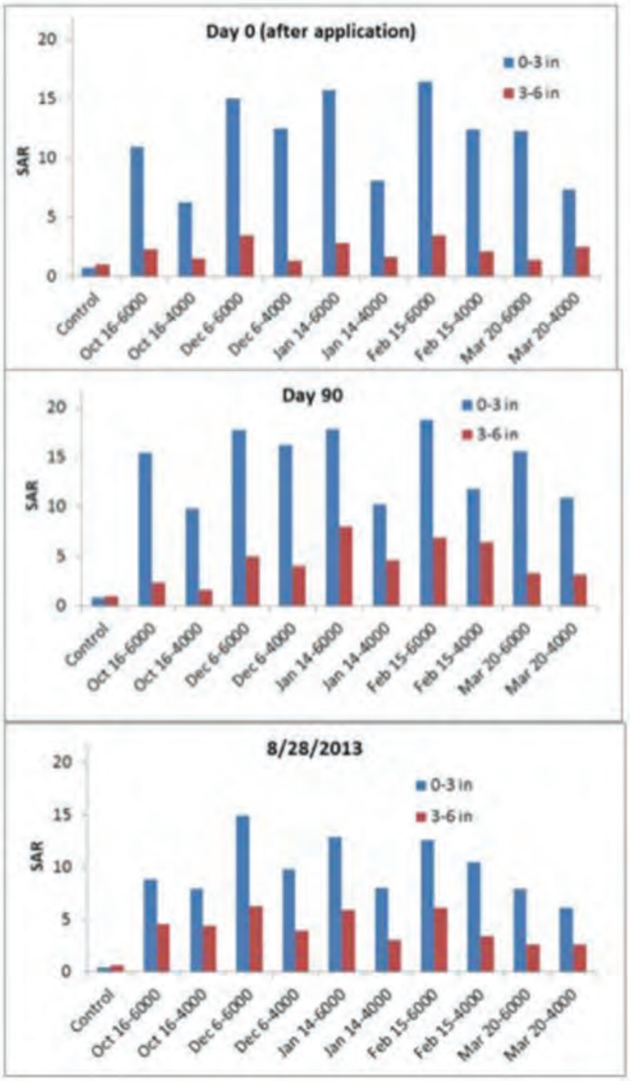

Figure 4. Changes in soil sodium adsorption ratio (SAR) at depth, from day 0 (initially after application) to 90 days after application, and on 8-28-13 (5 to 10 months after application. The numbers "4000" and "6000" indicate the rate of total dissolved salts applied (lbs/acre).

August 2013, indicating that salts were leaching downward out of the root zone.

The importance of rainfall for soil recovery is clearly evident by observing the application on October 16; after 90 days, there was little change in soil EC and SAR compared to day 0. This is because only 0.5 inches of rain had fallen during that time period. Contrast that to the applications made in January and thereafter; soil EC decreased dramatically within 90 days due to an amount of rainfall exceeding 6 inches.

Impact of application rate on recovery

As expected, plots that received the 4,000 lbs TDS/acre always had lower soil EC and SAR compared to the 6,000 lbs/acre rate (Figures 5 and 6). Although the governing body (Oklahoma Corporation Commission) allows application of up

Figure 5. Wheat pictured on April 19, 2013. This plot received water-base mud (WBM) at pre-plant (October 16, 2012).

to 6,000 lbs TDS/acre, it will always be better to apply a lower rate of salts by spraying the WBM over a larger acreage.

Impact on final grain yield

Wheat grain yield was largely unaffected by the application of WBM. Figure 6 shows the resulting grain yield harvested on June 20. Note that treatments which share the same letter are not significantly different from each other. The only significant differences were the following: control (no application) was greater than WBM (both rates) applied on March 20. Also, the 4000 lbs TDS acre^{-1} applied on January 14 and February 15 were greater than that applied on March 20.

Apparently, the wheat was most sensitive to WBM applications on March 20. At this time the wheat displayed more than two nodes above the surface (approximately Feekes growth stage #7).

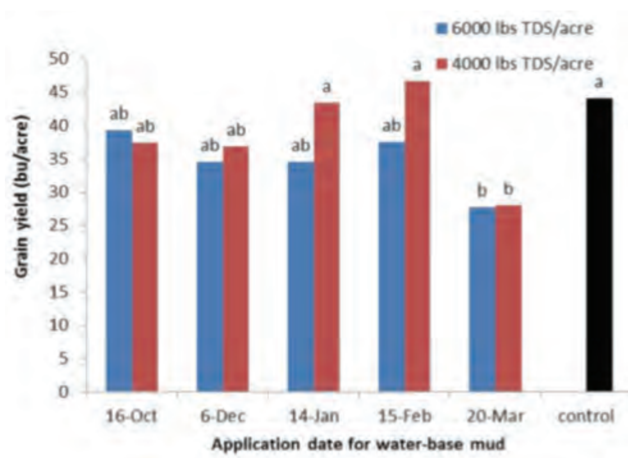

Figure 6. Wheat grain yield harvested on June 20, 2013. Each date indicates when the water-base mud was applied. Note that October 16 was pre-plant and control received no water-base mud.

Summary

Application of the highest allowable amount of salt (according to the OCC) to a clay loam soil only temporarily increased soil salt levels (EC) in the topsoil beyond general threshold levels. Averaged over 0 inch to 6 inches, soil SAR never exceeded the threshold value of 13, even immediately after application. Rainfall is critical for the recovery of the soil after application of WBM. This allows the salts to leach from the root zone. Soil salt levels were mostly acceptable within 90 days after application of WBM, except in the case when there was very little rainfall. Without rainfall (or irrigation), there can be no recovery. Regardless, the application of WBM had little to no impact on wheat grain yield, except when applied at Feekes growth stage #7. Therefore, it is recommended no WBM application be made to wheat beyond February 15 (approximately Feekes #4), which is prior to the first hollow stem. Application beyond this growth stage is likely to result in a decrease in grain yield. It is important to note that this experiment only tested the chemical impact of WBM applications on wheat. Specifically, landowners should be aware that appreciable wheel traffic from WBM applications may also have a negative effect on wheat growth.

Although the application of 6,000 lbs TDS/acre generally had no negative impact on wheat yield, it is always better to apply WBM at the lowest rates possible. In other words, when a landowner is approached with a proposition to receive a certain volume of WBM, it is in the best interest of the landowner to provide as much area as possible in order to prevent potential problems. Only work with land application companies that have a good reputation among landowners.

Current OCC regulations do not consider the application rate of sodium to the soil through WBM rates; instead, only the background level (pre-application) of sodium is considered via a SAR test. However, depending on the soil texture and WBM salt (EC) and sodium concentrations, application rates of 6,000 lbs TDS/acre could result in exceeding the SAR threshold of 13 in the 0-inch to 6-inch layer. In this context, soil texture is a “double-edged sword.” Specifically, a heavy textured soil (such as the clay loam in the experiment at Lahoma) is generally able to receive a greater amount of sodium without exceeding the threshold SAR level of 13, compared to a light texture soil. On the other hand, if a light texture soil is amended to SAR levels beyond 13, it can recover much faster and display less physical problems compared to a heavy texture soil at an equivalent SAR level.

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Exhibit 28

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Irrigation Water Quality Standards and Salinity Management Strategies

Irrigation Water Quality Standards and Salinity Management

Guy Fipps*

Nearly all waters contain dissolved salts and trace elements, many of which result from the natural weathering of the earth's surface. In addition, drainage waters from irrigated lands and effluent from city sewage and industrial waste water can impact water quality. In most irrigation situations, the primary water quality concern is salinity levels, since salts can affect both the soil structure and crop yield. However, a number of trace elements are found in water which can limit its use for irrigation.

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Generally, "salt" is thought of as ordinary table salt (sodium chloride). How-ever, many types of salts exist and are commonly found in Texas waters (Table 1). Most salinity problems in agriculture result directly from the salts carried in the irrigation water. The process at work is illustrated in Figure 1, which shows a beaker of water containing a salt concentration of 1 percent. As water evaporates, the dissolved salts remain, resulting in a solution with a higher concentration of salt. The same process occurs in soils. Salts as well as other dissolved substances begin to accumulate as water evaporates from the surface and as crops withdraw water.

Water Analysis: Units, Terms and Sampling

Numerous parameters are used to define irrigation water quality, to assess salinity hazards, and to determine appropriate management strategies. A complete water quality analysis will include the determination of:

1) the total concentration of soluble salts,
2) the relative proportion of sodium to the other cations,
3) the bicarbonate concentration as related to the concentration of calcium and magnesium, and

Table 1. Kinds of salts normally found in irrigation waters, with chemical symbols and approximate proportions of each salt.[1] (Longenecker and Lyerly, 1994)

Chemical name	Chemical symbol	Approximate proportion of total salt content
Sodium chloride	$NaCl$	Moderate to large
Sodium sulfate	Na_2SO_4	Moderate to large
Calcium chloride	$CaCl_2$	Moderate
Calcium sulfate (gypsum)	$CaSO_4\ 2H_2O$	Moderate to small
Magnesium chloride	$MgCl_2$	Moderate
Magnesium sulfate	$MgS0_4$	Moderate to small
Potassium chloride	KCl	Small
Potassium sulfate	K_2SO_4	Small
Sodium bicarbonate	$NaHCO_3$	Small
Calcium carbonate	$CaCO_3$	Very Small
Sodium carbonate	Na_2CO_3	Trace to none
Borates	BO^{-3}	Trace to none
Nitrates	NO^{-3}	Small to none

[1]Waters vary greatly in amounts and kinds of dissolved salts. This water typifies many used for irrigation in Texas.

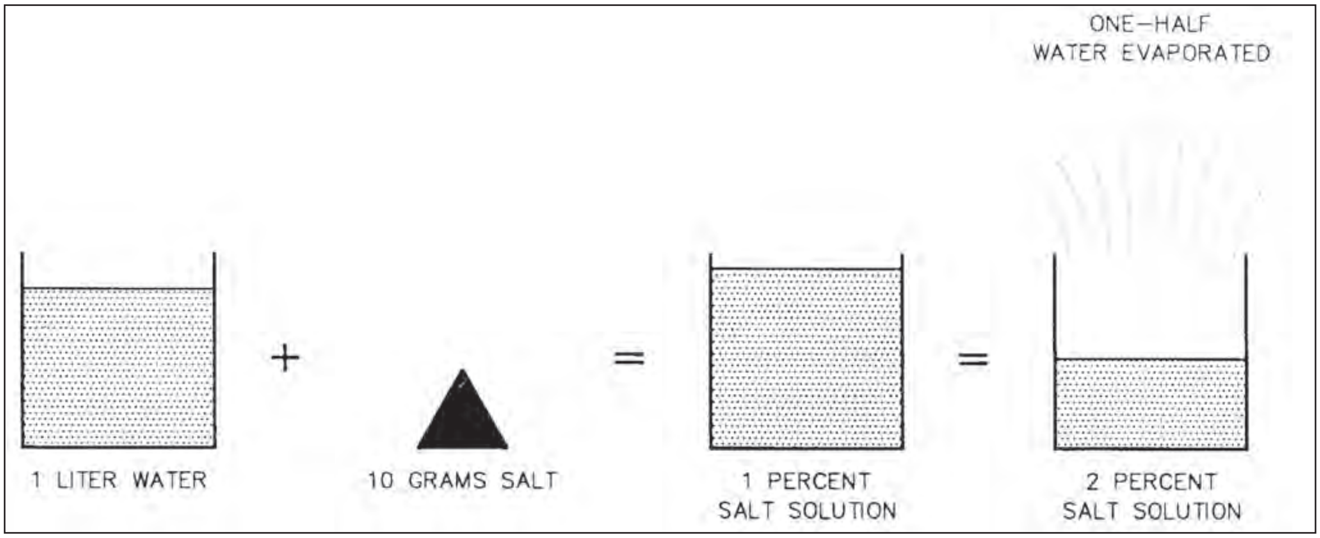

Figure 1. Effect of water evaporation on the concentration of salts in solution. A liter is 1.057 quarts. Ten grams is .035 ounces or about 1 teaspoonful.

4) the concentrations of specific elements and compounds.

The amounts and combinations of these substances define the suitability of water for irrigation and the potential for plant toxicity. Table 2 defines common parameters for analyzing the suitability of water for irrigation and provides some useful conversions.

When taking water samples for laboratory analysis, keep in mind that water from the same source can vary in quality with time. Therefore, samples should be tested at intervals throughout the year, particularly during the potential irrigation period. The Soil and Water Testing Lab at Texas A&M University can do a complete salinity analysis of irrigation water and soil samples, and will provide a detailed computer printout on the interpretation of the results. Contact your county Extension agent for forms and information or contact the Lab at (979) 845-4816.

Two Types of Salt Problems

Two types of salt problems exist which are very different: those associated with the total salinity and those associated with sodium. Soils may be affected only by salinity or by a combination of both salinity and sodium.

Salinity Hazard

Water with high salinity is toxic to plants and poses a ***salinity hazard***. Soils with high levels of total salinity are call ***saline soils***. High concentrations of salt in the soil can result in a "physiological" drought condition. That is, even though the field appears to have plenty of moisture, the plants wilt because the roots are unable to absorb the water. Water salinity is usually measured by the TDS (total dissolved solids) or the EC (electric conductivity). TDS is sometimes referred to as the total salinity and is measured or expressed in parts per million (ppm) or in the equivalent units of milligrams per liter (mg/L).

EC is actually a measurement of electric current and is reported in one of three possible units as given in Table 2. Subscripts are used with the symbol EC to identify the source of the sample. EC_{iw} is the electric conductivity of the irrigation water. EC_e is the electric conductivity of the soil as measured in a soil sample (saturated extract) taken from the root zone. EC_d is the soil salinity of the saturated extract taken from below the root zone. EC_d is used to determine the salinity of the drainage water which leaches below the root zone.

Types of Salinity Problems

salinity hazard	affects →	plants	can lead to →	saline soil condition
sodium	affects →	soils	can lead to →	sodic soil condition

Table 2. Terms, units, and useful conversions for understanding water quality analysis reports.

Symbol	Meaning	Units
Total Salinity		
a. EC	electric conductivity	mmhos/cm μmhos/cm dS/m
b. TDS	total dissolved solids	mg/L ppm
Sodium Hazard		
a. SAR	sodium adsorption ratio	—
b. ESP	exchangeable sodium percentage	—

Determination	Symbol	Unit of measure	Atomic weight
Constituents			
(1) cations			
calcium	Ca	mol/m^3	40.1
magnesium	Mg	mol/m^3	24.3
sodium	Na	mol/m^3	23.0
potassium	K	mol/m^3	39.1
(2) anions			
bicarbonate	HCO_3	mol/m^3	61.0
sulphate	SO_4	mol/m^3	96.1
chloride	Cl	mol/m^3	35.5
carbonate	CO_3	mol/m^3	60.0
nitrate	NO_3	mg/L	62.0
Trace Elements			
boron	B	mg/L	10.8

Conversions

1 dS/m = 1 mmhos/cm = 1000 μmhos/cm

1 mg/L = 1 ppm

TDS (mg/L) ≈ EC (dS/m) x 640 for EC < 5 dS/m

TDS (mg/L ≈ EC (dS/m) x 800 for EC > 5 dS/m

TDS (lbs/ac-ft) ≈ TDS (mg/L) x 2.72

Concentration (ppm) = Concentration (mol/m3) times the atomic weight

Sum of cations/anions

(meq/L) ≈ EC (dS/m) x 10

Key

mg/L = milligrams per liter

ppm = parts per million

dS/m = deci Siemens per meter at 25° C

Sodium Hazard

Irrigation water containing large amounts of sodium is of special concern due to sodium's effects on the soil and poses a ***sodium hazard***. Sodium hazard is usually expressed in terms of SAR or the *sodium adsorption ratio*. SAR is calculated from the ratio of sodium to calcium and magnesium. The latter two ions are important since they tend to counter the effects of sodium. For waters containing significant amounts of bicarbonate, the adjusted sodium adsorption ratio (SAR_{adj}) is sometimes used.

Continued use of water having a high SAR leads to a breakdown in the physical structure of the soil. Sodium is adsorbed and becomes attached to soil particles. The soil then becomes hard and compact when dry and increasingly impervious to water penetration. Fine textured soils, especially those high in clay, are most subject to this action. Certain amendments may be required to maintain soils under high SARs. Calcium and magnesium, if present in the soil in large enough quantities, will counter the effects of the sodium and help maintain good soil properties.

Soluble sodium per cent (SSP) is also used to evaluate sodium hazard. SSP is defined as the ration of sodium in epm (equivalents per million) to the total cation epm multiplied by 100. A water with a SSP greater than 60 per cent may result in sodium accumulations that will cause a breakdown in the soil's physical properties.

Ions, Trace Elements and Other Problems

A number of other substances may be found in irrigation water and can cause toxic reactions in plants (Table 3). After sodium, chloride and boron are of most concern. In certain areas of Texas, boron concentrations are excessively high and render water unsuitable for irrigations. Boron can also accumulate in the soil.

Crops grown on soils having an imbalance of calcium and magnesium may also exhibit toxic symptoms. Sulfate salts affect sensitive crops by limiting the uptake of calcium and increasing the adsorption of sodium and potassium, resulting in a disturbance in the cationic balance within the plant. The bicarbonate ion in soil solution harms the mineral nutrition of the plant through its effects on the uptake and metabolism of nutrients. High concentrations of potassium may introduce a magnesium deficiency and iron chlorosis. An imbalance of magnesium and potassium may be toxic, but the effects of both can be reduced by high calcium levels.

Table 3. Recommended limits for constituents in reclaimed water for irrigation. (Adapted from Rowe and Abdel-Magid, 1995)

Constituent	Long-term use (mg/L)	Short-term use (mg/L)	Remarks
Aluminum (Al)	5.0	20	Can cause nonproductivity in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity.
Arsenic (As)	0.10	2.0	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Beryllium (Be)	0.10	0.5	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans.
Boron (B)	0.75	2.0	Essential to plant growth, with optimum yields for many obtained at a few-tenths mg/L in nutrient solutions. Toxic to many sensitive plants (e.g., citrus) at 1 mg/L. Most grasses relatively tolerant at 2.0 to 10 mg/L.
Cadmium (Cd)	0.01	0.05	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L in nutrient solution. Conservative limits recommended.
Chromium (Cr)	0.1	1.0	Not generally recognized as essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants.
Cobalt (Co)	0.05	5.0	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Copper (Cu)	0.2	5.0	Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solution.
Fluoride (F^-)	1.0	15.0	Inactivated by neutral and alkaline soils.
Iron (Fe)	5.0	20.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum.
Lead (Pb)	5.0	10.0	Can inhibit plant cell growth at very high concentrations.
Lithium (Li)	2.5	2.5	Tolerated by most crops at up to 5 mg/L; mobile in soil. Toxic to citrus at low doses recommended limit is 0.075 mg/L.
Manganese (Mg)	0.2	10.0	Toxic to a number of crops at a few-tenths to a few mg/L in acid soils.
Molybdenum (Mo)	0.01	0.05	Nontoxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high levels of available molybdenum.
Nickel (Ni)	0.2	2.0	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Selenium (Se)	0.02	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of added selenium.
Vanadium (V)	0.1	1.0	Toxic to many plants at relatively low concentrations.
Zinc (Zn)	2.0	10.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils.

Classification of Irrigation Water

Several different measurements are used to classify the suitability of water for irrigation, including EC_{iw}, the total dissolved solids, and SAR. Some permissible limits for classes of irrigation water are given in Table 4. In Table 5, the sodium hazard of water is ranked from low to very high based on SAR values.

Classification of Salt-Affected Soils

Both EC_e and SAR are commonly used to classify salt-affected soils (Table 6). ***Saline soils*** (resulting from salinity hazard) normally have a pH value below 8.5, are relatively low in sodium and contain principally sodium, calcium and magnesium chlorides and sulfates. These compounds cause the white crust which forms on the surface and the salt streaks along the furrows. The compounds which cause saline soils are very soluble in water; therefore, leaching is usually quite effective in reclaiming these soils.

Sodic soils (resulting from sodium hazard) generally have a pH value between 8.5 and 10. These soils are called "black alkali soils" due to their darkened appearance and smooth, slick looking areas caused by the dispersed condition. In sodic soils, sodium has destroyed the permanent structure which tends to make the soil impervious to water. Thus, leaching alone will not be effective unless the high salt dilution method or amendments are used.

Table 6. Classification of salt-affected soils based on analysis of saturation extracts. (Adapted from James et al., 1982)

Criteria	Normal	Saline	Sodic	Saline-Sodic
EC_e (mmhos/cm)	<4	>4	<4	>4
SAR	<13	<13	>13	>13

Water Quality Effects on Plants and Crop Yield

Table 7 gives the expected yield reduction of some crops for various levels of ***soil salinity*** as measured by EC under normal growing conditions, and Table 8 gives potential yield reduction due to ***water salinity*** levels. Generally forage crops are the most resistant to salinity, followed by field crops, vegetable crops, and fruit crops which are generally the most sensitive.

Table 9 lists the ***chloride tolerance*** of a number of agricultural crops. ***Boron*** is a major concern in some areas. While a necessary nutrient, high boron levels cause plant toxicity, and concentrations should not exceed those given in Table 10. Some information is available on the susceptibility of crops to ***foliar injury*** from spray irrigation with water containing sodium and chloride (Table 11). The tolerance of crops to sodium as measured by the exchangeable sodium percentage (ESP) is given in Table 12.

Table 4. Permissible limits for classes of irrigation water.

Classes of water	Concentration, total dissolved solids	
	Electrical conductivity μmhos*	Gravimetric ppm
Class 1, Excellent	250	175
Class 2, Good	250-750	175-525
Class 3, Permissible[1]	750-2,000	525-1,400
Class 4, Doubtful[2]	2,000-3,000	1,400-2,100
Class 5, Unsuitable[2]	3,000	2,100

*Micromhos/cm at 25 degrees C.
[1]Leaching needed if used
[2]Good drainage needed and sensitive plants will have difficulty obtaining stands

Table 5. The sodium hazard of water based on SAR Values.

SAR values	Sodium hazard of water	Comments
1-10	Low	Use on sodium sensitive crops such as avocados must be cautioned.
10 - 18	Medium	Amendments (such as Gypsum) and leaching needed.
18 - 26	High	Generally unsuitable for continuous use.
> 26	Very High	Generally unsuitable for use.

Table 7. Soil salinity tolerance levels[1] for different crops. (Adapted from Ayers and Westcot, 1976)					
	Yield potential, EC_e				
Crop	100%	90%	75%	50%	Maximum EC_e
Field crops					
Barley[a]	8.0	10.0	13.0	18.0	28
Bean (field)	1.0	1.5	2.3	3.6	7
Broad bean	1.6	2.6	4.2	6.8	12
Corn	1.7	2.5	3.8	5.9	10
Cotton	7.7	9.6	13.0	17.0	27
Cowpea	1.3	2.0	3.1	4.9	9
Flax	1.7	2.5	3.8	5.9	10
Groundnut	3.2	3.5	4.1	4.9	7
Rice (paddy)	3.0	3.8	5.1	7.2	12
Safflower	5.3	6.2	7.6	9.9	15
Sesbania	2.3	3.7	5.9	9.4	17
Sorghum	4.0	5.1	7.2	11.0	18
Soybean	5.0	5.5	6.2	7.5	10
Sugar beet	7.0	8.7	11.0	15.0	24
Wheat[a]	6.0	7.4	9.5	13.0	20
Vegetable crops					
Bean	1.0	1.5	2.3	3.6	7
Beet[b]	4.0	5.1	6.8	9.6	15
Broccoli	2.8	3.9	5.5	8.2	14
Cabbage	1.8	2.8	4.4	7.0	12
Cantaloupe	2.2	3.6	5.7	9.1	16
Carrot	1.0	1.7	2.8	4.6	8
Cucumber	2.5	3.3	4.4	6.3	10
Lettuce	1.3	2.1	3.2	5.2	9
Onion	1.2	1.8	2.8	4.3	8
Pepper	1.5	2.2	3.3	5.1	9
Potato	1.7	2.5	3.8	5.9	10
Radish	1.2	2.0	3.1	5.0	9
Spinach	2.0	3.3	5.3	8.6	15
Sweet corn	1.7	2.5	3.8	5.9	10
Sweet potato	1.5	2.4	3.8	6.0	11
Tomato	2.5	3.5	5.0	7.6	13
Forage crops					
Alfalfa	2.0	3.4	5.4	8.8	16
Barley hay[a]	6.0	7.4	9.5	13.0	20
Bermudagrass	6.9	8.5	10.8	14.7	23
Clover, Berseem	1.5	3.2	5.9	10.3	19
Corn (forage)	1.8	3.2	5.2	8.6	16
Harding grass	4.6	5.9	7.9	11.1	18
Orchard grass	1.5	3.1	5.5	9.6	18
Perennial rye	5.6	6.9	8.9	12.2	19
Sudan grass	2.8	5.1	8.6	14.4	26
Tall fescue	3.9	5.8	8.61	3.3	23
Tall wheat grass	7.5	9.9	13.3	19.4	32
Trefoil, big	2.3	2.8	3.6	4.9	8
Trefoil, small	5.0	6.0	7.5	10.0	15
Wheat grass	7.5	9.0	11.0	15.0	22

Salinity and Growth Stage

Many crops have little tolerance for salinity during seed germination, but significant tolerance during later growth stages. Some crops such as barley, wheat and corn are known to be more sensitive to salinity during the early growth period than during germination and later growth periods. Sugar beet and safflower are relatively more sensitive during germination, while the tolerance of soybeans may increase or decrease during different growth periods depending on the variety.

Leaching for Salinity Management

Soluble salts that accumulate in soils must be leached below the crop root zone to maintain productivity. Leaching is the basic management tool for controlling salinity. Water is applied in excess of the total amount used by the crop and lost to evaporation. The strategy is to keep the salts in solution and flush them below the root zone. The amount of water needed is referred to as the *leaching requirement* or the *leaching fraction*.

Excess water may be applied with every irrigation to provide the water needed for leaching. However, the time interval between leachings does not appear to be critical provided that crop tolerances are not exceeded. Hence, leaching can be accomplished with each irrigation, every few irrigations, once yearly, or even longer depending on the severity of the salinity problem and salt tolerance of the crop. An occasional or annual leaching event where water is ponded on the surface is an easy and effective method for controlling soil salinity. In some areas, normal rainfall provides adequate leaching.

Table 7. Soil salinity tolerance levels[1] for different crops. (continued)

Crop	Yield potential, EC_e 100%	90%	75%	50%	Maximum EC_e
Fruit crops					
Almond	1.5	2.0	2.8	4.1	7
Apple, Pear	1.7	2.3	3.3	4.8	8
Apricot	1.6	2.0	2.6	3.7	6
Avocado	1.3	1.8	2.5	3.7	6
Date palm	4.0	6.8	10.9	17.9	32
Fig, Olive, Pomegranate	2.7	3.8	5.5	8.4	14
Grape	1.5	2.5	4.1	6.7	12
Grapefruit	1.8	2.4	3.4	4.9	8
Lemon	1.7	2.3	3.3	4.8	8
Orange	1.7	2.3	3.2	4.8	8
Peach	1.7	2.2	2.9	4.1	7
Plum	1.5	2.1	2.9	4.3	7
Strawberry	1.0	1.3	1.8	2.5	4
Walnut	1.7	2.3	3.3	4.8	8

[1]Based on the electrical conductivity of the saturated extract taken from a root zone soil sample (EC_e) measured in mmhos/cm.

[a]During germination and seedling stage EC_e should not exceed 4 to 5 mmhos/cm except for certain semi-dwarf varieties.

[b]During germination EC_e should not exceed 3 mmhos/cm.

Table 8. Irrigation water salinity tolerances[1] for different crops. (Adapted from Ayers and Westcot, 1976)

Crop	Yield potential, EC_{iw} 100%	90%	75%	50%
Field crops				
Barley	5.0	6.7	8.7	12.0
Bean (field)	0.7	1.0	1.5	2.4
Broad bean	1.1	1.8	2.0	4.5
Corn	1.1	1.7	2.5	3.9
Cotton	5.1	6.4	8.4	12.0
Cowpea	0.9	1.3	2.1	3.2
Flax	1.1	1.7	2.5	3.9
Groundnut	2.1	2.4	2.7	3.3
Rice (paddy)	2.0	2.6	3.4	4.8
Safflower	3.5	4.1	5.0	6.6
Sesbania	1.5	2.5	3.9	6.3
Sorghum	2.7	3.4	4.8	7.2
Soybean	3.3	3.7	4.2	5.0
Sugar beet	4.7	5.8	7.5	10.0
Wheat	4.0	4.9	6.4	8.7
Vegetable crops				
Bean	0.7	1.0	1.5	2.4
Beet	2.7	3.4	4.5	6.4
Broccoli	1.9	2.6	3.7	5.5

Determining Required Leaching Fraction

The leaching fraction is commonly calculated using the following relationship:

$$LF = \frac{EC_{iw}}{EC_e} \qquad (1)$$

where

LF = leaching fraction - the fraction of applied irrigation water that must be leached through the root zone

EC_{iw} = electric conductivity of the irrigation water

EC_e = the electric conductivity of the soil in the root zone

Equation (1) can be used to determine the leaching fraction necessary to maintain the root zone at a targeted salinity level. If the amount of water available for leaching is fixed, then the equation can be used to calculate the salinity level that will be maintained in the root zone with that amount of leaching. Please note that equation (1) simplifies a complicated soil water process. EC_e should be checked periodically and the amount of leaching adjusted accordingly.

Based on this equation, Table 13 lists the amount of leaching needed for different classes of irrigation waters to maintain the soil salinity in the root zone at a desired level. However, additional water must be supplied because of the inefficiencies of irrigation systems (Table 14), as well as to remove the existing salts in the soil.

Table 8. Irrigation water salinity tolerances[1] for different crops. (continued)

Crop	Yield potential, EC_{iw}			
	100%	90%	75%	50%
Cabbage	1.2	1.9	2.9	4.6
Cantaloupe	1.5	2.4	3.8	6.1
Carrot	0.7	1.1	1.9	3.1
Cucumber	1.7	2.2	2.9	4.2
Lettuce	0.9	1.4	2.1	3.4
Onion	0.8	1.2	1.8	2.9
Pepper	1.0	1.5	2.2	3.4
Potato	1.1	1.7	2.5	3.9
Radish	0.8	1.3	2.1	3.4
Spinach	1.3	2.2	3.5	5.7
Sweet corn	1.1	1.7	2.5	3.9
Sweet potato	1.0	1.6	2.5	4.0
Tomato	1.7	2.3	3.4	5.0
Forage crops				
Alfalfa	1.3	2.2	3.6	5.9
Barley hay	4.0	4.9	6.3	8.7
Bermudagrass	4.6	5.7	7.2	9.8
Clover, Berseem	1.0	2.1	3.9	6.8
Corn (forage)	1.2	2.1	3.5	5.7
Harding grass	3.1	3.9	5.3	7.4
Orchard grass	1.0	2.1	3.7	6.4
Perennial rye	3.7	4.6	5.9	8.1
Sudan grass	1.9	3.4	5.7	9.6
Tall fescue	2.6	3.9	5.7	8.9
Tall wheat grass	5.0	6.6	9.0	13.0
Trefoil, big	1.5	1.9	2.4	3.3
Trefoil, small	3.3	4.0	5.0	6.7
Wheat grass	5.0	6.0	7.4	9.8
Fruit crops				
Almond	1.0	1.4	1.9	2.7
Apple, Pear	1.0	1.6	2.2	3.2
Apricot	1.1	1.3	1.8	2.5
Avocado	0.9	1.2	1.7	2.4
Date palm	2.7	4.5	7.3	12.0
Fig, Olive, Pomegranate	1.8	2.6	3.7	5.6
Grape	1.0	1.7	2.7	4.5
Grapefruit	1.2	1.6	2.2	3.3
Lemon	1.1	1.6	2.2	3.2
Orange	1.1	1.6	2.2	3.2
Peach	1.1	1.4	1.9	2.7
Plum	1.0	1.4	1.9	2.8
Strawberry	0.7	0.9	1.2	1.7
Walnut	1.1	1.6	2.2	3.2

[1]Based on the electrical conductivity of the irrigation water (EC_{iw}) measured in mmhos/cm.

Subsurface Drainage

Very saline, shallow water tables occur in many areas of Texas. Shallow water tables complicate salinity management since water may actually move upward into the root zone, carrying with it dissolved salts. Water is then extracted by crops and evaporation, leaving behind the salts.

Shallow water tables also contribute to the salinity problem by restricting the downward leaching of salts through the soil profile. Installation of a subsurface drainage system is about the only solution available for this situation. The original clay tiles have been replaced by plastic tubing. Modern drainage tubes are covered by a "sock" made of fabric to prevent clogging of the small openings in the plastic tubing.

A schematic of a subsurface drainage system is shown in Figure 2. The design parameters are the distance between drains (L) and the elevation of the drains (d) above the underlying impervious or restricting layer. Proper spacing and depth maintain the water level at an optimum level, shown here as the distance *m* above the drain tubes. The USDA Natural Resources Conservation Service (NRCS) has developed drainage design guidelines that are used throughout the United States. A drainage computer model developed by Wayne Skaggs at North Carolina State University, DRAINMOD, is also widely used throughout the world for subsurface drainage design.

Seed Placement

Obtaining a satisfactory stand is often a problem when furrow irrigating with saline water. Growers sometimes compensate for poor germination by planting two or three times as much seed as normally would be required.

However, planting procedures can be adjusted to lower the salinity in the soil around the germinating seeds. Good salinity control is often achieved with a combination of suitable practices, bed shapes and irrigation water management.

In furrow-irrigated soils, planting seeds in the center of a single-row, raised bed places the seeds exactly where salts are expected to concentrate (Figure 3). This situation can be avoided using "salt ridges." With a double-row raised planting bed, the seeds are placed near the shoulders and away from the area of greatest salt accumulation. Alternate-furrow irrigation may help in some cases. If alternate furrows are irrigated, salts often can be moved beyond the single seed row to the non-irrigated side of the planting bed. Salts will still accumulate, but accumulation at the center of the bed will be reduced.

With either single- or double-row plantings, increasing the depth of the water in the furrow can improve germination in saline soils. Another practice is to use sloping beds, with the seeds planted on the sloping side just above the water line (Fig. 3b). Seed and plant placement is also important with the use of drip irrigation. Typical wetting patterns of drip emitters and micro-sprinklers are shown in Figure 4. Salts tend to move out and upward, and will accumulate in the areas shown.

Other Salinity Management Techniques

Techniques for controlling salinity that require relatively minor changes are more frequent irrigations, selection of more salt-tolerant crops, additional leaching, preplant irrigation, bed forming and seed placement. Alternatives that require significant changes in management are changing the irrigation method, altering the water supply, land-leveling, modifying the soil profile, and installing subsurface drainage.

Residue Management

The common saying "salt loves bare soils" refers to the fact that exposed soils have higher evaporation rates than those covered by residues. Residues left on the soil surface reduce evaporation. Thus, less salts will accumulate and rainfall will be more effective in providing for leaching.

More Frequent Irrigations

Salt concentrations increase in the soil as water is extracted by the crop. Typically, salt concentrations are lowest following an irrigation and higher just before the next irrigation. Increasing irrigation frequency maintains a more constant moisture content in the soil. Thus, more of the salts are then kept in solution which aids the leaching process. Surge flow irrigation is often effective at reducing the minimum depth of irrigation that can be applied with furrow irrigation systems. Thus, a larger number of irrigations are possible using the same amount of water.

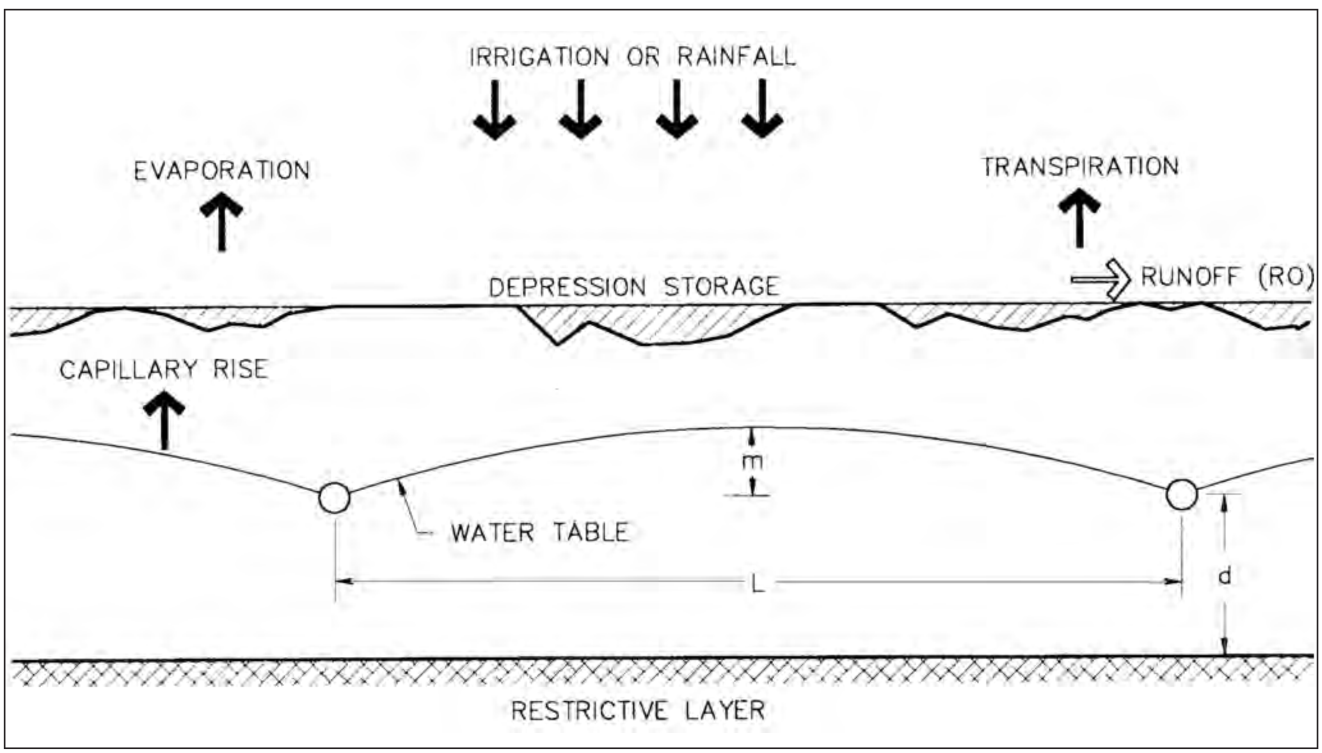

Figure 2. A subsurface drainage system. Plastic draintubes are located a distance (L) apart.

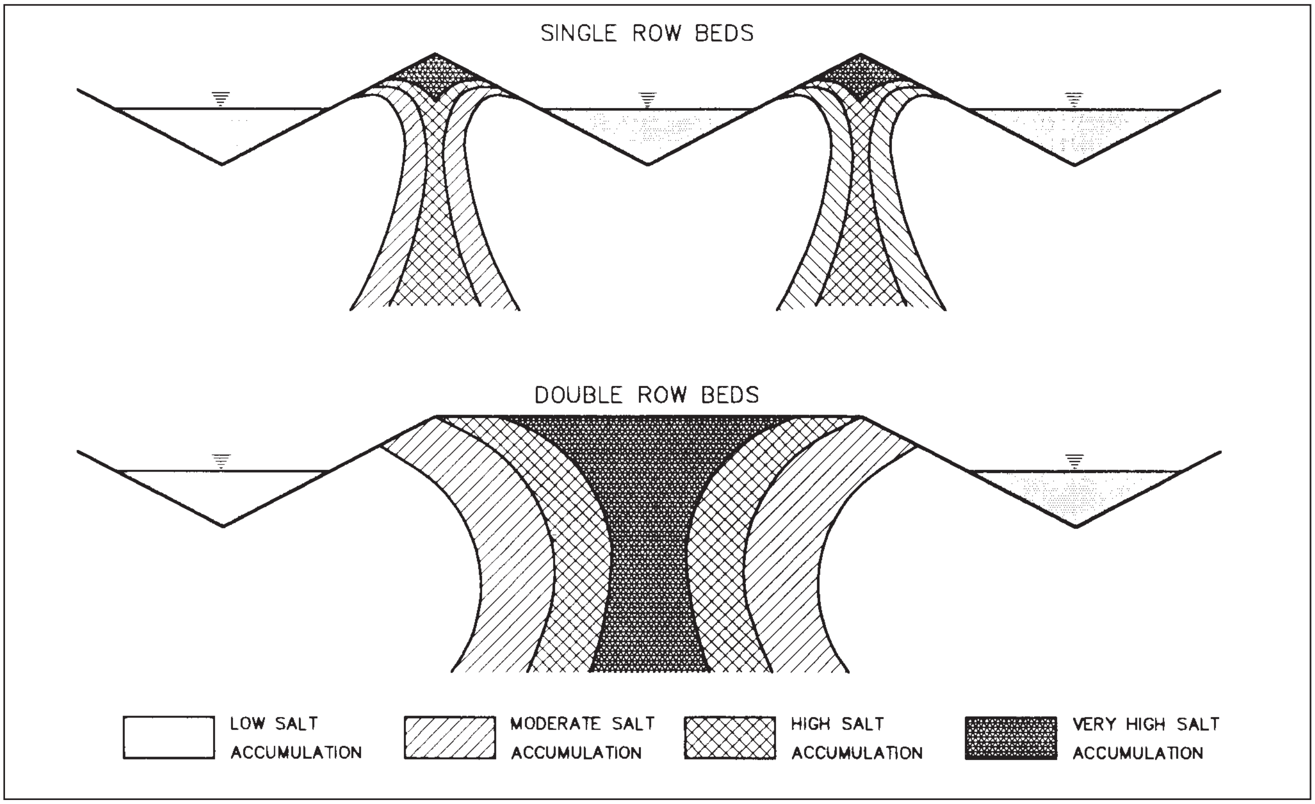

Figure 3a. Single-row versus double-row beds showing areas of salt accumulation following a heavy irrigation with salty water. Best planting position is on the shoulders of the double-row bed.

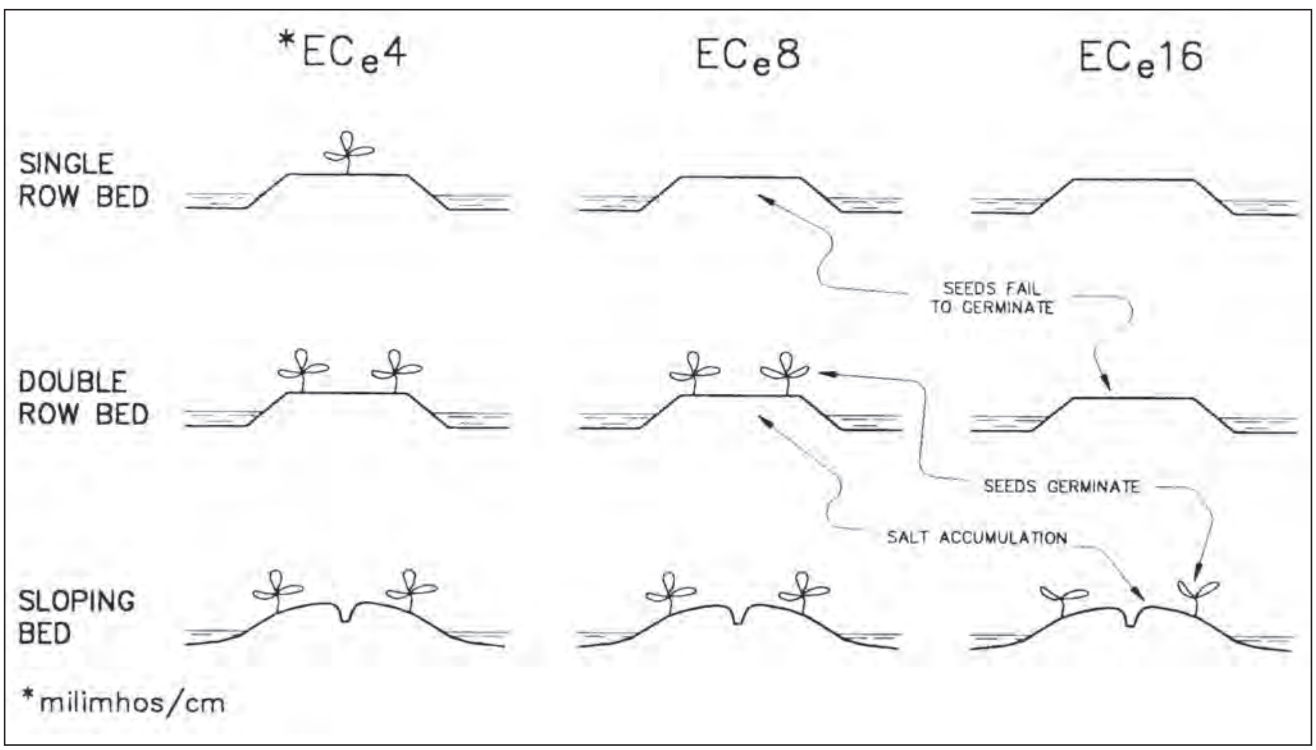

Figure 3b. Pattern of salt build-up as a function of seed placement, bed shape and irrigation water quality.

Table 9. Chloride tolerance of agricultural crops. Listed in order of tolerance[a]. (Adapted from Tanji. 1990)		
	Maximum Cl^- concentration[b] without loss in yield	
Crop	mol/m^3	ppm
Strawberry	10	350
Bean	10	350
Onion	10	350
Carrot	10	350
Radish	10	350
Lettuce	10	350
Turnip	10	350
Rice, paddy[c]	30[d]	1,050
Pepper	15	525
Clover, strawberry	15	525
Clover, red	15	525
Clover, alsike	15	525
Clover, ladino	15	525
Corn	15	525
Flax	15	525
Potato	15	525
Sweet potato	15	525
Broad bean	15	525
Cabbage	15	525
Foxtail, meadow	15	525
Celery	15	525
Clover, Berseem	15	525
Orchardgrass	15	525
Sugarcane	15	525
Trefoil, big	20	700
Lovegras	20	700
Spinach	20	700
Alfalfa	20	700
Sesbania[c]	20	700
Cucumber	25	875
Tomato	25	875
Broccoli	25	875
Squash, scallop	30	1,050
Vetch, common	30	1,050
Wild rye, beardless	30	1,050
Sudan grass	30	1,050
Wheat grass, standard crested	35	1,225
Beet, red[c]	40	1,400
Fescue, tall	40	1,400
Squash, zucchini	45	1,575
Harding grass	45	1,575
Cowpea	50	1,750
Trefoil, narrow-leaf bird's foot	50	1,750

With proper placement, drip irrigation is very effective at flushing salts, and water can be applied almost continuously. Center pivots equipped with LEPA water applicators offer similar efficiencies and control as drip irrigation at less than half the cost. Both sprinkler and drip provide more control and flexibility in scheduling irrigation than furrow systems.

Preplant Irrigation

Salts often accumulate near the soil surface during fallow periods, particularly when water tables are high or when off-season rainfall is below normal. Under these conditions, seed germination and seedling growth can be seriously reduced unless the soil is leached before planting.

Changing Surface Irrigation Method

Surface irrigation methods, such as flood, basin, furrow and border are usually not sufficiently flexible to permit changes in frequency of irrigation or depth of water applied per irrigation. For example, with furrow irrigation it may not be possible to reduce the depth of water applied below 3-4 inches. As a result, irrigating more frequently might improve water availability to the crop but might also waste water. Converting to ***surge flow irrigation*** may be the solution for many furrow systems. Otherwise a sprinkler or drip irrigation system may be required.

Chemical Amendments

In sodic soils (or sodium affected soils), sodium ions have become attached to and adsorbed onto the soil particles. This causes a breakdown in soil structure and results in soil sealing or "cementing," making it difficult for water to infiltrate. Chemical amendments are used in order to help facilitate the displacement of these sodium ions. Amendments are composed

Table 9. Chloride tolerance of agricultural crops. Listed in order of tolerance[a]. (continued)

Crop	Maximum Cl^- concentration[b] without loss in yield	
	mol/m^3	ppm
Ryegrass, perennial	55	1,925
Wheat, Durum	55	1,925
Barley (forage)[c]	60	2,100
Wheat[c]	60	2,100
Sorghum	70	2,450
Bermudagrass	70	2,450
Sugar beet[c]	70	2,450
Wheat grass, fairway crested	75	2,625
Cotton	75	1,625
Wheat grass, tall	75	2,625
Barley[c]	80	2,800

[a]These data serve only as a guideline to relative tolerances among crops. Absolute tolerances vary, depending upon climate, soil conditions and cultural practices.

[b]Cl^- concentrations in saturated-soil extracts sampled in the rootzone.

[c]Less tolerant during emergence and seedling stage.

[d]Values for paddy rice refer to the Cl^- concentration in the soil water during the flooded growing conditions.

of sulphur in its elemental form or related compounds such as sulfuric acid and gypsum. Gypsum also contains calcium which is an important element in correcting these conditions. Some chemical amendments render the natural calcium in the soil more soluble. As a result, calcium replaces the adsorbed sodium which helps restore the infiltration capacity of the soil. Polymers are also beginning to be used for treating sodic soils.

It is important to note that use of amendments does not eliminate the need for leaching. Excess water must still be applied to leach out the displaced sodium. Chemical amendments are only effective on sodium-affected soils. Amend-ments are ineffective for saline soil conditions and often will increase the existing salinity problem. Table 15 lists the most common amendments. The irrigation books listed under the References section present equations that are used to determine the amount of amendments needed based on soil analysis results.

Pipe Water Delivery Systems Stabilize Salinity

As illustrated in Fig. 1, any open water is subject to evaporation which leads to higher salt concentrations in the water. Evaporation rates from water surfaces often exceed 0.25 inch a day during summer in Texas. Thus, the salinity content of irrigation water will increase during the entire time water is transported through irrigation canals or stored in reservoirs. Replacing irrigation ditches with pipe systems will help stabilize salinity levels. In addition, pipe systems, including gated pipe and lay-flat tubing, reduce water lost to canal seepage and increase the amount of water available for leaching.

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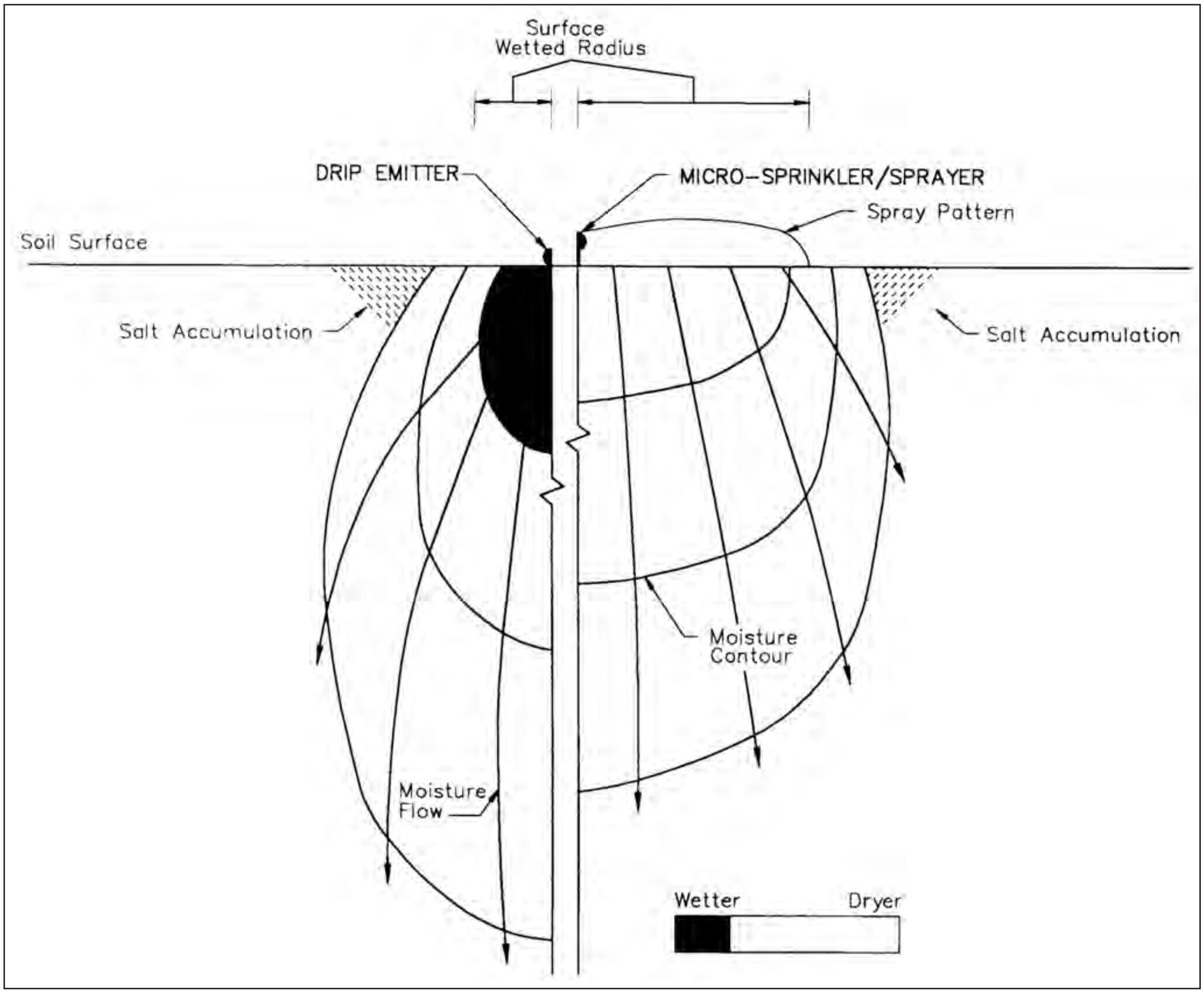

Figure 4. Typical wetting patterns and areas of salt accumulation with drip emitters and micro-sprinklers sprayers.

Table 10. Limits of boron in irrigation water. (Adapted from Rowe and Abdel-Magid, 1995)

A. Permissible Limits (Boron in parts per million)

Class of water	Crop group		
	Sensitive	**Semitolerant**	**Tolerant**
Excellent	<0.33	<0.67	<1.00
Good	0.33 to 0.67	0.67 to 1.33	1.00 to 2.00
Permissible	0.67 to 1.00	1.33 to 2.00	2.00 to 3.00
Doubtful	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
Unsuitable	>1.25	>2.5	>3.75

B. Crop groups of boron tolerance (in each plant group, the first names are considered as being more tolerant; the last names, more sensitive).

Sensitive (1.0 mg/L of Boron)	**Semitolerant (2.0 mg/L of Boron)**	**Tolerant (4.0 mg/L of Boron)**
Pecan	Sunflower (native)	Athel (Tamarix aphylla)
Walnut (Black, Persian, or English)	Potato	Asparagus
Jerusalem artichoke	Cotton (Acala and Pima)	Palm (Phoenix canariensis)
Navy bean	Tomato	Date palm (P. dactylifera)
American elm	Sweetpea	Sugar beet
Plum	Radish	Mangel
Pear	Field pea	Garden beet
Apple	Ragged Robin rose	Alfalfa
Grape (Sultania and Malaga)	Olive	Gladiolus
Kadota fig	Barley	Broad bean
Persimmon	Wheat	Onion
Cherry	Corn	Turnip
Peach	Milo	Cabbage
Apricot	Oat	Lettuce
Thornless blackberry	Zinnia	Carrot
Orange	Pumpkin	
Avocado	Bell pepper	
Grapefruit	Sweet potato	
Lemon	Lima bean	
(0.3 mg/L of Boron)	(1.0 mg/L of Boron)	(2.0 mg/L of Boron)

Table 11. Relative susceptibility of crops to foliar injury from saline sprinkling waters. (Tanji, 1990)

Na or Cl concentration (mol/m3) causing foliar injury[a]			
<5	**5-10**	**10-20**	**>20**
Almond	Grape	Alfalfa	Cauliflower
Apricot	Pepper	Barley	Cotton
Citrus	Potato	Corn	Sugar beet
Plum	Tomato	Cucumber	Sunflower
		Safflower	
		Sesame	
		Sorghum	

[a]Foliar injury is influenced by cultural and environmental conditions. These data are presented only as general guidelines for daytime sprinkling.

Table 12. Tolerance of Various Crops to Exchangeable-Sodium Percentage. (James et al., 1982)		
Tolerance to ESP (range at which affected)	**Crop**	**Growth Responsible Under Field Conditons**
Extremely sensitive (ESP = 2-10)	Deciduous fruits Nuts Citrus Avocado	Sodium toxicity symptoms even at low ESP values
Sensitive (ESP = 10-20)	Beans	Stunted growth at low ESP values even though the physical condition of the soil may be good
Moderately tolerant (ESP = 20-40)	Clover Oats Tall fescue Rice Dallisgrass	Stunted growth due to both nutritional factors and adverse soil conditions
Tolerant (ESP = 40-60)	Wheat Cotton Alfalfa Barley Tomatoes Beets	Stunted growth usually due to adverse physical conditions of soil
Most tolerant (ESP > 60)	Crested and Fairway wheatgrass Tall wheatgrass Rhodes grass	Stunted growth usually due to adverse physical conditions of soil

Table 13. Leaching requirement* as related to the electrical conductivities of the irrigation and drainage water.

Electrical conductivity of irrigation water (mmhos/cm)	Leaching requirement based on the indicated maximum values for the conductivity of the drainage water at the bottom of the root zone			
	4 mmhos/cm	**8 mmhos/cm**	**12 mmhos/cm**	**16 mmhos/cm**
	Percent	*Percent*	*Percent*	*Percent*
0.75	13.3	9.4	6.3	4.7
1.00	25.0	12.5	8.3	6.3
1.25	31.3	15.6	10.4	7.8
1.50	37.5	18.7	12.5	9.4
2.00	50.0	25.0	16.7	12.5
2.50	62.5	31.3	20.8	15.6
3.00	75.0	37.5	25.0	18.7
5.00	—	62.5	41.7	31.2

*Fraction of the applied irrigation water that must be leached through the root zone expressed as percent.

Table 14. Typical overall on-farm efficiencies for various types of irrigation systems.

System	Overall efficiency (%)
Surface	50-80
a. average	50
b. land leveling and delivery pipeline meeting design standards	70
c. tailwater recovery with (b)	80
d. surge	60-90*
Sprinkler (moving and fixed systems)	55-85
LEPA (low pressure precision application)	95-98
Drip	80-90**

*Surge has been found to increase efficiencies 8 to 28% over non-surge furrow systems.

**Drip systems are typically designed at 90% efficiency, short laterals (100 feet) or systems with pressure compensating emitters may have higher efficiencies.

Table 15. Various amendments for reclaiming sodic soil and amount equivalent to gypsum.

Amendment	Physical description	Amount equivalent 100% gypsum
Gypsum*	White mineral	1.0
Sulfur†	Yellow element	0.2
Sulfuric acid*	Corrosive liquid	0.6
Lime sulfur*	Yellow-brown solution	0.8
Calcium carbonate†	White mineral	0.6
Calcium chloride*	White salt	0.9
Ferrous sulfate*	Blue-green salt	1.6
Pyrite†	Yellow-black mineral	0.5
Ferric sulfate*	Yellow-brown salt	0.6
Aluminum sulfate*	Corrosive granules	1.3

*Suitable for use as a water or soil amendment.

†Suitable only for soil application.

Exhibit 29

Interpreting Drinking Water Tests for Dairy Cows

Authors

Dairy farms rely on good quality water to ensure maximum milk production and herd health. Experience in Pennsylvania has shown that aesthetic pollutants like iron, manganese and hydrogen sulfide, are the most common water-related causes of problems with dairy herds. These pollutants cause tastes or odors that result in reduced water intake and milk production. Other pollutants, such as nitrate or heavy metals, can cause health effects in dairy herds.

A recent research project on 243 dairy farms from 41 counties across Pennsylvania found that 26% of the farm water supplies had at least one water quality issue. Average milk production for these farms was 56 pounds per cow per day, compared to 62 pounds on the farms with good water quality. Interestingly, none of the farms with high milk production (above 75 pounds of milk per cow per day) had existing water quality problems while 32% of farms with low milk production (below 50 pounds of milk per cow) had at least one potential water quality problem.

Routine and inexpensive ($40 to $70) water testing can be used to identify existing water quality issues that might affect dairy herd health or milk production. The Penn State Agricultural Analytical Services Laboratory offers drinking water testing for dairy herds on their Livestock Drinking Water Testing page. The information in this article can be used to interpret these water tests for the most common parameters.

Note: While various studies have been done to link water quality problems with livestock health or performance, specific conclusions on the concentrations where water pollutants cause problems often vary between studies. This article attempts to provide the best consensus on levels of concern for common pollutants but readers should visit the references listed at the end to learn more about the range of conclusions for each pollutant.

pH

Few studies have linked water pH with any livestock health or performance issues. Adams and Sharpe (1995) suggested that water pH should fall between 5.1 and 9.0 based on experiences with dairy herds in Pennsylvania. They suggested that acidic water with a pH less than 5.1 may increase problems related to chronic or mild acidosis while water with a pH over 9.0 may result in problems related to chronic or mild alkalosis. Other authors have recommended a more strict pH range between 6.0 and 8.5 largely based on field observations rather than controlled studies. We suggest that water supplies with a pH below 6.0 or above 8.5 should be further evaluated where unexplained herd health or performance issues occur.

Total Dissolved Solids (TDS)

TDS is a sum of all of the inorganic contaminants in water. Drinking water with less than 1,000 milligrams per liter (mg/L) of TDS is ideal for dairy cows. Levels of 1,000 to 3,000 mg/L are usually satisfactory but may cause various performance issues depending on the exact contaminant causing the elevated TDS. Levels above 3,000 mg/L are more likely to cause poor tasting water that may result in reduced water intake and milk production again depending on the exact pollutants causing the high TDS concentration. Overall, water with a TDS above 1,000 mg/L has the potential to cause livestock problems and should be tested for all major water minerals, salts and metals.

Nitrate-Nitrogen and Nitrite-Nitrogen

Nitrates can occur in both feedstuffs and water and the risk is additive. For this reason, livestock producers should be aware of nitrate levels in both the drinking water and food. Although nitrate-nitrogen levels above 10 mg/L in drinking water can be harmful to human infants, research has shown that livestock can generally tolerate slightly higher nitrate-nitrogen concentrations. Drinking water concentrations above 20 mg/L as nitrate-nitrogen could present herd health issues depending on concentrations in food (which should be carefully evaluated). Nitrate-nitrogen levels over 100 mg/L in drinking water represent a higher risk for fertility and other health issues again depending on the intake from feed.

Hardness, Calcium, Magnesium

Hardness is mostly a measure of the calcium and magnesium in water. Hard water causes many aesthetic problems with the use of the water, such as restricted water flow from mineral deposits, but it generally does not adversely affect cows. Extremely high concentrations of calcium or magnesium above 500 mg/L should be included in ration formulation.

Sodium

Sodium in water is rarely problematic for dairy cattle but sodium concentrations should be included in the ration formulation if levels exceed 20 mg/L.

Iron and Manganese

Iron and manganese are very common pollutants that can occur naturally in groundwater or from nearby mining activities. Both cause severe staining and a metallic taste to water resulting in reduced water intake and reduced milk production. Iron levels above 0.3 mg/L and manganese concentrations exceeding 0.05 mg/L are sufficient to cause unpleasant tastes in water that may cause reduced water intake and milk production.

Chloride

Chloride in water may occur naturally from deep brines or as a result of various activities such as gas and oil well drilling or road deicing. Chlorides above 250 mg/L can impart a salty taste to water which could result in reduced water intake and milk production. Water supplies serving herds with performance problems should be tested for chlorides as a potential explanation. High chlorides should also be considered when formulating diets to prevent an excess which could be detrimental to rumen function.

Sulfate

Various research studies have produced differing levels of concern for sulfate in water for livestock. Sulfate concentrations below 1,000 mg/L are generally thought to be safe for adult animals but some authors have suggested limits as low as 500 mg/L. High sulfate has been linked to reduced milk fat and increased needs for selenium, vitamin E, and copper. Over time, some animals become acclimated to elevated sulfates in water resulting in reduced symptoms.

Copper

Copper usually occurs in water from corrosion of metal plumbing components. It may also be elevated in mining areas or from treatment of ponds with copper sulfate algaecides. Copper levels above 1.0 mg/L may cause a metallic taste resulting in reduced water intake and milk production. High copper concentrations may also cause liver damage.

Coliform Bacteria

Coliform bacteria occur in all surface waters (streams, ponds, etc.) and many groundwater wells. Coliform bacteria in wells usually come from surface water contaminating the well or from insects under the well cap. Water used for washing equipment, udders and teats should have zero total coliform bacteria per 100 mL of water.

There is less certainty about the effect of coliform bacteria on drinking water for dairy cows. Recent research on over 200 dairy herds in Pennsylvania was unable to show a correlation between bacteria and herd health issues. Also, the concentration of coliform bacteria is strongly related to the location where the water is collected. Water samples from drinking troughs may have large concentrations of coliform bacteria, especially if the troughs are cleaned infrequently. Samples collected at drinking areas compared to the source well water will indicate the need for better sanitation. Clean and sanitize drinking cups, bowls, and tanks daily to reduce bacteria loads. Use a raised base around bowls or tanks to reduce manure contamination of water.

E. coli Bacteria

E. coli bacteria occur from direct contamination by animal or human waste. As such, the occurrence of E. coli bacteria is much more serious than total coliform bacterial contamination. E. coli bacteria can be found frequently in bowls and troughs due to direct contact with animals. Frequent cleaning of water locations can minimize exposure to E. coli or other fecal bacteria in water. It is recommended that E. coli or fecal coliform bacteria should be absent from drinking water for cattle.

More Information

Table 1 summarizes common water quality parameters for livestock in Pennsylvania. Included in the table are the human drinking water standard, median concentrations typically found in groundwater in Pennsylvania, and levels potentially causing livestock health or performance problems. Parameters with a "--" in the final column indicate those with a lack of consensus among research studies about any definitive problem in drinking water for livestock.

Various other metals in water such as aluminum, arsenic, boron, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, vanadium and zinc may affect herd health or performance. Consult the references below for more information about these metals and the data in the table.

Table 1. A summary of common water quality parameters of concern for livestock drinking water sources in Pennsylvania. All concentrations are in mg/L except pH (pH units) and bacteria (colonies per 100 mL).

Parameter	Human Drinking Water Problems[1]	Approximate Median Concentration in Pennsylvania Groundwater[2]	Possible Animal Problems[3]
pH	Under 6.5 or over 8.5	7.6	Under 6.0 or over 8.5
Total Dissolved Solids	Over 500	190.5	Over 1,000
Nitrate-Nitrogen	Over 10	0.90	Over 20
Calcium	-	20.92	--
Copper	Over 1.0	0.02	Over 1.0
Iron	Over 0.30	0.10	Over 0.30
Manganese	Over 0.05	0.01	Over 0.05
Magnesium	-	6.25	--
Sodium	-	6.87	--
Chloride	Over 250	10.1	Over 250
Sulfate	Over 250	11.4	Over 1,000
Hardness	-	89.6	--
Total coliform bacteria	Over 1	1.0	--
E. coli bacteria	Over 1	Below 1	Over 1 colony per 100 mL in source water

[1] Based on human drinking water standards from Pennsylvania Department of Environmental Protection.
[2] Median groundwater concentrations from samples submitted to the Penn State Agricultural Analytical Water Laboratory.
[3] Consult the Sources of More Information listed on page 2 for more discussion about the range of levels of concern that have been recommended by various authors. Parameters with a "--" indicate those with no clear consensus on livestock effects in research literature. While no levels of concern are provided for calcium, magnesium, sodium and hardness, high levels of these constituents should be accounted for in the overall ration.

Effects of Water Quality on Water Consumption

Water quality issues can manifest as health issues in dairy cows or, more often, as reduced water intake. The most accurate measurement of water intake is from water meters installed on lines to drinking devices. Penn State Extension encourages dairy farms to install water meters to evaluate the herd's water consumption level as an indicator of existing water quality problems. Cows should be prevented from accessing other water sources and meters should be read over a 5 to 10 day period to minimize weather-related differences. Simple water meter measurements provide a good estimate of water use but more accurate measures would include both metered water use and ration water intake from high moisture feed ingredients.

Expected water intakes for various dairy cattle are listed in Table 2. The range of water use for each cow type is related to air temperature and ration moisture content. Note that water use may be above these ranges for air temperatures above 80 degrees F and lower intake may be observed below 50 degrees F.

The large range in water use for lactating is related to more complex relationships with ration moisture content and milk production. Precise water use within this range can be estimated from equations that include ration water intake, dry matter intake, and milk production at ambient air temperatures between 50 and 80 F. Note that drinking water for lactating cows depends on milk production and ration water intake. Requirements for milking cows include water from both drinking and the ration consumed. Ration water intake depends primarily on amounts of ensiled or fresh forage consumed versus dry hay and grains. Water intake is usually considered to be a problem if it varies more than ±15 to 20 percent of expected values.

Table 2. Ranges of water intake for dairy cattle.

Cow Type	Age/Condition	Gallons Per Day
Holstein calves	1 month	1.3 to 2.0
Holstein calves	2 months	1.5 to 2.4
Holstein calves	3 months	2.1 to 2.8
Holstein calves	4 months	3.0 to 3.5
Holstein heifers	5 months	3.8 to 4.6
Holstein heifers	15 to 18 months	5.9 to 7.1
Holstein heifers	18 to 24 months	7.3 to 9.6
Dry cows	Pregnant, 6 to 9 months	9.0 to 13.0
Lactating cows	All	18 to 40

When water intake is found to be below normal levels, water quality is only one of several potential causes. In some cases, poor water quality can indirectly reduce water intake by clogging water supply lines or reduced water pressure, most often from hard water, iron or slime-forming bacteria. Stray electrical voltage in or near drinking devices can be one cause of reduced water intake. In cases of stray voltage, obvious animal fear of the drinking devices is often noticeable. In less severe cases of reduced water intake, symptoms may be more subtle such as constipated manure, low urine output, infrequent drinking and high packed-cell volume or hematocrit in blood (over 38 percent in a group of dairy cows).

There are rare instances where water intake is excessive causing increased urine production, loose manure or bloated conditions. Excessive water intake can be related to high intakes of salt or sodium bicarbonate. High urine production can be caused by elevated mercury, protein, non-protein nitrogen (i.e. urea) or nitrate intake.

It should be noted that water intake problems for dairy cattle may be multifaceted. In addition to water quality, forage quality, feed management, nutrition, facilities and others may be contributing to the problem and should not be overlooked.

Sources of More Information

Beede, D.K. 2019, [Evaluation of Water Quality and Nutrition for Dairy Cattle](), eXtension online.

Schroeder, J.W., 2015, [Water Needs and Quality Guidelines for Dairy Cattle](), North Dakota State University.

Exhibit 30

Permitting Guidance for Oil and Gas Hydraulic Fracturing Activities Using Diesel Fuels:

Underground Injection Control Program Guidance #84

Office of Water (4605M) EPA 816-R-14-001 February 2014

I. Introduction

This guidance provides technical recommendations for protecting underground sources of drinking water (USDWs) from potential endangerment posed by hydraulic fracturing (HF) activities where diesel fuels are used.

The U.S. Environmental Protection Agency (EPA) developed this guidance for EPA permit writers to ensure protection of USDWs in accordance with the Safe Drinking Water Act (SDWA) and Underground Injection Control (UIC) regulatory authority. This authority is limited to when diesel fuels are used in fluids or propping agents pursuant to oil, gas and geothermal activities. This document does not establish any new permitting requirements for HF activities using diesel fuels, but describes the EPA's interpretation of existing legal requirements as well as non-binding recommendations for EPA permit writers to consider in applying UIC Class II[1] regulations to HF when diesel fuels are used in fracturing fluids or propping agents. This document does not address geothermal activities.

The EPA expects that EPA UIC Program Directors, and the permit writers acting on their behalf, will follow the interpretation of the statutory term "diesel fuels" presented in this guidance document. They should also consider, although are not required to follow, the recommendations reflected in this guidance on how to apply the Class II regulations to HF activities using diesel fuels when issuing permits for such activities under the federal UIC Program. Recommendations are consistent with the discretion accorded under the existing UIC Class II regulations, and reflect existing UIC requirements for other well classes, voluntary industry standards, state rules, and other model guidelines for HF. However, permit writers, acting on behalf of the UIC Director have the discretion to consider alternative approaches that are consistent with statutory and regulatory requirements. Decisions about permitting HF operations that use diesel fuels will be made on a case-by-case basis, considering the facts and circumstances of the specific injection activity and applicable statutes, regulations and case law.

Under the 2005 amendments to the SDWA, a UIC Class II permit must be obtained prior to conducting the underground injection of diesel fuels for hydraulic fracturing. The EPA, where it directly implements the program, as well as states and tribes with primary enforcement authority, must issue a Class II permit prior to the injection of diesel fuels in the HF fluid or propping agents. The primary audience for these technical recommendations is the EPA Regional offices directly implementing the existing UIC Class II Program requirements (40 *Code of Federal Regulations* (CFR) parts 124 and 144 through 147).

Stakeholders and the public have recognized the importance of safely and responsibly managing unconventional oil and gas development, including hydraulic fracturing. Many states have updated their oil and gas regulations and a variety of organizations have developed model guidelines and best practices. The EPA engaged with states, tribes, industry, and other stakeholders during the development of this document and reviewed best practices available at

[1] Class II is the primary well classification used for injection wells that are associated with oil and gas storage and production (40 CFR 144.6).

the time. The EPA used information from these efforts to inform this guidance for the UIC program.

An EPA analysis of data on HF fluids posted in 2012 on the chemical disclosure registry website FracFocus[2] found that diesel fuels appeared in fewer than two percent of the wells.[3] While FracFocus data are voluntarily submitted and not statistically representative of the presence of diesel fuels or other chemical substances in HF fluids, they are useful in providing an indication of the extent to which industry relies on diesel fuels for HF activities. While diesel fuels as defined in this guidance are currently used in a small percentage of HF wells, the EPA will work with states and industry to promote best practices in HF operations, including partnering with stakeholders to support voluntary use of greener alternatives in HF fluids generally.

Although developed specifically for hydraulic fracturing where diesel fuels are used, many of the recommended practices found in this document are consistent with best practices for hydraulic fracturing in general, including those found in state regulations, voluntary standards from the American Petroleum Institute (API), and model guidelines for hydraulic fracturing developed by industry and stakeholders. In particular, the EPA's recommendations for applying UIC requirements on area of review, well construction, operations, and monitoring – including testing for mechanical integrity of the well and baseline and follow-up water quality monitoring – will also promote adoption of some best practices identified by industry, states, and other groups.

The practices described in this guidance are critical for ensuring that underground sources of drinking water are protected during hydraulic fracturing using diesel fuels. For example, delineating a site-specific area of review, including for the horizontal section of a well, ensures there are no conduits that could allow the escape of contaminants into USDWs. During the area of review delineation an owner/operator looks for artificial or natural conduits to ensure adequate confinement and takes corrective action if necessary to prevent fluid or gas migration. Similarly, mechanical integrity tests (MITs) ensure that the protective physical components of the well, including the casing and cement, are competent prior to injection and throughout the life of the well. High injection pressures, such as those occurring during HF, have the potential to damage the mechanical integrity of the well causing leaks, which may allow for the migration of fluids into USDWs. Conducting MITs ensures that injection well integrity is maintained at all times. Baseline and post-fracture water quality monitoring are used to help ensure that a permitted well has not endangered USDWs.

In addition to reflecting UIC program requirements, state regulations and industry best practices, a number of the practices contained in this guidance were outlined by the Secretary of Energy's Advisory Board (SEAB) Shale Gas Production Subcommittee in its August and November 2011 reports (US DOE, 2011). Thus, states and tribes responsible for issuing permits and/or updating regulations for hydraulic fracturing may find the recommendations in this document useful in improving the protection of underground sources of drinking water and public health wherever hydraulic fracturing is practiced.

[2] FracFocus (http://fracfocus.org/) is the national HF chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission.
[3] An August 2012 search of FracFocus identified only one well that used diesel fuels as a carrier fluid.

II. Background Information

How are diesel fuels used in the HF operations?

HF is a technique used to produce economically viable quantities of oil and natural gas, especially from unconventional reservoirs, such as shale, tight sands, coalbeds and other formations. HF involves the injection of fluids (commonly a mixture of water, chemical additives and proppants) under pressures great enough to open and enlarge fractures within the oil-and gas-producing formations. The resulting fractures are held open using propping agents, such as fine grains of sand or ceramic beads, to allow oil and gas to flow to the production well. The types and concentrations of chemical additives and proppants used in the HF fluids vary depending on site-specific conditions and are usually tailored to the properties of the formation and the needs of the project.

Diesel fuels are among a number of oil-based fracturing fluids that can be used to avoid damage such as reduced permeabilities to water sensitive formations and allow for better production (DeVine et al., 2003). Diesel fuels may be used as an additive to adjust fluid properties (e.g., viscosity and lubricity) or act as a solvent to aid in the delivery of gelling agents. Diesel fuels' properties of high viscosity and immiscibility in water may also prevent fluid leak-off or loss into a formation without impeding the production of hydrocarbons (McCabe et al., 1990; Rae and DiLullo, 1996). Also, the lower freezing point of diesel fuels relative to water may be useful in cold climate operations as an effective winterizing agent by preventing liquids from freezing in low temperatures (Shibley and Leonard, 1987).

Diesel fuels may contain a number of chemicals of concern including benzene, toluene, ethylbenzene, and xylene compounds (BTEX). BTEX compounds are highly mobile in ground water and are regulated under the SDWA national primary drinking water regulations (NPDWRs) because of the risks they pose to human health. The EPA has set a maximum contaminant level goal (MCLG)[4] and a maximum contaminant level (MCL)[5] for each compound. For example, the MCLG for benzene is zero and the MCL is 0.005 mg/L.[6] People consuming drinking water containing any of these chemicals in excess of the standards set by the EPA over many years could experience:

- An increase in anemia or a decrease in blood platelets from benzene exposure[7];
- An increased risk of cancer from benzene exposure[8];
- Problems with the nervous system, kidneys or liver from toluene exposure[9];
- Problems with the liver or kidneys from ethylbenzene exposure[10]; and

[4] The EPA sets the level of protection for MCLGs based on the best available science to prevent potential health problems.
[5] The EPA sets MCLs as close to the MCLGs as possible, considering cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies.
[6] US EPA, http://water.epa.gov/drink/contaminants/basicinformation/benzene.cfm
[7] US EPA, *Ibid*
[8] US EPA, *Ibid*
[9] US EPA, http://water.epa.gov/drink/contaminants/basicinformation/toluene.cfm

- Damage to the nervous system from exposure to xylene[11].

BTEX compounds are classified as aromatic hydrocarbons, a class of substances found in petroleum products including diesel fuels. The total content of aromatic hydrocarbons in petroleum products varies based on the refining process. The diesel fuels identified in this guidance memorandum can contain up to 25 percent aromatic hydrocarbons, by weight (API, 2012). These diesel fuels can also contain 20 to 60 percent polynuclear aromatic hydrocarbons (PAHs) by volume (API, *Ibid*). PAHs can be a toxic component of petroleum products and some PAHs are listed as Priority Pollutants under the Clean Water Act[12].

Because other substances used in HF fluids may contain similar levels of BTEX, even if the Chemical Abstract Service Registry Number (CASRN) does not identify the substance as diesel fuel, the EPA will work with states and industry to explore approaches to promote voluntary use of safer alternatives in HF fluids.

The EPA conducted an analysis of data on HF fluids posted in 2012 on the chemical disclosure registry website FracFocus to determine how diesel fuels are currently used in HF operations. Based on this analysis, diesel fuels were most commonly used as an additive to reduce friction. Diesel fuels appeared in fewer than two percent of the wells,[13] and no regional patterns of diesel fuels usage were identified from data registered in FracFocus.

When does a HF activity require a UIC Class II permit?

A HF activity is subject to UIC Class II permitting requirements under the SDWA if any portion of the injectate contains "diesel fuels." The EPA interprets this statutory term to mean any of the following five CASRNs:

- **68334-30-5 Primary Name: Fuels, diesel**
  Common Synonyms: Automotive diesel oil; Diesel fuel; Diesel oil (petroleum); Diesel oils; Diesel test fuel; Diesel fuels; Diesel fuel No. 1; Diesel fuel [United Nations-North America (UN/NA) number 1993]; Diesel fuel oil; European Inventory of Existing Commercial Chemical Substances (EINECS) 269-822-7.

- **68476-34-6 Primary Name: Fuels, diesel, No. 2**
  Common Synonyms: Diesel fuel No. 2; Diesel fuels No. 2; EINECS 270-676-1; No. 2 Diesel fuel.

- **68476-30-2 Primary Name: Fuel oil No. 2**
  Common Synonyms: Diesel fuel; Gas oil or diesel fuel or heating oil, light [UN1202] No. 2 Home heating oils; API No. 2 fuel oil; EINECS 270-671-4; Fuel oil No. 2; Home heating oil No. 2; No. 2 burner fuel; Distillate fuel oils, light; Fuel No. 2; Fuel oil (No.

[10] US EPA, http://water.epa.gov/drink/contaminants/basicinformation/ethylbenzene.cfm
[11] US EPA, http://water.epa.gov/drink/contaminants/basicinformation/xylenes.cfm
[12] 40 CFR Part 423 (Appendix A)—126 Priority Pollutants
[13] See footnote 3.

1,2,4,5 or 6) [NA1993].

- **68476-31-3 Primary Name: Fuel oil, No. 4**
  Common Synonyms: Caswell No.[14] 333AB; Cat cracker feed stock; EINECS 270-673-5; EPA Pesticide Chemical Code 063514; Fuel oil No. 4; Diesel fuel No. 4.

- **8008-20-6 Primary Name: Kerosene**
  Common Synonyms: JP-5 navy fuel/marine diesel fuel; Deodorized kerosene; JP5 Jet fuel; AF 100 (pesticide); Caswell No. 517; EINECS 232-366-4; EPA Pesticide Chemical Code 063501; Fuel oil No. 1; Fuels, kerosine; Shell 140; Shellsol 2046; Distillate fuel oils, light; Kerosene, straight run; Kerosine, (petroleum); Several Others.

The use of diesel fuels in oil and gas production applications is not subject to UIC Class II permitting requirements in certain cases. Specifically, those cases are non HF activities such as when diesel fuels are a component of drilling muds or pipe joint compounds used in the well construction process, or when diesel fuels are used in motorized equipment at the surface.

[14] A Caswell No. is an alphanumeric chemical identifier implemented by Robert L. Caswell in the 1960s and 1970s in conjunction with acceptable common names of pesticides for labeling purposes.

Exhibit 31

FIELD INSTALLATION

QUALITY ASSURANCE MANUAL

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Contents

1 INTRODUCTION

1.1 Purpose

Quality assurance refers to means and actions employed GeoCHEM, Inc. to assure conformity of the lining system installation with the Quality Assurance Plan, drawings and specifications.

This manual addresses the quality assurance of the installation of flexible membrane liners and other geosynthetic products used by GeoCHEM, Inc. in waste disposal landfills, surface impoundments or other installations as specified by the owner and/or Engineer. This manual is a general guide and not site specific, and delineates our quality procedures and standards for installation.

Commonly used geosynthetic components of a lining system are discussed in this manual. These include polyethylene geomembranes, geotextiles, geonets and geocomposites. This manual can be a useful guide in delineating the quality assurance procedures and requirements for the installation of all the above geosynthetic products.

1.2 Scope of Quality Assurance

The scope of this manual includes quality assurance methods applicable to shipment, handling, and installation of all geosynthetics. This manual does not address design guidelines, installation specifications, or selection of geomembranes or other geosynthetics (which includes compatibility between geosynthetics and contained material).

This manual does not address the quality assurance of soils, except in cases where soil placement may have an influence on the geosynthetics.

1.3 Construction Meetings

1.3.1 Progress Meetings

It is recommended an informal daily installation Progress Meeting be held among appropriate parties to discuss current progress.

1.4 Delivery, Storage, and handling

Geosynthetic materials delivered to the site shall be unloaded prior to our crew arrival and stored with a minimum of handling. Each roll will be uniquely labeled.

Inventory shall be taken at the time of delivery. As the membrane is unloaded, it shall be inspected for damage. Any damage will be noted and repaired per specification. The Inventory Report form will be completed as material is delivered or when ILP’s crew arrives at the site. Any shortages or damaged material shall be noted on the Inventory Report.

Geosynthetic materials shall be handled with equipment that will not cause damage. The storage area shall be reasonably flat and well drained. The surface shall be free of sharp rocks or other objects that may damage the membrane.

The storage area must be as close as practical to the work area in order to minimize on site handling. The storage area must also be secure to prevent vandalism and theft and must be such that the material is not likely to be damaged by passing vehicles.

1.5 Equipment

1.5.1 Welding Equipment

Two practical types of welding equipment can be utilized: Hot Wedge, and Extrusion.

1.5.1.1 Hot Wedge Welding

For panel seaming, the installer shall provide automated welding equipment. The equipment shall be capable of measuring and controlling both the temperature at the wedge and the welding speed to ensure correct and consistent parameters are maintained during the welding process.

1.5.1.2 Extrusion Welding

For extrusion welding, the installer shall provide a field extrusion welder capable of adhering a continuous bead between the panels with a nominal width of one inch. Extrusion welders shall have a fixed preheat nozzle attached to the front of the extrusion welder.

1.5.2 Generators

Typically, a 6.5 Kw or larger generator will be used at the work area and electrical extension cords will be used to power the welding equipment.

The power source utilized for welding equipment shall be capable of providing constant voltage under a combined-line load.

1.5.3 Miscellaneous Equipment

Small tools will include hook blade utility knives, hot air tools, and angle grinders.

2 Geomembrane Installation

2.1 Earthwork

2.1.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing the subgrade according to the project specifications and the following minimum industry subgrade standard necessary to properly install the liner.

- The surface to be lined shall be prepared so as to be free of irregularities, protrusions, vegetation, standing water, loose soil or abrupt changes in grade.
- The supporting surface shall not contain stones or other matter of such composition, shape or size which may be damaging to the geomembrane and
- There are no excessively soft surface areas

Under no circumstances shall the installer deploy any geomembrane in areas not acceptable within these guidelines. A completed surface acceptance from shall be provided to the customer specifically indicating the areas accepted for geomembrane installation during each day's activities. This form shall be provided after installation activities within that area. If at any time during the installation of the geosynthetic lining system the prepared subgrade deteriorates, becomes damaged, or in any way is determined to be unacceptable by the Site Supervisor, all liner installation work shall stop in those areas and the condition of those areas brought to the attention of the appropriate party.

2.1.2 Anchor Trench

The anchor trenches shall be constructed by the Earthwork Contractor to the lines, widths and depths as shown on the drawings and specifications. This task should be performed prior to geomembrane deployment. Pile excavated dirt away from the area to be lined.

The edges where the geosynthetics enter the trench should be free of irregularities, protrusions, etc. to avoid potential damage to the material. Backfilling of the anchor trench shall be the responsibility of the Earthwork Contractor in accordance with specifications. Backfilling should occur when the geosynthetic material is at its most contracted state to avoid potential bridging problems. Care must be taken to avoid damaging the geosynthetics during backfilling.

2.2 Geomembrane Deployment

Deployment of geomembrane or geosynthetic materials will be performed in a manner that complies with the following guidelines;

- Deployment equipment does not damage the subgrade or previously deployed geosynthetic materials.
- Personnel who are in contact with the liner do not smoke, wear damaging (non-soft sole) shoes or engage in other activities which risk damage to the liner.
- Use of a low ground pressure, rubber-tired all terrain vehicle (i.e. ATV) is allowed on the geosynthetic surface, provided proper care is taken to avoid damage and excessive traffic.

- Field panel placement installation sequence should take into account site drainage, wind direction, subgrade surface, access to the site, and production schedule of the project. Field panels should be seamed as soon as possible after deployment and all deployed material shall be marked with appropriate identification.
- Panels deployed will be marked with a unique identification number.
- Panels will be marked with the geomembrane manufacturer's roll number.
- Panel numbers, roll numbers, and panel lengths will be recorded in the Panel Placement Log.
- Geomembrane panels will be ballasted during installation to prevent uplift by wind.
- The Site Supervisor and/or the QA Technician and the designated Independent Inspector shall visually inspect each panel as soon as possible after deployment for damage. Any damage found shall be marked for repair.

2.3 Field Seaming

Field seaming involves the bonding of adjacent panels using thermal methods.

2.3.1 Seam Layout

In general, seams shall be oriented parallel to the direction of maximum slope, i.e. oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seams should occur on a panel less than five lineal feet from the toe of the slope. On slopes of less that 10% (6 H: 1 V), this rule shall not apply. A cross slope seam may be utilized provided the panel ends are cut at an angle of approximately 45°.

A seam is considered a separate entity if it is the principal attachment that joins two or more panels. Repairs are not considered seams in this context.

A numbering system using adjacent panel numbers shall identify each seam.

2.3.2 Seaming Equipment and Products

Approved processes for field seaming and repairing are extrusion welding and fusion welding. All welding equipment shall have accurate temperature monitoring devices to ensure proper measurement of the welder temperatures.

2.3.2.1 Fusion Process

This process shall be used for seaming panels together and is not generally used for patching or detailed work. The apparatus shall be of hot wedge type and is commonly equipped with a "split wedge" to allow air pressure seam testing.

Fusion welding equipment shall be self propelled devices and shall be equipped with functioning wedge temperature and seaming speed controllers to assure proper control by the Welding Technician.

2.3.2.2 Extrusion Process

This process shall be used primarily for repairs, patching, and special detail fabrication. This method is also useful to connect new panels to previously installed liner that does not have an exposed edge capable of being fusion welded.

The extrusion welding apparatus (hand welder) shall be equipped with temperature monitoring devices.

2.3.3 Seam Preparation

Seaming shall be performed in ambient temperatures between 35°F and 104°F. Ambient temperature is to be measured at least 6" from the surface of liner. The Welding Technician shall verify that prior to seaming the seam area is free of moisture, dust, sand, or debris of any kind; the seam is properly heat tacked and abraded when extrusion welding; and seams are aligned to minimize "fish mouths".

2.3.4 Trial Seams (Trial Welds)

Prior to production seaming, trial seams shall be made and accepted using project specified criteria. Trial seams shall be made on appropriate sized pieces of identical or equivalent geomembrane material to verify that seaming conditions and procedures are adequate. Five (5) one inch wide specimens will be tested from each trial weld sample. Each trial seam sample shall be assigned a number and the test results recorded in the Trial Weld Log.

Trial seams shall be performed for each welder to be used and by each operator of extrusion welders, and by the primary operator of each fusion welder.

A passing trial seam shall be made prior to the beginning of each seaming period. Typically this is at the start of the day and after lunch break.

Fusion welded trial seam samples shall be approximately six feet long by one foot wide with the seam centered lengthwise. For extrusion welding, the trial seam sample size shall be approximately five feet long by one foot wide with the seam centered lengthwise.

All specimens shall exhibit a film tearing bond.

2.3.5 Panel Seams (Production Seaming)

Upon Acceptance of the trial seams, work may begin on deployed panels. All seams shall be labeled with seam number, welding technician identification, machine number, and the date and time the seam is welded. This information will also be recorded in the Seam Log along with lengths of welded seams. Seams will be welded on the same day panels are deployed.

2.3.6 Non-Destructive Seam Testing.

ILP will non-destructively test field seams for their full length using an air pressure test or a vacuum test. The purpose of non-destructive tests is to demonstrate the absence of leaks in the seam.

The Site Supervisor shall schedule all non-destructive testing operations in order to ensure prompt demonstration of weld quality and the orderly progress of the project.

The QA Technician shall ensure that any leaks found are marked for repair, and are retested when repairs are completed. All non-destructive tests and repair locations will be recorded on the Non-Destructive Test/ Repair Log.

2.3.6.1 Vacuum Testing

Vacuum testing is routinely performed on extrusion welds and can be performed on the fusion welds. The equipment shall consist of a vacuum box assembly with a vacuum gauge, a pumping device, and a soap solution.

The following procedure shall be followed:

- Wet a section of the seam with the soap solution. The seam section must be longer that the vacuum box.
- Place the vacuum box over the wetted area and apply body weight to form a seal between the gasket and the liner.
- Evacuate air to create a negative pressure of approximately 5 psig.
- Observe, for not less than 10 seconds, the seam through the viewing window for soap bubbles emitting from the seam.
- If no bubbles are observed, reposition the box on the next wetted area for testing with slight overlap.
- If bubbles are detected, this indicates a leak in the seam, mark the area of the leak for repair, and retest after repairs are completed.

2.3.6.2 Air Pressure Testing

Air pressure testing is performed on seams made by a double-seam fusion welding apparatus.

The equipment shall be comprised of the following:

- An air pump, or air tank, capable of producing a minimum air pressure of 30 psig in the seam channel
- A sharp hollow needle to insert air into the air channel of the seam
- A hot air gun or other heating device to seal the ends of the air channel

The following procedures shall be followed:

- Seal both ends of the air channel of the seam to be tested.
- Insert the needle into the air chamber at either end of the seam to be tested.
- Pressurize the air channel to minimum of 30 psig. Allow the pressure to stabilize, and if necessary, re-pressurize to 30 psig and note the pressure.
- With a minimum pressure of 30 psig stabilized in the air channel, the time of day should be noted.
- After approximately 5 minutes, the air pressure should be read again.
- If the difference between the two readings is more than 2 psig, the seam needs to be repaired and retested.

Upon completion of the air pressure test, the seam shall be marked and points requiring repair identified.

2.3.6.3 Procedures for Air Pressure Test Failure

Should the seam fail the air pressure test, the following procedure shall be followed:

- Reposition the apparatus and retest the same section.
- While the seam air-channel is under pressure, traverse the length of the seam and listen for the leak.
- While the seam air-channel is under pressure, apply a soapy solution to the seam edge (do not trim excess material from edge of seam) and observe for bubbles formed by escaping air.
- Re-test the seam in progressively smaller increments, until the area of leakage is identified.
- Repair the identified leak area by extrusion welding the excess material at the edge of the seam and then vacuum test.
- In areas where the air channel is closed and the integrity of the weld is not suspect, vacuum testing is acceptable.

2.3.7 Destructive Seam Testing

Destructive seam testing will only be performed at selected locations, if required by Engineer's specifications. The purpose of these tests is to evaluate bonded seam strength. Testing shall be performed as work progresses.

2.3.7.1 Location and Frequency

The frequency of sample removal is commonly no more that one sample per 500 lineal feet of seam.

2.3.7.2 Size of Samples

A sample segment twelve inches by twelve inches shall be cut with the seam centered lengthwise. An additional segment of 12”x 18” shall be cut for independent lab testing, and a 12”x 12” segment for archival retain or other uses.

2.3.7.3 Sample Identification

Each segment shall be marked with the appropriate destructive sample number.

2.3.7.4 Field Testing

Samples shall be tested in peel and in shear using the following procedure:

- Ten specimens of one inch width shall be cut with a coupon cutter from the segment with a machine press and die.
- Five specimens shall be tested for peel. Fusion welds shall be tested from both sides.
- Five Specimens shall be tested for shear.

If specified, a field tensiometer will be supplied. Testing will occur at a rate of two inches per minute.

The results of all field destructive tests will be recorded in the Destructive Test Log.

2.3.7.5 Pass/Fail Criteria

All specimens tested shall exhibit a film tear bond (FTB). For projects which utilize a tensiometer, the following table provides minimum acceptable values.

Seam Strength HDPE Geomembranes				
	Shear		Peel	
Thickness (mils)	Extrusion (lb/in)	Fusion (lb/in)	Extrusion (lb/in)	Fusion (lb/in)
30	54	54	35	44
40	81	81	52	65
60	121	121	78	98
80	162	162	104	130

Seam Strength LLDPE Geomembranes				
	Shear		Peel	
Thickness (mils)	Extrusion (Ib/in)	Fusion (Ib/in)	Extrusion (Ib/in)	Fusion (Ib/in)
30	40	40	32	34
40	60	60	48	50
60	90	90	72	75
80	120	120	96	100

In addition to these values, the sample shall not fail within the seam area. A minimum of four out of five specimens must meet the above criteria, with the fifth meeting or exceeding 80% of the value above.

If the seam fails the test, the following procedure shall be followed. Additional sample segments of the same size shall be removed approximately 10 lineal feet in each direction from the failed seam. Both of these sample segments shall be tested in accordance with the criteria listed above and each segment must pass. This procedure is repeated until a passing result is obtained. In lieu of taking an excessive number of samples, the entire seam may be repaired as outlined in Section 2.3.7.7.

2.3.7.6 Defects and Repairs

All seams and non-seam areas of the polyethylene lining system shall be examined for identification of defects. Identification of defects or repair may be made by marking on the sheet/seam with an appropriate marking device.

The suspected defect shall be demonstrably out of specification and detrimental to the performance of the liner.

2.3.7.7 Repair Procedures

Any portion of the polyethylene lining system exhibiting a defect which has been marked for repair shall be repaired with any one or combination of the following methods:

- Patching: using to repair holes, tears
- Grind and re-weld: used to repair small sections of extruded seams
- Spot welding: used to repair small minor, localized flaws
- Flap welding: used to extrusion weld the flap of a fusion weld in lieu of a full cap
- Capping: used to repair failed seams

- Topping: application of an extrudate bead directly to an existing weld

The following conditions shall apply to all the above methods:

- Surfaces of the polyethylene which are to be repaired by extrusion welding shall be lightly abraded to assure cleanliness
- All surfaces intended to receive extrudate must be clean and dry at the time of the repair
- All patches and caps shall extend at least four inches beyond the edge of the defect, and all patches shall have rounded corners.

2.3.7.8 Verification of Repairs

Repairs shall be non-destructively tested according to the criteria established in Section 2.3.6.

A passing non-destructive test will be taken as an indication of an adequate repair. Failed tests indicate that the repair must be done again and re-tested until a passing test result is achieved.

2.3.8 Lining System Acceptance

After work is complete, the Site Supervisor and/or QA Technician shall conduct a final inspection (walk-down) of the area for confirmation that all repairs have been appropriately performed, all test results are acceptable and the area has all scrap, trash and debris removed. Only after careful evaluation by the Site Supervisor and acceptance by the Customer shall any covering material be placed upon the lining system.

The geosynthetic lining system will be accepted by the customer when:

- Installation of materials is completed.
- Verification of the adequacy of all seams and repairs, including associated testing and documentation is completed.

Acceptance will be indicated by all parties involved by signing a Certificate of Acceptance (see Attached). Partial area of the installation may be accepted in order to allow further construction of the project.

3 ANCILLARY GEOSYNTHETICS INSTALLATION

Geonet, Geotextile Geocomposite, and Geosynthetic Clay Liners

3.1 Handling

All geotextile, geonets, and geocomposites shall be handled in such a manner as to ensure they are not damaged.

Sandbags shall be used to secure the edges of the material when the potential for wind damage is significant.

Cutting the material shall be done in such a manner as to prevent damage to any underlying or adjacent geosynthetic materials.

Care should be taken when deploying geosynthetic materials that stones, debris or other material is not trapped by the geonet, geocomposites, geotextile or geosynthetic clay liner which might damage the geosynthetics or geomembrane.

3.2 Deployment and Installation

3.2.1 Geonet – Drainage Net

Geonet shall be overlapped approximately four inches and fastened together with plastic cable ties.

3.2.2 Geotextile/ Geonet Geocomposite

The geonet component shall be overlapped approximately four inches and fastened together with plastic cable ties. The unbonded edge of the geotextile component shall remain overlapped.

3.2.3 Geotextile

Geotextile may be installed by overlapping, by heat bonding (spot or continual basis) or by sewing as indicated in the specifications.

3.2.4 Geosynthetic Clay Liner

Seaming of GCLs is achieved by overlapping the GCL panels approximately six inches. End-of-roll seams shall be overlapped a mnimum of 12”. Supplemental granular bentonite where recommended by the GCL manufacturer. The granular bentonite shall be applied at the rate recommended by the GCL manufacturer or as required by project specifications.

3.3 Geosynthetic Repair

3.3.1 Geonet – Drainage Net

Any tear larger than twelve inches shall be repaired. Patches shall extend at least six inches from all sides of the tear and shall be fastened with plastic cable ties.

3.3.2 Geotextile/ Geonet Geocomposite

Holes and tears in the composite material shall be repaired with a patch of identical or similar material extending at least 6” from all sides of the hole or tear and fastened with plastic cable ties.

3.3.3 Geotextile

Holes in geotextile material shall be repaired using a patch of identical or similar materials extending approximately six inches on all sides from the hole or tear and heat bonded to parent material.

3.3.4 Geosynthetic Clay Liner

The area to be repaired (patched) must be free of contamination by foreign matter. Patches should overlap the damaged area by approximately twelve inches. For fabric-encased GCLs, the patch is to be tucked into place with supplemental bentonite poured over the overlap. Temporary attachment of patches may be required to ensure that they are not dislodged when covering with geomembrane or soil.

4 INSTALLATION FORMS

4.1 Inventory Checklist

4.2 Subgrade Acceptance

4.3 Panel Placement Log

4.4 Trial Weld Log

4.5 Seam Log

4.6 Non-Destructive Test/Repair Log

4.7 Destructive Test Log

4.8 Certificate of Acceptance

Inventory Check List Date: ________

Project: ____________________ Site Manager: ____________________

Project #: ____________________ QA Technician: ____________________ Page: ______of______

Material	Roll #	Date Used	Material	Roll #	Date Used	Material	Roll #	Date Used	Material	Roll #	Date Used

SUBGRADE SURFACE ACCEPTANCE

Customer:______________________________ Date:_______________________

Project Name:___________________________ Project Number:_______________

Location:______________________________ Partial:________Final: __________

I, the undersigned duly authorized representative of GeoCHEM, Inc., certify that upon visual inspection the subgrade surface described below meets criteria for installation of:

____

By signing below, however, GeoCHEM, Inc. acknowledges no responsibility for the subgrade design, degree of moisture or compaction, integrity, elevation, or maintenance thereof, in any way.

Approximate size of area accepted:____________________________

Description of the area accepted: ____

____

____

____

____

____

____

____________________	____________________	____________________
GeoCHEM, Inc. Representative	**Owner/Contractor**	**Inspector**

GeoCHEM
INCORPORATED

Panel Placement Log

Project Name: ______________________ Site Manager __________________

Location: ______________________ Material: _____________________

Job Number: _______________________ Sheet Thickness: _______________

Q.A Technician: ____________________ Smooth: ______ Textured: _______

Panel Number	Roll Number	Deployment Date	Width (Feet)	Length (Feet)	Square Feet Smooth	Square Feet Textured

GeoCHEM INCORPORATED

Trial Weld Log

Project Name: ______________________ Site Manager: ________________________

Location: __________________________ Material: ____________________________

Job Number: ______________________ Sheet Thickness: ______________________

Q.A Technician: ____________________ Smooth: _________ Textured: ___________

Trial No.	Date of Trial	Time of Trial	Technicians Id Number	Machine Number	Ambient Temp.	Wedge Mass	Speed Preheat	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	FTB Y/N	Pass Fail

GeoCHEM INCORPORATED

Seam Log

Project Name: ________________________ Site Manager____________________

Location: ________________________ Material: _______________________

Job Number: _________________________ Sheet Thickness:_________________

Q.A Technician: ______________________ Smooth: ______ Textured: _______

Seam Number	Time of Weld	Date of Weld	Type of Weld	Length of Seam	Machine Number	Technician ID Number

GeoCHEM INCORPORATED

Non-Destructive Test/ Repair Log

Project Name: ______________________ Site Manager__________________

Location: ______________________ Material: ______________________

Job Number: ________________________ Sheet Thickness: ________________

Q.A Technician: ____________________

Seam Number	Test Date	Technician ID Number	Test Type (A or V)	Air Pressure Test		Test Result (P or F)	Repair Locations
				Psi Start	Psi Finish		

GeoCHEM INCORPORATED

Destructive Test Log

Project Name:	Site Manager:	Fusion (ppi)	Extrusion (ppi)
Location:	Material:	Min. Peel	Min. Peel
Job Number	Sheet Thickness:	Min. Shear	Min. Shear
Q. A. Technician:	Smooth:	Textured:	

Sample No.	Date Welded	Seam Number	Techician ID Number	Machine Type & No.	Location	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear Ppi	FTB Y/N	Pass/ Fail

CERTIFICATE OF ACCEPTANCE

Project Name:______________________________ Contract Number: _______________

Description of the Project: ____

____

____

____

____

____

Total Area: __________________________ SF

I, the undersigned duly authorized representative of ____ do hereby take over and accept the work described above from the date hereof and confirm that, to the best of my knowledge, the work has been completed in accordance with the specifications and the terms and conditions of the contract. There appears to be no damage to the plastic lining, nor any unacceptable interference with the surrounding works. Scrap and off-cuts have been removed and the work site has been left in a clean and tidy condition. GeoCHEM, Inc. undertakes to rectify any damage resulting from defective materials or workmanship within compliance of our standard installation warranty and the material manufacturer's standard warranty and these warranties shall commence on the date below. The commencement of this warranty at this time shall not shorten the warranty period agreed upon in our written contract.

Name: ______________________________ Signature: ____________________________

Title: ______________________________ Date: ________________________________

Certified and accepted by GeoCHEM, Inc. Representative

Name: ______________________________ Signature: ____________________________

Title: ______________________________ Date: ________________________________

Exhibit 32

The ASTM D882 tests tensile properties of thin plastic sheeting

Standard Test Method for Tensile Properties of Thin Plastic Sheeting

The ASTM D882 tests the tensile properties of thin plastic sheeting. ASTM D882 is used to measure tensile properties including ultimate tensile strength, yield strength, elongation, tensile energy to break and tensile modulus of elasticity of thin plastic sheeting and films. The samples are cut in strips that minimally have to be eight times longer than wide. No dumbbell shape is cut for materials of that thickness. Cut samples need to be free of nicks and other cutting defects since they will have an important impact on the test results variation. The samples are tested in specific conditions of pre-treatment, sample orientation, temperature, humidity, and rate of pulling. ASTM D882 can be used for testing materials thinner than 1mm in thickness. Thicker materials should be tested using ASTM D638.

Micom offers ASTM D882 testing as part of its material testing offering

ASTM D882 Typical Experimental Parameters

Number of specimens per product: 5. In some cases, the tensile properties need to be measured both in the machine and perpendicular to the machine direction since they can vary substantially from one orientation to the other. This behavior is called anisotropy.

Crosshead speed: Between 12,5 mm/min and 500 mm/min. This varies as a function of the initial strain rate as given in table 1 of the test method.

Specimen shape: Square strips 8 times longer than wider

Conditioning and testing temperature: 23 ± 2 °C.

Conditioning and testing relative humidity: 50± 5%

Other Test Methods Related to ASTM D882 Tensile Testing

ASTM D882 is very similar to the ASTM D638 test, which has its own important specifications. We also invite you to learn more about our Plastics testing as well as Material testing services.

If you have any questions about ASMT D882, we invite you to contact our material testing lab. It will be our pleasure to talk to you about various plastic and polymers tests and review your custom testing requirements.

Exhibit 33

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING, GEOMEMBRANE OR GEOSYNTHETIC CLAY LINER

CODE 521

(sf)

DEFINITION

A liner for an impoundment constructed using a geomembrane or a geosynthetic clay material.

PURPOSE

This practice is applied to–

- Reduce seepage losses from an impoundment for water conservation.
- Protect soil and water from contaminants.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where in-place natural soils have excessive seepage rates.

CRITERIA

General Criteria Applicable to All Purposes

Design

The structure to be lined must meet all applicable NRCS standards. All inlets, outlets, ramps, and other appurtenances may be installed before, during, or after the liner placement, but must be done in a manner that does not damage or impair the proper operation of the liner.

Design and install the liner in accordance with manufacturer recommendations. The installer or manufacturer must certify that the liner installation meets the material and installation requirements of the plans and specifications.

Follow manufacturer's recommendations with regard to protection from weather and ultraviolet exposure.

Materials

Geomembrane and geosynthetic clay liner (GCL) materials must meet the requirements in table 1.

Table 1: Requirements for geomembrane and geosynthetic clay liner materials

Type[1]	Name	Minimum Thickness	
		Wastewater (mil)[2]	Clear Water (mil)
HDPE	High Density Polyethylene	60	30
LLDPE	Linear Low-Density Polyethylene	40	30
LLDPE-R	Reinforced Linear Low-Density Polyethylene	36	24
PVC	Polyvinyl Chloride	40	30

Type[1]	Name	Minimum Thickness	
		Wastewater (mil)[2]	Clear Water (mil)
EPDM	Ethylene Propylene Diene Terpolymer	45	45
FPP	Flexible Polypropylene	40	30
FPP-R	Reinforced Flexible Polypropylene	36	24
PE-R	Reinforced, Slit – Film, Woven Polyethylene	NR[3]	24
GCL	Geosynthetic Clay Liner	0.75 lbs./square foot	

[1] Geomembrane materials must meet the criteria in NRCS National Engineering Handbook (NEH), Part 642, Chapter 3, "Material Specification 594 – Geomembrane Liner." GCL materials must meet the criteria in NRCS NEH, Part 642, Chapter 3, "Material Specification 595 – Geosynthetic Clay Liner."

[2] 1 mil = 1/1000 inch

[3] NR – Not recommended

Safety
Include appropriate safety features in the design to minimize the hazards of the completed pond structure. Use warning signs, fences, ladders, ropes, bars, rails, and other devices, as appropriate, to ensure the safety of humans, wildlife, and livestock.

Underliner drainage and venting
Design the drainage and venting system beneath the geomembrane liner based on subsurface conditions such as soil type and groundwater levels. Liners used for waste storage require venting at the top of slope and a drainage system if the invert elevation of the pond is within 2 feet of the seasonal high water table. Hydrostatic pressures from fluctuating groundwater levels or leakage through the liner may cause the liner to float. Gas production and buildup beneath the liner due to the presence of organic material in the soil or leachate leakage through the liner may cause gas to accumulate, resulting in bubbling of the liner. Incorporate a drainage and venting system when conditions exist that may result in floating of the geomembrane liner. Ponds with an underliner drainage system must have a bottom slope of at least 1 percent.

Groundwater and leakage detection
If a soil investigation indicates that the groundwater level may be near the invert elevation of the pond, install groundwater monitoring wells to verify the expected water table location. Use NRCS Conservation Practice Standard (CPS) Monitoring Well (Code 353). In some situations, monitoring wells may need to be installed for a year or more to determine the groundwater levels and gather enough information to properly determine the required flow capacity of the drainage system. If the monitoring wells indicate a seasonal high water table within 2 feet of the pond invert, install subsurface or other type of drainage to control the potential uplift pressures.

A liner used for waste storage must have a leak detection line to a free outlet or observation well. Sites with granular subbase material require a secondary liner across the bottom and around the leak detection line to assure leakage is detected. The maximum permeability rate of the secondary liner is 1×10^{-4} cm/sec.

Gas venting
All pond liners with anchor trenches require venting near the top of the side slopes. Design and install venting in accordance to the manufacturer's recommendations, with a spacing not to exceed 20 feet between vents. Investigate the need for additional venting beneath wastewater pond liners as part of the design. If the investigation determines the potential of gas buildup under the liner, the liner must be vented in accordance to the manufacturer's recommendations. Site conditions conducive to gas

production include sites which have been subject to long-term seepage of animal waste into the foundation soil, sites with naturally occurring organics in the soil, or fine-grained foundation soils where fluctuating groundwater levels may trap gases present in the soil. If site conditions are determined to be conducive to gas production, the bottom of the liner must include features to allow gas to flow along the bottom and up the side slopes to the liner vents in the crown.

Cushion
Place a cushion layer beneath the liner if the subgrade particles contain sharp angular stones that could damage the liner or if particles greater than 3/8 inch for geomembrane liners and 1/2 inch for GCLs are exposed on the surface. The cushion may be a 10-ounce-per-square-yard or heavier nonwoven geotextile or a layer at least 6 inches thick of soil meeting the particle size and shape requirements of the subgrade. Geotextile cushion material must meet the requirements of the Geosynthetic Research Institute (GRI) Test Method GT12(a). Follow the manufacturer’s recommendations for any additional protective measures.

Subgrade preparation
Prepare the subgrade to conform to manufacturer’s recommendations. The subgrade materials must be free from sharp, angular stones, and the surface free from oversized particles, or any objects that could damage the liner. If angular particles are present, treat the subgrade by placing a cushion layer between the subgrade and the liner. The subgrade surface must provide a smooth, flat, and unyielding foundation for the liner. No standing water, mud, vegetation, snow, frozen subgrade, or excessive moisture may be present at the time of liner placement.

Liner protection
Protect liners from mechanical damage from all sources, including equipment access points and agitation operations. If pond management plans indicate locations where agitation operations may result in abrasion or other mechanical damage to the liner, provide protective measures. Measures to ensure the integrity of the liner include increasing the liner thickness above the minimum values listed in table 1 or providing protective ramps and aprons at agitation locations. For GCL liners, analyze the wastewater, subgrade soil, and cover soil to ensure that undesirable cation exchange (calcium and magnesium for sodium) will not occur in the GCL.

Anchorage
Anchor the liner to prevent uplift due to wind or slippage down the side slope, in accordance with manufacturer’s recommendations.

Penetrations
Install penetrations through the liner in accordance with manufacturer’s recommendations. Penetrations associated with waste storage must be watertight.

Cover soil
Cover PVC liners and GCLs with a minimum of 12 inches of soil measured perpendicular to the finished surface. Cover soil may be used on other liners but is not required unless essential for the proper performance, protection, and durability of the installation. Do not use cover soil that contains sharp, angular stones or any objects that could damage the liner. The maximum allowable particle size of soil cover material is 3/8 inch for geomembrane liners and 1/2 inch for GCLs. Use cover materials that are stable against slippage down the slope under all operational and exposure conditions, such as rapid drawdown or saturation by precipitation or snowmelt.

Place cover soil within 24 hours after placement of the liner to minimize the potential for damage from various sources, including precipitation, wind, and ultraviolet light exposure.

Cover soil for GCLs must provide uniform confinement pressure as recommended by the manufacturer. Do not install a drainage layer or venting system beneath a GCL, as they could compromise the liner.

CONSIDERATIONS

Designs for waste storage facilities should consider leakage through the liner due to liner damage. Giroud and Bonaparte (1989) recommends designing the drainage system based on a frequency of one hole (0.16 square-inch) per acre of surface area. Therefore, drainage and venting systems are strongly recommended for all waste storage facilities.

Minimize the number of penetrations through the liner for pond management appurtenances. Detail the trenching and backfilling of pipes to prevent charging of the underside of the liner with subsurface water.

For HDPE liners associated with waste water with penetrations over 2 inches in diameter, consider using concrete pads matching the slope with embedded channels to connect the liner, instead of manufactured boots.

PVC geomembranes are not recommended for aquatic production. The stabilizers in the PVC liner material leach out and may be harmful to aquatic species. Consult with manufacturers before selecting a geomembrane material used for aquatic production.

Where access is needed, consider installing concrete ramps with embedded channels to connect the liner. Pond corners are typically good locations for concrete ramps due to the flatter slopes. Consider placing the access ramp at a corner location.

If the entire waste storage pond is lined and access is needed on the bottom, consider placing concrete over the liner, bedded with geotextile.

Consider the use of a geosynthetic such as a geonet or geocomposite under the liner to facilitate collection, drainage of liquids, and venting of gas. If geocomposite materials are used for drainage and/or venting, use materials recommended by the manufacturer in the system design. Use GRI Standard GC8, “Standard Guide for the Allowable Flow Rate of a Drainage Geocomposite” to determine the allowable flow rate of the geocomposite. Slope the pond bottom a minimum of 1 percent to permit positive flow of the liquids or gases. In most cases, the geocomposite will serve both purposes of drainage and venting. For large impoundments, the bottom may need to be sloped in multiple directions in order to decrease the required drainage and venting flow travel distances.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for a geomembrane or GCL for a pond or a waste storage impoundment that describe the requirements for applying the practice to achieve its intended purpose. As a minimum, include—

- Layout of the containment structure, collection points, waste transfer locations or pipelines, and topography of the site.
- Soils investigation and subgrade details, including tolerances on smoothness of the finished grade.
- Required properties of selected liner, geosynthetics, and cushion materials.
- Quantities of liner materials, cover soil, and geosynthetic materials as needed.
- Subsurface drainage and venting details.
- Construction and material specifications.
- Safety requirements for installed liner.
- Details of liner installation, seaming requirements, and requirements for attachments and appurtenances.
- Minimum qualifications of installers and quality control testing requirements.
- Warranty requirements, if desired.
- Fence and signage requirements, if required.

OPERATION AND MAINTENANCE

Prepare a plan for O&M of the liner and structure consistent with the purposes of the type of liner chosen, intended life, safety requirements, and design criteria. Include site-specific information regarding design capacity and liquid level of the structure and repair procedures for liner material. Maintenance activities required for this practice consist of those operations necessary to prevent and repair damage to the geomembrane or GCL. These include, but are not limited to—

- Excluding animals and equipment from the treated area.
- Repairing damage to the liner and restoring the liner and cover to its original thickness and condition.
- Removing roots from trees and large shrubs at first appearance.
- Monitoring leak-detection system.
- Protecting the liner during filling and agitation procedures.

Provide guidance on items to inspect periodically, including—

- Visible portions of the liner for tears, punctures, or other damage.
- Liner interface with inlets, outlets, ramps, or other appurtenances for damage.
- Liquid level in the structure.
- Ballooning of the liner indicating presence of gas beneath the liner.

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Exhibit 34

Geomembrane liner failure: modelling of its influence on contaminant transfer

Conference Paper · September 2000

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Geomembrane liner failure: modelling of its influence on contaminant transfer

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Keywords: Geomembranes, Leak detection, Monitoring, Quality control, Wrinkles

ABSTRACT: The statistical results of the electrical damage detection system installed at more than 300 sites covering more than 3.250.000 m^2 are presented with respect to the cause of the damage vs. size of damage and location of damage respectively. Another important result is that in cases of more than a few membrane failures per one site, the distribution of damage is not regular. The failures generally amalgamate in specific areas located irregularly in the geomembrane liner: flat floor areas, edges, corners, penetration of geomembrane, end of road access, joint of slopes and bottom, seams, temporary storage of granular materials, areas of loading and unloading of such materials, areas of regular motion of heavy plants, etc. The mathematical modelling based on such statistical results show very important information. The main critical parameters are the location of failures and then a density of their occurrence. The size of a hole (even though it may look very critical in time when it is revealed) is less important than previous ones. These results point out the fact that in order to adequately quantify the rate of liquid flow through a composite liner, more information than the density of holes in the geomembrane is needed. Indeed, it is necessary to know the exact position of the holes, and their relative positions with regard to the position of wrinkles in the geomembrane. These results are only partial ones and the research continues.

1 INTRODUCTION

Every single day of our lives has significant value. Everyday we surround ourselves with critical actions, which decreases life's value. We strongly depend on the environment and its contamination decreases our chance to live longer. It was not long ago when a scientist discovered that a clay layer between dangerous material and subgrade is not enough protection and that some other synthetic impermeable material should be used. Geomembranes appear to be the best material for the separation of dangerous, toxic solids and liquid materials. While knowledge of quality installations of geosynthetic layers increases, the problem of their integrity after the installation appears to be a crucial factor in their overall usefulness.

During our active work in the field of geosynthetics, and our active contributions during conferences, meetings, etc., we discovered that the subject of the quality of geomembrane installation is discussed everywhere. It has been only a few years since electrical leak detection and location methods have become commercially used as a tool for deciphering some information regarding the integrity of the geomembrane after installation and placing protection on the top of their surface. Several authors have presented their results and some of them (Laine, Darilek 1993; Crozier, Walker 1995; Nosko et al. 1996; etc.) bring very useful contributions to highlight the problem. Since then, more and more people have been involved in such a business to answer the question "How dangerous it is to leave the damage unrevealed and not repaired?".

2 ANALYSES OF GEOMEMBRANE LINER FAILURES

Therefore, based on such indications, we started to create and study some statistical data mainly obtained by SENSOR DDS® technology. This technology has been widely used in the last ten years for in-situ monitoring of the integrity of geomembrane liners. During that period we have been collecting and analyzing data from several thousand failures from 16 countries, which represents more than 300 sites and approximately 3.250.000 m^2. This study was performed based on three criteria: position of damage, size of damage, and cause of damage. The obtained data are shown in tables as a function of location of damage and cause of damage versus size of damage, respectively (see Table 1 and 2).

One of the main purpose of this study is to present the distribution details of damage throughout the controlled area. We have discovered that in cases of multiple holes, the cause of the damage can be grouped in several common categories which are defined below in Table 1. In addition, we would like to highlight the relationship between the location and cause of the damage inside the same inspected area. The controlled area is divided into 5 regions representing the typical locations of the landfill cells and for our identification purpose. (see Figure 1).

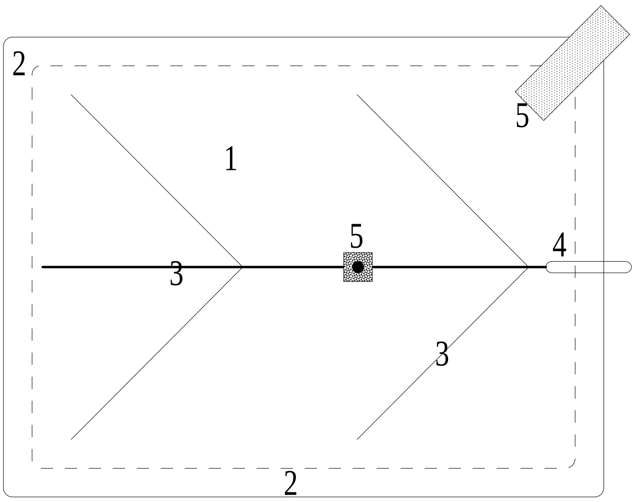

Figure 1. Schematic view of a landfill with the numbering of the parts.

One can easily notice that the majority of damage were caused by stones within the protection layer and heavy equipment (bulldozer, caterpillar, front loader, etc.). Engineers as well the site workers and operators should be able to make proper provisions to minimise these types of damage occurring.

Another very important fact that we discovered was that the most failures were located within flat areas (#1) where again stones and heavy equipment caused the majority of failures. We can see slightly different pattern in other areas like corners and drainage areas (#2) such that more damage caused by extrusion welds and by heavy equipment are noticed. However, the damage due to the stones are the key contributor of the failures. It is understandable that the other results we obtained in the case of pipe penetrations through a geomembrane (#4) were comprised mostly of failures of extrusion welds.

Regarding damage done by various sizes of stones, we found the problem of counting the exact amount of single holes. Mostly the damage by stones occur as one typical area with several (sometimes tens) small and single holes grouped together. Hence, we adopted an idea that a single hole caused by the stones is defined as an area with holes are clustered together within 5 cm diameter region. If another group of holes clustered is separated by more than 5 cm, we would consider that as a separate hole.

Table 1. Cause of damage vs. size of damage

Size of damage (cm^2)	Stone	%	Heavy equip.	%	Welds	%	Cuts	%	Worker directly	%	Total
< 0.5	332	11.1	-	-	115	43.4	5	8.5	-	-	452
0.5 – 2.0	1720	57.6	41	6.3	105	39.6	36	61.0	195	84.4	2097
2.0 – 10	843	28.2	117	17.9	30	11.3	18	30.5	36	15.6	1044
>10	90	3.0	496	75.8	15	5.7	-	-	-	-	601
Amount	2985		654		265		59		231		4194
Total	71.17 %		15.59 %		6.32 %		1.41 %		5.51 %		

Table 2. Location of damage

Amount of damage	Flat floor 1*	Corner, edge, etc. 2	Under a drainage pipes 3	Pipe penetration 4	Other 5**
4194	3261	395	165	84	289
100 %	77.8 %	9.4 %	3.9 %	2.0 %	6.9 %

* (see plan view of model landfill pond)
** (road access, temp. storage, concrete structure, etc.)

The tables 3 to 7 show the analysis of the cause of the damage vs. location. Such information is very useful to help understand what goes on at the landfill construction sites in terms of the geomembranes.

Table 3. Flat floor

Type of failure	Amount of holes	%
Stones	2641	81.00
Heavy equipment	430	13.20
Worker	130	4.00
Cuts	33	1.00
Welds	26	0.80
Total	3261	100.00

Table 4. Corner, edge, etc.

Type of failure	Amount of holes	%
Stones	234	59.20
Heavy equipment	75	18.90
Worker	14	3.50
Cuts	4	0.90
Welds	69	17.50
Total	395	100.00

Table 5. Under a drainage pipes

Type of failure	Amount of holes	%
Stones	50	30.30
Heavy equipment	24	14.30
Worker	24	14.50
Cuts	23	13.70
Welds	45	27.20
Total	165	100.00

Table 6. Pipe penetration

Type of failure	Amount of holes	%
Stones	-	-
Heavy equipment	-	-
Worker	7	8.50
Cuts	1	0.60
Welds	77	90.90
Total	84	100

Table 7. Other (road access, temp. storage, concrete structure, etc.)

Type of failure	Amount of holes	%
Stones	60	20.60
Heavy equipment	125	43.40
Worker	56	19.30
Cuts	-	0.00
Welds	48	16.70
Total	289	100.00

3 ESTIMATION OF THE RATES OF LIQUID FLOW DUE TO HOLES IN GEOMEMBRANE OF COMPOSITE LINERS

3.1 *Assumptions*

The general liner system considered (Figure 2) follows from Rowe (1998) and Touze-Foltz et al. (1999) and includes a geomembrane resting on a low-permeability clay liner of thickness H_L and hydraulic conductivity k_L. The z-axis origin corresponds to the top of the soil liner with upward being positive. It is assumed that the geomembrane is not in perfect contact with the soil liner and that there is a uniform transmissive zone between the geomembrane and the soil liner surface that is referred to as the "transmissive layer". In the following, it is assumed that: (i) liquid flow is under steady state conditions; (ii) the soil liner and the foundation layer are saturated; and (iii) liquid flow through the liner is vertical.

Analytical solutions have been developed by Touze-Foltz et al. (1999) for the axi-symmetric (circular hole in flat surface of geomembrane) and two-dimensional (hole in a wrinkle) cases as presented on Figure 2. These solutions will be used in the following to quantify the influence of the hydraulic head and of the size of the hole on the rate of liquid flow either for the axi-symmetric and two-dimensional cases. No particular assumptions are made regarding the dimension, position, or the number of holes in the wrinkles, but rather it is assumed that the rate of liquid flow in the composite liner is not limited by the holes (the hole limiting case is discussed by Rowe (1998) and Touze-Foltz et al. (1999)).

In the following calculations, the values of hydraulic conductivities of CCLs and of hydraulic transmissivities of the transmissive layer between CCLs and geomembranes given by Rowe (1998) are adopted. Two values of hydraulic transmissivities are used for the transmissive layer between geomembranes and CCLs: The first one is $\theta = 1.6\times10^{-8}\ m^2s^{-1}$ when the hydraulic conductivity k_L of the CCL is equal to $10^{-9}\ ms^{-1}$. This hydraulic transmissivity corresponds to "good contact" conditions as defined by Giroud (1997) in developing his semi-empirical equations (Rowe 1998). The second one is $\theta = 10^{-7}\ m^2s^{-1}$ when the hydraulic conductivity k_L of the CCL is also equal to $10^{-9}\ ms^{-1}$. This hydraulic transmissivity corresponds to "poor contact" conditions as defined by Giroud

(1997). It can correspond to the transmissivity obtained in case a geotextile is put in the transmissive layer.

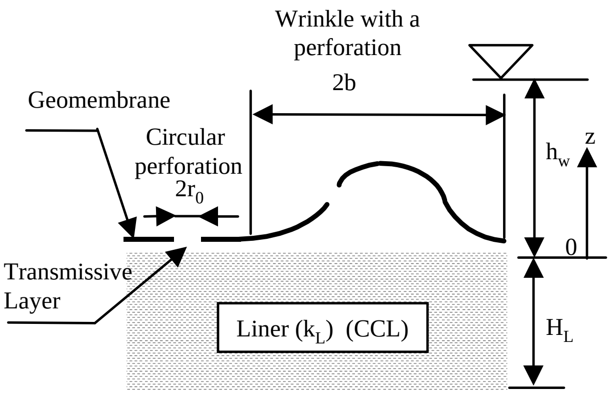

Figure 2 : Schematic showing a hole of radius r_0 and a wrinkle with a perforation in a geomembrane and the underlying stratum (modified from Rowe, 1998 and Touze-Foltz et al.,1999)

The liner thickness which is not an important parameter in determining the rate of liquid flow is set equal to 1 m.

The hydraulic head h_w on top of the composite liner is varied from 0.03 m to 3 m, to test the influence of the position of the hole (distance to the leachate sump). The hole area is varied from 0.1 cm^2 to 10 cm^2 according to data presented previously.

The boundary condition at the downstream end of the transmissive layer will be referred to as field boundary conditions. It corresponds to a zero-flow and zero-hydraulic head and is the limit of validity of solutions developed by Touze-Foltz et al. (1999).

3.2 *Results obtained*

3.2.1 *Axi-symmetric case*

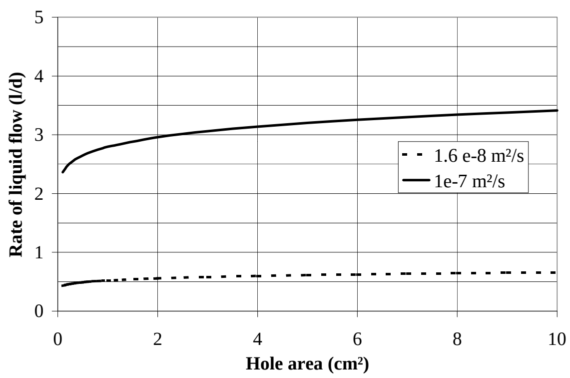

Figure 3: Evolution of the rate of liquid flow with the hole area, for the two values of hydraulic transmissivities adopted for the axi-symmetric case

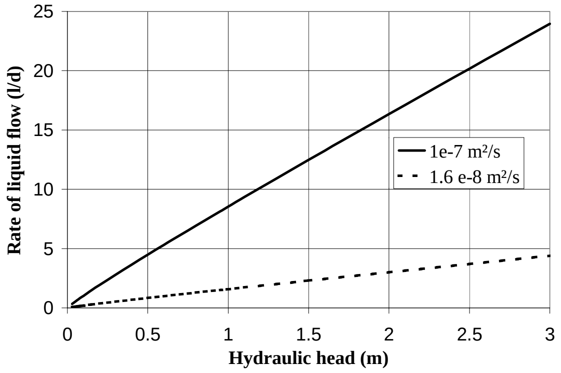

Figure 4: Evolution of the rate of liquid flow with the hydraulic head, for the two values of hydraulic transmissivities adopted for the axi- symmetric case

Figure 3 Shows the evolution of the rate of liquid flow obtained for a single hole for both values of hydraulic transmissivities adopted. The hydraulic head on top of the composite liner was equal to 0.3m for the calculations performed. One can notice that the hole size is not the influent parameter on the rate of liquid flow, whatever the value of hydraulic transmissivity. As shown on Figure 3 the hydraulic head is a much more important parameter. Indeed, the rate of liquid flow is nearly proportional to the hydraulic head applied on top of the composite liner. As a result, it seems that as far as circular holes are concerned, it is much more important to perfectly know their location than their size in order to adequately estimate the rate of liquid flow through the composite liner.

One can notice as well on Figures 3 and 4 that an increase in the hydraulic transmissivity by a factor close to 5 results in an increase in the rate of liquid flow by nearly the same factor. As a consequence, the use of a geotextile in the transmissive layer resulting in an increase of the hydraulic transmissivity may not be a convenient practice as it will significantly contribute to increase the rate of liquid flow. More research is needed to clarify this point and especially to quantify the hydraulic transmissivity of the transmissive layer at field scale.

3.2.2 *Two-dimensional case*

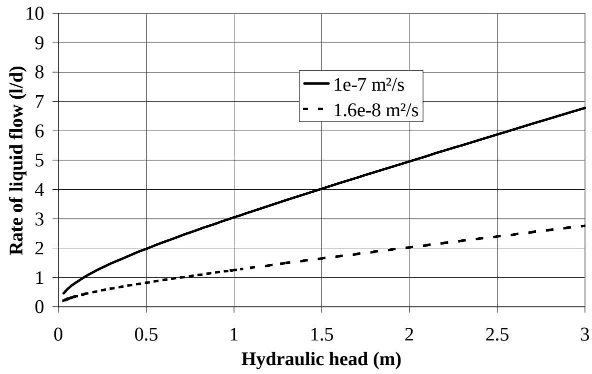

Figure 5: Evolution of the rate of liquid flow with the hydraulic head, for the two values of hydraulic transmissivities adopted for the two-dimensional case

For calculations performed assuming a damaged wrinkle in the geomembrane, the width of wrinkle adopted was 0.2 m. Figure 5 shows the rates of liquid flow obtained as a function of the hydraulic head applied on top of the composite liner. The evolution of the rate of liquid flow (given here for a meter of wrinkle) with the hydraulic head is nearly linear, especially for hydraulic heads greater than 0.5 m. The rate of liquid flow is less sensitive to an increase in the hydraulic transmissivity than in the axi-symmetric case. Indeed, the increase from a value of θ equal to 1.6×10^{-8} m^2s^{-1} to a value of θ equal to 1.6×10^{-8} m^2s^{-1} results in a increase by a factor 2.5 of the rate of liquid flow.

These results point out the fact that in order to adequately quantify the rate of liquid flow through a composite liner a density of holes in the geomembrane is not a sufficient information. Indeed, it is necessary to know the exact positions of holes, and their relative positions with regard to the position of wrinkles in the geomembrane.

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Exhibit 35

https://www.crossroadstoday.com/news/waste-spills-at-a-disposal-site-near-nordheim/article_e941bce0-f390-11ed-a3ec-df18b668a357.html

Waste spills at a disposal site near Nordheim

Karina F. Garcia - 25 News Now A'Darius McCormick - 25 News Now
May 15, 2023

DEWITT COUNTY, Texas - Over 60,000 gallons of rainwater spilled across Hohn Road near Nordheim.

The disposal site dealt with 10 inches of rain this past week. The heavy rain caused flooding at the site. The rainwater made its way to the street.

Concerned citizens began to worry about the possibility of waste in the rainwater. An environmental activist Sister Elizabeth felt fear about the situation.

"I'm not an engineer, and I'm not an expert on the sites," Sister Elizabeth said. "But, it sounds to me like there's potential for harmful things to happen here."

The company that owns the site continues to work with the Railroad Commission and Texas Commission on Environmental Quality to monitor the issue.

Howie Gordon
Meteorologist

Karina Garcia
Evening News Anchor

A’Darius McCormick
News Reporter

Exhibit 36

Humbarson

STF-062
LT-0343
(Transfer Req)

RECEIVED
RRC OF TEXAS
JUL 12 2017
O & G
AUSTIN, TX

PetroWaste
ENVIRONMENTAL

July 11, 2017

Railroad Commission of Texas
Attn: Technical Permitting
P.O. Box 12967
Austin, Texas 78711-2967

Re: Hohn Road Facility
Permit Nos.: STF-062, LT-0343, P011994, P011995, P011996, P011997, P011998A – P011998H, P011999A – P011999H
Permit Transfer Request

Dear Sirs:

This is letter is being submitted to transfer the referenced permits from Pyote Reclamation Systems, LLC (RRC Operator No. 684407) to Petro Waste Environmental LP (PWE) (Operator No. 660029). P-5 information for each operator is included in Attachment A.

Updated H-11 applications, signed by George Wommack, CEO of PWE, for each pit are included in Attachment B. Note that this facility has not been constructed. All pits will be constructed and operated as originally specified in the Permits.

PWE currently has no plans to modify the permitted construction or operation of the facility. I have reviewed the closure cost estimate of $3,663,384.00 required for financial security and have determined that it is appropriate. A copy of the closure cost estimate is included in Attachment C.

A draft Restrictive Covenant is included in Attachment D.

The Hohn Road Facility has not been constructed, consequently, no waste has been received at the facility. A NORM survey is therefore not required.

A Summary of Leasehold Interest in DeWitt County Land, with Exhibits, is included in Attachment E.

The acknowledgement and agreement of Pyote Reclamation Systems, LLC to this permit transfer is shown below.

Please contact me if you have any questions.

Sincerely,

Lyn Holmes

Lyn Holmes, P.E.
HSE Manager
Petro Waste Environmental LP
(210) 782-9534
Lyn@PetroWasteLP.com

Acknowledged and Agreed
PYOTE RECLAMATION SYSTEMS, LLC

By: ______________________

George Wommack
Managing Member

Exhibit 37

Updating of DEQ Permits Public Notice Mailing List

The DEQ Permits Public Notice Mailing List is composed of two Lists:

List One: Hardcopy Mailout

This mailout list is composed of names and addresses of individuals who have requested to receive hard copies of the notices. The notices are sent with "Return Service Requested". If public notices are returned, the mailout list is updated in the following manner:

a. The name and addresses of individuals for which the notices are returned by the post office marked "Undeliverable as Sent" and/or "No Forwarding Address" are deleted from the mailout list.

b. Addresses are updated, if new information is provided by the post office.

List Two: Electronic Mailout (Listserve)

Individuals can receive electronic copies of public notices by subscribing to the statewide or parish mailout list. Participants can subscribe and unsubscribe at https://internet.deq.louisiana.gov/portal/SUBSCRIBES/PUBLIC-NOTIFICATION, or by contacting the Public Participation Group in writing at LDEQ, P.O. Box 4313, Baton Rouge, LA 70821-4313, by email at DEQ.PUBLICNOTICES@LA.GOV or by contacting the LDEQ Customer Service Center at (225) 219-LDEQ (219-5337).

Exhibit 38

https://www.victoriaadvocate.com/counties/dewitt/residents-learn-risks-of-possible-facilities/article_12bdb914-5536-58bd-89a7-dec61f6ae6f8.html

/NEWS/COUNTIES/DEWITT-COUNTY /NEWS/LOCAL-NEWS

Residents learn risks of possible facilities

By Sara Sneath ssneath@vicad.com Reporter
Mar 14, 2014

YORKTOWN - Two oil-field waste facilities are being proposed near the town of Nordheim.

The applications for the sites have been denied once, but the applications have been amended and again are in the hands of the Texas Railroad Commission.

Known and suspected cancer-causing compounds as well as mutagens are among the chemicals that will be going into the two facilities, said environmental scientist Wilma Subra in a public meeting Thursday night at the Yorktown Public Library.

One of the sites proposed is a quarter-mile east of Nordheim. The site will be about the same size as the town of Nordheim itself.

"I don't want it that close to my town. Period," said Kathy Payne, mayor of Nordheim.

Residents near these facilities can expect to smell something similar to fingernail polish remover and/or rotten eggs, Subra said

"It's going to be really bad, and it's going to be really hard to get relocated," Subra said.

Residents of Nordheim and Yorktown who attended the meeting said they were concerned about potential air and water pollution from the site.

The applications for the site were first filed in April 2013, said Pete Dlugosch, the landowner who is leasing the proposed sites in a letter he prepared for Thursday's meeting.

A public hearing on the waste facilities will be in Austin within the next 60 to 90 days, Dlugosch said in his letter.

"We can prevent it from coming here. That's what we need to do," said Lyn Janssen, who lives on the same road as one of the proposed sites.

Residents near Nordheim created a group to fight the first applications called Concerned About Pollution, or CAP. The group, which has about 70 members, has hired a lawyer, a petrochemical professional and a groundwater professional to help in the fight, said John Hohn, whose family lives on Hohn Road, one of the waste facility proposed sites.

"We're not saying that they're wrong. The industry needs them. They're just in the wrong place. They're less than a mile down the road of our public schools," Hohn said.

The mayors of Nordheim and Yorktown were among the 66 people who attended the meeting Thursday night. Both mayors said they opposed the locations.

Proposed sites

Hohn facility:

• Location: A quarter-mile east of Nordheim

• Size: 204 acres

• Amount of waste accepted per month: 6,000 to 10,000 barrels at waste disposal site, 29,000-38,000 barrels at land treatment site

Eckhardt facility:

• Location: 31/2 miles northeast of Nordheim

• Size: 574 acres

• Amount of waste accepted per month: 8,000 cubic yards at waste disposal site, 8,000 cubic yards at land treatment site

Source: Subra company research

Exhibit 39

SCS-2009-08

AgriLIFE EXTENSION
Texas A&M System

Land Application of Drilling Fluids: Landowner Considerations

Mark L. McFarland, *Professor and Extension State Water Quality Specialist*
Sam E. Feagley, *Professor and Extension State Environmental Specialist*
Tony L. Provin, *Associate Professor and Extension Laboratory Director*

Texas AgriLife Extension Service

BACKGROUND

Petroleum and natural gas are major sources of revenue in Texas. However, disturbance caused by construction of drilling locations, oilfield roads, and installation of pipelines can result in reduced crop production, increased susceptibility of the damaged sites to erosion, and increases in noxious and poisonous plant densities. In addition, on-site disposal of drilling fluids used in the drilling process can create problems if not managed properly. Drilling fluids have been and currently are land applied in many parts of Texas. In some areas, the use of clayey drilling fluids on sandy soils has improved water holding capacity and plant growth. However, in many areas of the state, improper rates of application of high salt drilling fluids have resulted in the death of plants and severely damaged soils that have failed to recover even after many decades (Photo 1).

Photo 1. Denuded oil well reserve pit in west Texas with high soil salt concentrations.

The Environmental Protection Agency (EPA) classifies oil and gas drilling fluids as "special wastes" which are exempted from amendments to the Resource Conservation and Recovery Act (RCRA) issued by Congress in 1980. As a result, regulations regarding the handling and disposal of oil-field generated wastes vary from state to state. The Railroad Commission of Texas (RRC) is authorized to regulate disposal of drilling fluids under Title 16 (Economic Regulation), Part 1 (Railroad Commission of Texas), Chapter 3 (Oil and Gas Division) of the Texas Administrative Code. Under Statewide Rule 8, adopted by the Railroad Commission, authorized disposal procedures include landfarming and burial of certain drilling wastes, including drilling fluids.

Drilling fluids, also called drilling muds, typically consist of about a 5% slurry of bentonite clay in a base fluid of water, diesel, or mineral oil, an organic material such as lignite or lignosulfonate to stabilize the slurry, and a density increasing material, usually barite ($BaSO_4$), to help float out rock particles. However, the quantity and chemical composition of a particular drilling fluid will vary with conditions in the hole, such as depth and type of formation. These fluids remove cuttings from the hole, cool the drill bit, and seal off porous geologic strata. The fluid is periodically pumped into a reserve pit (constructed earthen pit) circulated to allow cuttings to settle, and then reused (Photo 2). When drilling is completed, much or all of the fluid is disposed of in the pit, allowed to dry, and then mixed with soil from the pit berms or simply covered. In other situations, drilling fluids may be disposed of by removal and transport to an approved landfill, or by land application.

Photo 2. Oil well reserve pit containing drilling fluids.

Landfarming or land application is a process whereby drilling fluids are spread on the land surface. The rate of application depends on the characteristics of the soil and the chemical composition of the drilling fluid. Land application is often preferred to reduce the costs of disposal, and may be conducted either on-site (where the drilling occurred) or at an off-site location. This process also is used to treat and/or dilute potentially harmful constituents in the drilling fluid, when present. These constituents may include petroleum hydrocarbons, salts and/or heavy metals.

Petroleum hydrocarbons including oil and grease can be toxic to plants in modest concentrations either due to direct contact or through adverse effects on soil properties. When oil is spilled on growing plants, low molecular weight compounds, for example fuel oil, act as a solvent on the lipid membranes of tender plant parts. Total soil hydrocarbon concentrations greater than 1% have been found to be toxic to most plant species and this level is normally considered the threshold between non-contamination and contamination. Soil oxygen levels are reduced because diffusion of oxygen through the oil and/or grease layer is poor and because microbes use the available oxygen as they breakdown the oil. As a result, the soil can become anaerobic (low oxygen), which is limiting to plant growth. In addition, plant available nutrients (particularly nitrogen and phosphorus) are rapidly used by these microbes in the process of degrading the oil and can become deficient for plant growth. Finally, and commonly the most damaging to plant growth, soil particles coated with oil can become hydrophobic which reduces water infiltration, drainage and storage in the soil, and its availability to plants.

Salts in drilling fluids can affect both plants and the soil. The salts present in drilling fluids can come from 1) the materials used to formulate the drilling fluids, and/or 2) poor quality groundwater or salt containing geologic formations that are contacted during drilling. High levels of soluble salts decrease water availability to plants, basically creating a drought-like stress which can cause plants to wilt and potentially die. A soil is typically considered salt-affected or “saline” when the electrical conductivity of the saturated paste extract exceeds 4 millimhos per centimeter (mmhos/cm). However, sensitive plants may be affected by even lower soil salt levels. In loamy to clayey soils and under drying conditions, salts will often wick to the soil surface and accumulate, sometimes producing a white appearance (Photo 3). Several of the salt elements like sodium and chloride can be toxic to plants in high concentrations.

Photo 3. Salt accumulation on the surface of the soil at a reserve pit.

Another element, boron, can be toxic to some plants even at relatively low concentrations (< l part per million, ppm) in the soil. Sodium also can have an adverse effect on the soil by degrading soil structure. Soils affected by sodium often will be powdery and structureless on the surface when dry, or can become hard and very compacted. This reduces air and water movement into the soil and will limit plant growth. A sodium adsorption ratio (SAR) of 10 or more indicates the potential for adverse effects of sodium on soil physical properties.

Heavy metals are elements that may or may not be plant nutrients, but can be harmful to plant and/or animal health in low to high concentrations depending on the element. Some heavy metals will cause plant death at high concentrations. Others can accumulate in plant tissue (without harm to the plant) to levels which are harmful or toxic to animals and/or humans. The heavy metals most commonly found in drilling fluids include arsenic, barium, chromium, copper, lead, nickel and zinc. The amounts present will depend on the formulation of the drilling fluid and the geologic formations encountered during the drilling process.

LAND APPLICATION

The decision to land apply drilling fluids should be based on the chemical composition of the drilling fluid, and the amount and characteristics of the land area available. The first step is to obtain a chemical analysis of the drilling fluid and a representative (composite) sample of the native soil from the proposed land application area. No single measurement, such as a simple chloride analysis, is sufficient to properly evaluate and manage drilling fluid disposal. A thorough analysis should include the following measurements for both the drilling fluid and native soil unless otherwise specified:

1. Total salts – measured as the electrical conductivity (EC) of the saturated paste extract and reported in parts per million (ppm) or millimhos per cm (mmhos/cm).
2. Extractable individual ions – calcium, magnesium, sodium, boron, chloride, and sulfate-sulfur measured in the saturated paste extract and reported in milligrams per kilogram (mg/kg) or ppm.
3. Sodium Adsorption Ratio (SAR) – calculated from the saturated paste analyses for calcium, magnesium, and sodium.
4. Total heavy metals – arsenic, barium, chromium, copper, lead, nickel, and zinc reported in mg/kg.
5. Total petroleum hydrocarbons (TPH) – drilling fluid only, reported in mg/kg.
6. Routine + micronutrient soil nutrient test – pH, and extractable nitrate-nitrogen, phosphorus, potassium, calcium, magnesium, sodium, sulfur, copper, iron, manganese, and zinc.
7. Soil texture – native soil only.
8. Cation exchange capacity – native soil only.

Photo 4. Revegetated reserve pit.

A qualified professional can utilize the results of these tests to determine if land application is appropriate for a particular situation. If so, they can provide the proper rate of application (barrels per acre, tons per acre, or inches of depth) of drilling fluid so that the process does not cause long-term adverse effects on soil properties. These results also can be used to determine if additional soil amendments may be needed to promote treatment of the waste. For example, gypsum (calcium sulfate) may be recommended to offset high levels of sodium in the drilling fluid and prevent problems with soil structure. In other cases, nutrients are applied to support the growth of soil microbes capable of decomposing hydrocarbons, and to enhance plant growth for site recovery.

Land application should be conducted carefully to ensure that the rate of application is correct. Excessive rates can seriously damage the soil, and create long-term problems which are very difficult and expensive to correct. Once the drilling fluid has been applied it is typically disked or otherwise thoroughly mixed and incorporated into the upper 4 to 6 inches of soil. This assists with the decomposition of any organic materials and initially dilutes salts and other elements that may be present in high concentrations. The area may then be prepared and planted with a desirable plant species or species mixture (Photo 4).

Land owners are advised to develop a formal contractual agreement with the company or individual responsible for disposal of the drilling fluid. The agreement should stipulate testing requirements for drilling fluids and native soils, the land application procedures and limits, and any expectations for replanting and/or recovery of the impacted land. This may include periodic monitoring and further soil testing on the site. In some cases, it is desirable to require annual or semi-annual testing to ensure that constituent levels are within acceptable concentrations. In addition, specific requirements for vegetation recovery may be established, such as percent ground cover and/or survival for a specified period of time into the future (e.g. 1 to 3 years). The landowner should consider requiring the land application company to post a bond to insure longer-term compliance with specific land management requirements. The costs of sample collections, analyses, soil amendments such as gypsum and fertilizer, and selected seeds or vegetation, etc. can be included in the contractual agreement as the responsibility of the company or individual responsible for the disposal of the drilling fluids.

Careful development of a management plan for land application of drilling fluids is important to ensure that the land resource is utilized in an environmentally sound fashion and is protected for the future. By accomplishing this, the surrounding land and water resources also will be protected from potential off-site impacts. For questions and assistance related to drilling fluid disposal or a land application program, contact your local district office of the Railroad Commission of Texas (http://www.rrc.state.tx.us/). Web resources include a map of RRC district locations (http://www.rrc.state.tx.us/forms/maps/ogdivisionmap.php) and contact information for district offices (http://www.rrc.state.tx.us/contact/index.php). For more information on testing contact the Texas AgriLife Extension Service Soil, Water and Forage Testing Laboratory (979-845-4816), or your local county Extension office.

Produced by the Department of Soil and Crop Sciences
For further information go to www.soilcrop.tamu.edu.

Exhibit 40

United States
Environmental Protection
Agency

Land And
Emergency Management
5401R

EPA 510-B-17-003
October 2017
www.epa.gov/ust

How To Evaluate Alternative Cleanup Technologies For Underground Storage Tank Sites

A Guide For Corrective Action Plan Reviewers

Chapter V

Landfarming

Contents

List Of Exhibits

Chapter V
Landfarming

Overview

Landfarming, also known as land treatment or land application, is an above-ground remediation technology for soils that reduces concentrations of petroleum constituents through biodegradation. This technology usually involves spreading excavated contaminated soils in a thin layer on the ground surface and stimulating aerobic microbial activity within the soils through aeration and/or the addition of minerals, nutrients, and moisture. The enhanced microbial activity results in degradation of adsorbed petroleum product constituents through microbial respiration. If contaminated soils are shallow (i.e., $\leq$ 3 feet below ground surface), it may be possible to effectively stimulate microbial activity without excavating the soils. If petroleum-contaminated soil is deeper than 5 feet, the soils should be excavated and reapplied on the ground surface. A typical landfarming operation is shown in Exhibit V-1.

Landfarming has been proven effective in reducing concentrations of nearly all the constituents of petroleum products typically found at underground storage tank (UST) sites. Lighter (more volatile) petroleum products (e.g., gasoline) tend to be removed by evaporation during landfarm aeration processes (i.e., tilling or plowing) and, to a lesser extent, degraded by microbial respiration. Depending upon your state's regulations for air emissions of volatile organic compounds (VOCs), you may need to control the VOC emissions. Control involves capturing the vapors before they are emitted to the atmosphere, passing them through an appropriate treatment process, and then venting them to the atmosphere. The mid-range hydrocarbon products (e.g., diesel fuel, kerosene) contain lower percentages of lighter (more volatile) constituents than does gasoline. Biodegradation of these petroleum products is more significant than evaporation. Heavier (non-volatile) petroleum products (e.g., heating oil, lubricating oils) do not evaporate during landfarm aeration; the dominant mechanism that breaks down these petroleum products is biodegradation. However, higher molecular weight petroleum constituents such as those found in heating and lubricating oils, and, to a lesser extent, in diesel fuel and kerosene, require a longer period of time to degrade than do the constituents in gasoline. A summary of the advantages and disadvantages of landfarming is shown in Exhibit V-2.

The policies and regulations of your state determine whether landfarming is allowed as a treatment option. Before reading this chapter, consider whether your state allows the use of this remedial option.

Exhibit V-1
Typical Landfarming Operation

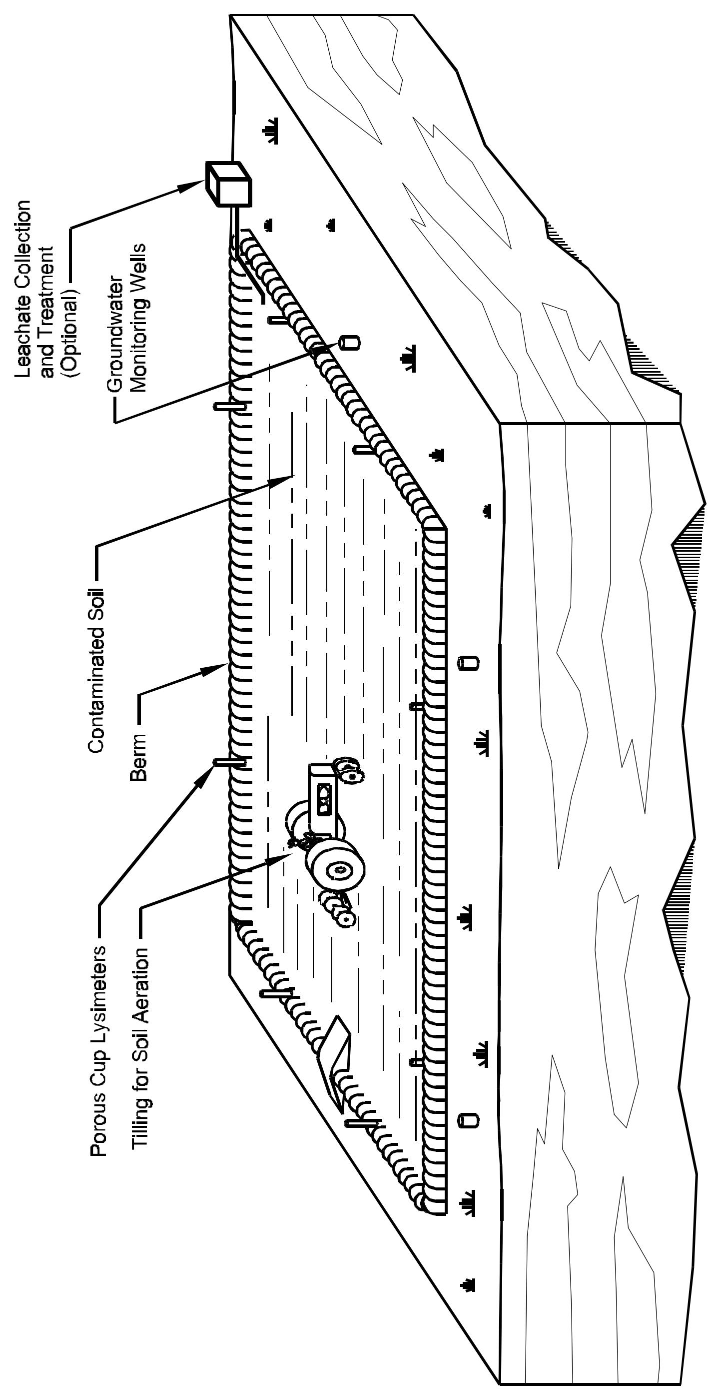


Exhibit V-2
Advantages And Disadvantages Of Landfarming

Advantages	Disadvantages
❍ Relatively simple to design and implement.	❍ Concentration reductions > 95% and constituent concentrations < 0.1 ppm are very difficult to achieve.
❍ Short treatment times: usually 6 months to 2 years under optimal conditions.	❍ May not be effective for high constituent concentrations (> 50,000 ppm total petroleum hydrocarbons).
❍ Cost competitive: $30-60/ton of contaminated soil.	❍ Presence of significant heavy metal concentrations (> 2,500 ppm) may inhibit microbial growth.
❍ Effective on organic constituents with slow biodegradation rates.	❍ Volatile constituents tend to evaporate rather than biodegrade during treatment.
	❍ Requires a large land area for treatment.
	❍ Dust and vapor generation during landfarm aeration may pose air quality concerns.
	❍ May require bottom liner if leaching from the landfarm is a concern.

This chapter will assist you in evaluating a corrective action plan (CAP) that proposes landfarming as a remedy for petroleum contaminated soil. The evaluation guidance is presented in the three steps described below. The evaluation process, which is summarized in a flow diagram shown in Exhibit V-3, will serve as a roadmap for the decisions you will make during your evaluation. A checklist has also been provided at the end of this chapter to be used as a tool to evaluate the completeness of the CAP and to help you focus on areas where additional information may be needed. The evaluation process can be divided into the following steps.

❍ **Step 1:** ***An evaluation of landfarming effectiveness***, in which you can identify the soil, constituent, and climatic factors that contribute to the effectiveness of landfarming and compare them to acceptable operating ranges. To complete the evaluation, you will need to compare these properties to ranges where landfarming is effective.

Exhibit V-3

Landfarming Evaluation Process Flow Chart

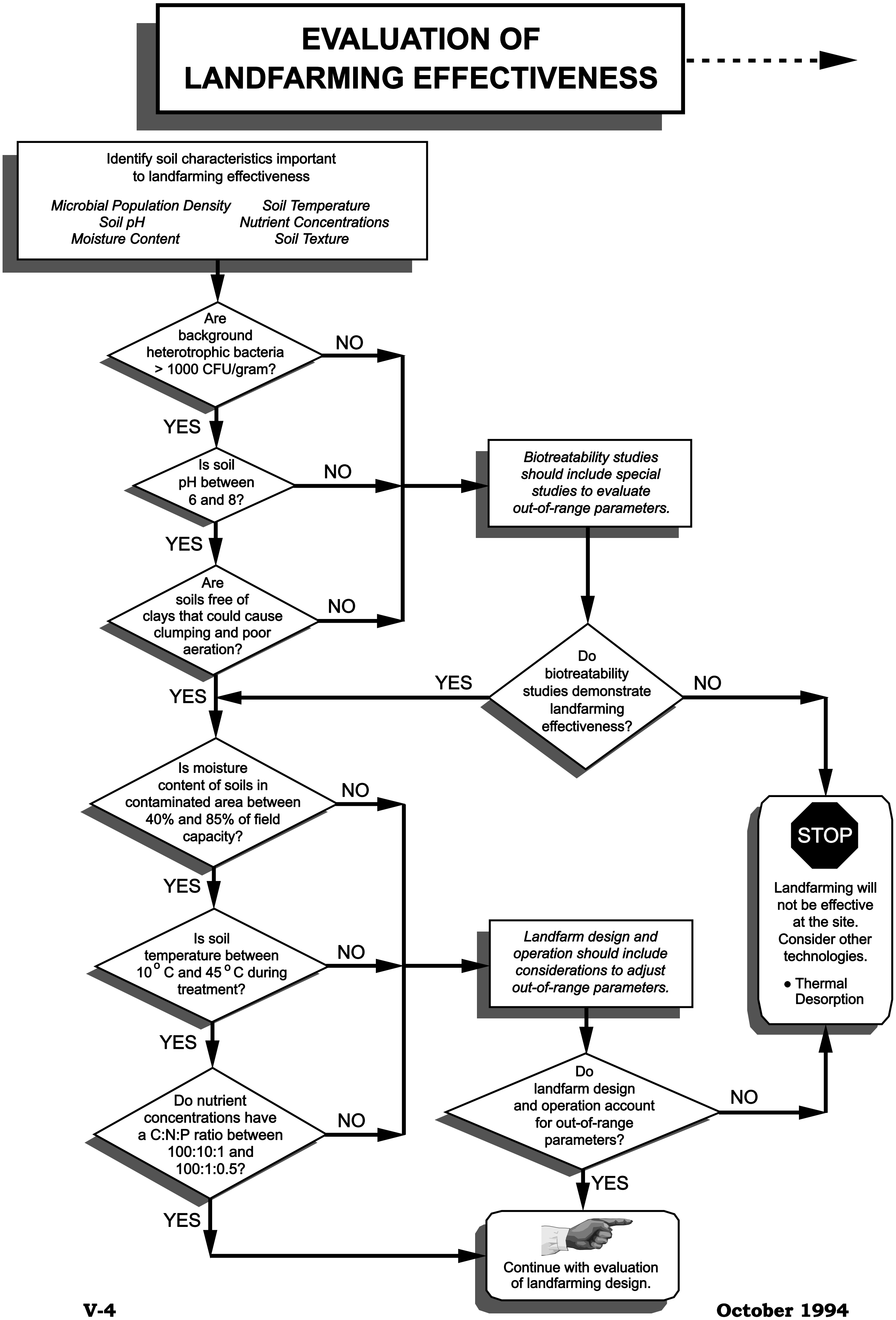


Exhibit V-3
Landfarming Evaluation Process Flow Chart

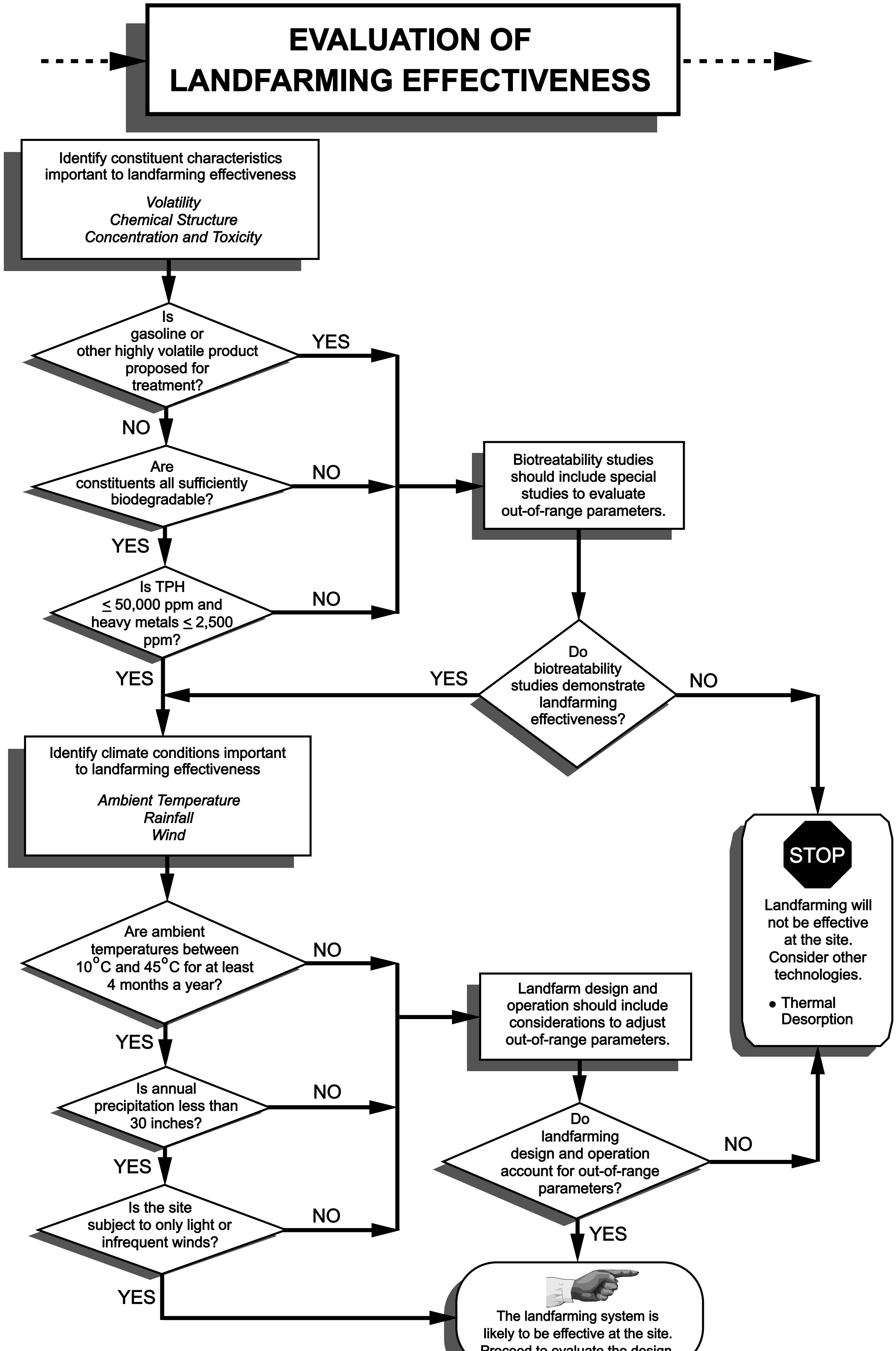
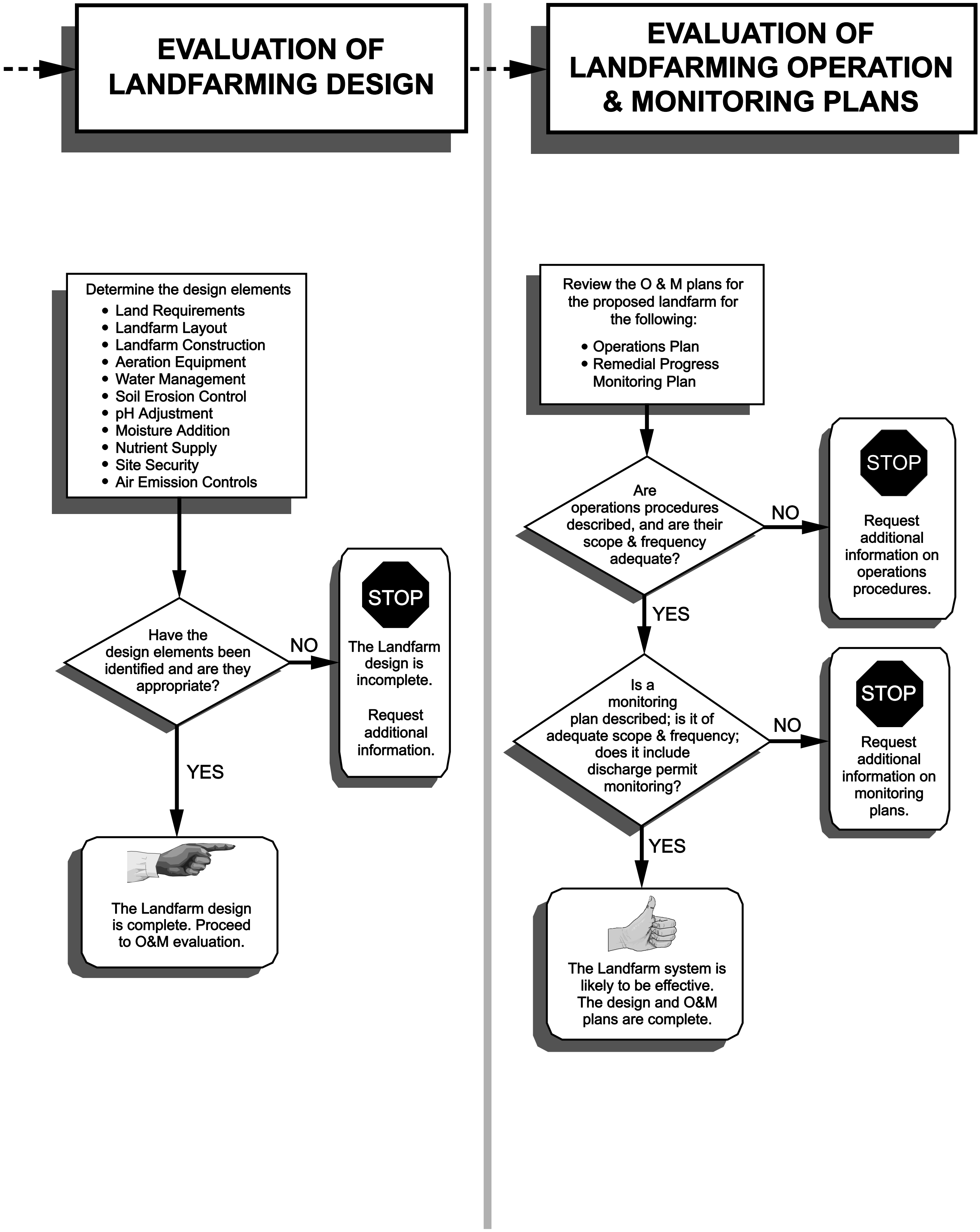


Exhibit V-3
Landfarming Evaluation Process Flow Chart



- **Step 2: *An evaluation of the landfarming system design*** will allow you to determine if the rationale for the design has been appropriately defined, whether the necessary design components have been specified, and whether the construction designs are consistent with standard practice.

- **Step 3: *An evaluation of the operation and monitoring plans,*** which are critical to the effectiveness of landfarming, will allow you to determine whether start-up and long-term system operation and monitoring plans are of sufficient scope and frequency.

Evaluation Of Landfarming Effectiveness

The effectiveness of landfarming depends on many parameters which are listed in Exhibit V-4. The parameters are grouped into three categories: soil characteristics, constituent characteristics, and climatic conditions.

Exhibit V-4
Parameters Used To Evaluate The Effectiveness Of Landfarming

Soil Characteristics	Constituent Characteristics	Climatic Conditions
Microbial population density	Volatility	Ambient temperature
Soil pH	Chemical structure	Rainfall
Moisture content	Concentration and toxicity	Wind
Soil temperature		
Nutrient concentrations		
Texture		

The following paragraphs contain descriptions of each parameter that include: why it is important; how it can be determined; and what its appropriate range is. During your evaluation, remember that because landfarming is an above-ground treatment technique, most parameters (except climatic conditions) can be controlled during the design and operation of the landfarm. Therefore, during your evaluation, identify those parameters that fall outside the effectiveness ranges provided and verify that the system design and proposed operating specifications compensate for any site conditions that are less than optimal.

Soil Characteristics

Microbial Population Density

Soil normally contains large numbers of diverse microorganisms including bacteria, algae, fungi, protozoa, and actinomycetes. In well-drained soils, which are most appropriate for landfarming, these organisms are generally aerobic. Of these organisms, bacteria are the most numerous and biochemically active group, particularly at low oxygen levels. Bacteria require a carbon source for cell growth and an energy source to sustain metabolic functions required for growth. Bacteria also require nitrogen and phosphorus for cell growth. Although sufficient types and quantities of microorganisms are usually present in the soil, recent applications of ex-situ soil treatment include blending the soil with cultured microorganisms or animal manure (typically from chickens or cows). Incorporating manure serves to both augment the microbial population and provide additional nutrients.

The metabolic process used by bacteria to produce energy requires a terminal electron acceptor (TEA) to enzymatically oxidize the carbon source to carbon dioxide. Microbes are classified by the carbon and TEA sources they use to carry out metabolic processes. Bacteria that use organic compounds (e.g., petroleum constituents and other naturally occurring organics) as their source of carbon are *heterotrophic*; those that use inorganic carbon compounds (e.g., carbon dioxide) are *autotrophic*. Bacteria that use oxygen as their TEA are *aerobic*; those that use a compound other than oxygen, (e.g., nitrate, sulfate), are *anaerobic*; and those that can utilize both oxygen and other compounds as TEAs are *facultative*. For landfarming applications directed at petroleum products, only bacteria that are both *aerobic* (or *facultative*) and *heterotrophic* are important in the degradation process.

In order to evaluate the presence and population of naturally occurring bacteria that will contribute to degradation of petroleum constituents, conduct laboratory analyses of soil samples from the site. These analyses, at a minimum, should include plate counts for total heterotrophic bacteria. Plate count results are normally reported in terms of colony-forming units (CFUs) per gram of soil. Microbial population densities in typical soils range from 10^4 to 10^7 CFU/gram of soil. For landfarming to be effective, the minimum heterotrophic plate count should be 10^3 CFU/gram or greater. Plate counts lower than 10^3 could indicate the presence of toxic concentrations of organic or inorganic (e.g., metals) compounds. In this situation, landfarming may still be effective if the soil is conditioned or amended to reduce the toxic concentrations and increase the microbial population density. More elaborate laboratory tests are sometimes conducted to identify the bacterial species present. This may be desirable if there is uncertainty about whether or not microbes capable of degrading specific petroleum hydrocarbons occur naturally in the soil. If insufficient numbers or types of microorganisms are present, the population density may be increased by introducing cultured microbes that are available from vendors. Exhibit V-5 shows the relationship between plate counts of total heterotrophic bacteria and the effectiveness of landfarming.

Exhibit V-5
Heterotrophic Bacteria And Landfarming Effectiveness

Total Heterotrophic Bacteria (prior to landfarming)	Landfarming Effectiveness
> 1000 CFU/gram dry soil	Generally effective.
< 1000 CFU/gram dry soil	May be effective; needs further evaluation to determine if toxic conditions are present.

Soil pH

To support bacterial growth, the soil pH should be within the 6 to 8 range, with a value of about 7 (neutral) being optimal. Soils with pH values outside this range prior to landfarming will require pH adjustment prior to and during landfarming operations. Soil pH within the landfarm can be raised through the addition of lime and lowered by adding elemental sulfur. Exhibit V-6 summarizes the effect of soil pH on landfarming effectiveness. Review the CAP to verify that soil pH measurements have been made. If the soil pH is less than 6 or greater than 8, make sure that pH adjustments, in the form of soil amendments, are included in the design and operational plans for the landfarm.

Exhibit V-6
Soil pH And Landfarming Effectiveness

Soil pH (prior to landfarming)	Landfarming Effectiveness
$6 \leq pH \leq 8$	Generally effective.
$6 > pH > 8$	Landfarm soils will require amendments to correct pH to effective range.

Moisture Content

Soil microorganisms require moisture for proper growth. Excessive soil moisture, however, restricts the movement of air through the subsurface thereby reducing the availability of oxygen which is also necessary for aerobic bacterial metabolic processes. In general, the soil should be moist but not wet or dripping wet. The ideal range for soil moisture is between 40 and 85 percent of the water-holding capacity (field capacity) of the soil or about 12 percent to 30 percent by weight. Periodically, moisture must be added in landfarming operations because soils become dry as a result of evaporation, which is increased during aeration operations (i.e., tilling and/or plowing). Excessive accumulation of moisture can occur at landfarms in areas with high precipitation or poor drainage. These conditions should be considered in the landfarm design. For example, an impervious cover can mitigate excessive infiltration and potential erosion of the landfarm. Exhibit V-7 shows the optimal range for soil moisture content.

Exhibit V-7
Soil Moisture And Landfarming Effectiveness

Soil Moisture	Landfarming Effectiveness
40% $\leq$ field capacity $\leq$ 85%	Effective.
Field capacity < 40%	Periodic moisture addition is needed to maintain proper bacterial growth.
Field capacity > 85%	Landfarm design should include special water drainage considerations.

Soil Temperature

Bacterial growth rate is a function of temperature. Soil microbial activity has been shown to decrease significantly at temperatures below 10°C and to essentially cease below 5°C. The microbial activity of most bacteria important to petroleum hydrocarbon biodegradation also diminishes at temperatures greater than 45°C. Within the range of 10°C to 45°C, the rate of microbial activity typically doubles for every 10°C rise in temperature. Because soil temperature varies with ambient temperatures, there will be certain periods during the year when bacterial growth and, therefore, constituent degradation, will diminish. When ambient temperatures return to the growth range, bacterial activity will be gradually restored. The period of the year when the ambient temperature is within the range for microbial activity is commonly called the “landfarming season.”

In colder parts of the United States, such as the Northeastern states, the length of the landfarming season is shorter, typically ranging from only 7 to 9 months. In very cold climates, special precautions can be taken, including enclosing the landfarm within a greenhouse-type structure or introducing special bacteria (psychrophiles), which are capable of activity at lower temperatures. In warm regions, the landfarming season can last all year. Exhibit V-8 shows how soil temperature affects landfarming operation.

Exhibit V-8
Soil Temperature And Landfarming Effectiveness

Soil Temperature	Landfarming Effectiveness
$10°C \leq$ soil temperature $\leq 45°C$	Effective.
$10°C >$ soil temperature $> 45°C$	Not generally effective; microbial activity diminished during seasonal temperature extremes but restored during periods within the effective temperature range. Temperature-controlled enclosures or special bacteria required for areas with extreme temperatures.

Nutrient Concentrations

Microorganisms require inorganic nutrients such as nitrogen and phosphorus to support cell growth and sustain biodegradation processes. Nutrients may be available in sufficient quantities in the site soils but, more frequently, nutrients need to be added to landfarm soils to maintain bacterial populations. However, excessive amounts of certain nutrients (i.e., phosphate and sulfate) can repress microbial metabolism. The typical carbon:nitrogen:phosphorus ratio necessary for biodegradation falls in the range of 100:10:1 to 100:1:0.5, depending upon the specific constituents and microorganisms involved in the biodegradation process.

The naturally occurring available nitrogen and phosphorus content of the soil should be determined by chemical analyses of samples collected from the site. These types of analyses are routinely conducted in agronomic laboratories that test soil fertility for farmers. These concentrations can be compared to the nitrogen and phosphorus requirements calculated from the stoichiometric ratios of the biodegradation process. A conservative approximation of the amount of nitrogen and phosphorus required for optimum degradation of petroleum products can be calculated by assuming that the total mass of hydrocarbon in the soil represents the mass of carbon available for biodegradation. This simplifying assumption is valid because the carbon content of the petroleum hydrocarbons commonly encountered at UST sites is approximately 90 percent carbon by weight.

As an example, assume that at a LUST site the volume of contaminated soil is 90,000 ft^3, the average TPH concentration in the contaminated soil is 1,000 mg/kg, and the soil bulk density is 50 kg/ft^3 (1.75 g/cm^3).

The mass of contaminated soil is equal to the product of volume and bulk density:

$$\text{soil mass} = 90{,}000\ \text{ft}^3 \times \frac{50\ \text{kg}}{\text{ft}^3} = 4.5 \times 10^6\ \text{kg}$$

The mass of the contaminant (and carbon) is equal to the product of the mass of contaminated soil and the average TPH concentration in the contaminated soil:

$$\text{contaminant mass} = 4.5 \times 10^6\ \text{kg} \times 1{,}000\ \frac{\text{mg}}{\text{kg}} = 4.5 \times 10^3\ \text{kg} \approx 10{,}000\ \text{lbs}$$

Using the C:N:P ratio of 100:10:1, the required mass of nitrogen would be 1,000 lbs, and the required mass of phosphorus would be 100 lbs. After converting these masses into concentration units (56 mg/kg for nitrogen and 5.6 mg/kg for phosphorus), they can be compared with the results of the soil analyses to determine if nutrient addition is necessary. If nitrogen addition is necessary, slow release sources should be used. Nitrogen addition can lower pH, depending on the amount and type of nitrogen added.

Soil Texture

Texture affects the permeability, moisture content, and bulk density of the soil. To ensure that oxygen addition (by tilling or plowing), nutrient distribution, and moisture content of the soils can be maintained within effective ranges, you must consider the texture of the soils. For example, soils which tend to clump together (such as clays) are difficult to aerate and result in low oxygen concentrations. It is also difficult to uniformly distribute nutrients throughout these soils. They also retain water for extended periods following a precipitation event.

You should identify whether clayey soils are proposed for landfarming at the site. Soil amendments (e.g., gypsum) and bulking materials (e.g., sawdust, or straw) should be blended into the soil as the landfarm is being constructed to ensure that the landfarming medium has a loose or divided texture. Clumpy soil may require shredding or other means of pretreatment during landfarm construction to incorporate these amendments.

Constituent Characteristics

Volatility

The volatility of contaminants proposed for treatment by landfarming is important because volatile constituents tend to evaporate from the landfarm, particularly during tilling or plowing operations, rather than being biodegraded by bacteria. Constituent vapors emitted from a landfarm will dissipate into the atmosphere unless the landfarm is enclosed within a surface structure such as a greenhouse or plastic tunnel or covered with a plastic sheet.

Petroleum products generally encountered at UST sites range from those with a significant volatile fraction, such as gasoline, to those that are primarily nonvolatile, such as heating and lubricating oils. Petroleum products generally contain more than one hundred different constituents that possess a wide range of volatility. In general, gasoline, kerosene, and diesel fuels contain constituents with sufficient volatility to evaporate from a landfarm. Depending upon state-specific regulations for air emissions of volatile organic compounds (VOCs), control of VOC emissions may be required. Control involves capturing vapors before they are emitted to the atmosphere and then passing them through an appropriate treatment process before being vented to the atmosphere.

Chemical Structure

The chemical structures of the contaminants present in the soils proposed for treatment by landfarming are important in determining the rate at which biodegradation will occur. Although nearly all constituents in petroleum products typically found at UST sites are biodegradable, the more complex the molecular structure of the constituent, the more difficult, and less rapid, is biological treatment. Most low molecular-weight (nine carbon atoms or less) aliphatic and monoaromatic constituents are more easily biodegraded than higher molecular weight aliphatic or polyaromatic organic constituents. Exhibit V-9 lists, in order of decreasing rate of potential biodegradability, some common constituents found at petroleum UST sites.

Evaluation of the chemical structure of the constituents proposed for reduction by landfarming at the site will allow you to determine which constituents will be the most difficult to degrade. You should verify that remedial time estimates, biotreatability studies, field-pilot studies (if applicable), and landfarm operation and monitoring plans are based on the constituents that are most difficult to degrade (or “rate limiting”) in the biodegradation process.

Exhibit V-9
Chemical Structure And Biodegradability

Biodegradability	Example Constituents	Products In Which Constituent Is Typically Found
More degradable	n-butane, n-pentane, n-octane	❍ Gasoline
	Nonane	❍ Diesel fuel
	Methyl butane, dimethylpentenes, methyloctanes	❍ Gasoline
	Benzene, toluene, ethylbenzene, xylenes	❍ Gasoline
	Propylbenzenes	❍ Diesel, kerosene
	Decanes Dodecanes Tridecanes Tetradecanes	❍ Diesel ❍ Kerosene ❍ Heating fuels ❍ Lubricating oils
Less degradable	Naphthalenes Fluoranthenes Pyrenes Acenaphthenes	❍ Diesel ❍ Kerosene ❍ Heating oil ❍ Lubricating oils

Concentration And Toxicity

The presence of very high concentrations of petroleum organics or heavy metals in site soils can be toxic or inhibit the growth and reproduction of bacteria responsible for biodegradation in landfarms. In addition, very low concentrations of organic material will also result in diminished levels of bacteria activity.

In general, soil concentrations of total petroleum hydrocarbons (TPH) in the range of 10,000 to 50,000 ppm, or heavy metals exceeding 2,500 ppm, are considered inhibitory and/or toxic to most microorganisms. If TPH concentrations are greater than 10,000 ppm, or the concentration of heavy metals is greater than 2,500 ppm, then the contaminated soil should be thoroughly mixed with clean soil to dilute the contaminants so that the average concentrations are below toxic levels. Exhibit V-10 provides the general criteria for constituent concentration and landfarming effectiveness.

Exhibit V-10
Constituent Concentration And Landfarming Effectiveness

Constituent Concentration	Landfarming Effectiveness
Petroleum constituents ≤ 50,000 ppm and Heavy metals ≤ 2,500 ppm	Effective; however, if contaminant concentration is > 10,000 ppm, the soil may need to be blended with clean soil to reduce the concentration of the contaminants.
Petroleum constituents > 50,000 ppm or Heavy metals > 2,500 ppm	Ineffective; toxic or inhibitory conditions to bacterial growth exist. Dilution by blending necessary.

In addition to maximum concentrations, you should consider the cleanup goals proposed for the landfarm soils. Below a certain "threshold" constituent concentration, the bacteria cannot obtain sufficient carbon (from degradation of the constituents) to maintain adequate biological activity. The threshold level can be determined from laboratory studies and should be below the level required for cleanup. Although the threshold limit varies greatly depending on bacteria-specific and constituent-specific features, generally constituent concentrations below 0.1 ppm are not achievable by biological treatment alone. In addition, experience has shown that reductions in TPH concentrations greater than 95 percent can be very difficult to achieve because of the presence of "recalcitrant" or nondegradable species that are included in the TPH analysis. If a cleanup level lower than 0.1 ppm is required for any individual constituent or a reduction in TPH greater than 95 percent is required to reach the cleanup level for TPH, either a pilot study is required to demonstrate the ability of landfarming to achieve these reductions at the site or another technology should be considered. Exhibit V-11 shows the relationship between cleanup requirements and landfarming effectiveness.

Climatic Conditions

Typical landfarms are uncovered and, therefore, exposed to climatic factors including rainfall, snow, and wind, as well as ambient temperatures.

Ambient Temperature

The ambient temperature is important because it influences soil temperature. As described previously, the temperature of the soils in the landfarm impacts bacterial activity and, consequently, biodegradation. The optimal temperature range for landfarming is 10°C to 45°C. Special considerations (e.g., heating, covering, or enclosing) can overcome the effects of colder climates and extend the length of the landfarming season.

Exhibit V-11
Cleanup Requirements And Landfarming Effectiveness

Cleanup Requirement	Landfarming Effectiveness
Constituent concentration > 0.1 ppm and TPH reduction < 95%	Effective.
Constituent concentration ≤ 0.1 ppm or TPH reduction ≥ 95%	Potentially ineffective; pilot studies are required to demonstrate contaminant reduction.

Rainfall

Rainwater that falls directly onto, or runs onto, the landfarm area will increase the moisture content of the soil and cause erosion. As previously described, effective landfarming requires a proper range of moisture content. During and following a significant precipitation event, the moisture content of the soils may be temporarily in excess of that required for effective bacterial activity. On the other hand, during periods of drought, moisture content may be below the effective range and additional moisture may need to be added.

If the site is located in an area subject to annual rainfall of greater than 30 inches during the landfarming season, a rain shield (such as a tarp, plastic tunnel, or greenhouse structure) should be considered in the design of the landfarm. In addition, rainfall runon and runoff from the landfarm should be controlled using berms at the perimeter of the landfarm. A leachate collection system at the bottom of the landfarm and a leachate treatment system may also be necessary to prevent groundwater contamination from the landfarm.

Wind

Erosion of landfarm soils can occur during windy periods and particularly during tilling or plowing operations. Wind erosion can be limited by plowing soils into windrows and applying moisture periodically.

Biotreatability Evaluation

Biotreatability studies are especially desirable if toxicity is a concern or natural soil conditions are not conducive to biological activity. Biotreatability studies are usually performed in the laboratory and should be planned so that, if successful, the proper parameters are developed to design and implement the landfarming approach. If biotreatability studies do not demonstrate effectiveness, field trials or pilot studies will be needed prior to implementation, or another remedial approach should be evaluated. If the soil, constituents, and climatic characteristics are within the range of effectiveness for landfarming, review biotreatability studies to confirm that landfarming has the potential for effectiveness and to verify that the parameters needed to design the full-scale landfarm have been obtained. Biotreatability studies should provide data on contaminant biodegradability, ability of indigenous microorganisms to degrade contaminants, optimal microbial growth conditions and biodegradation rates, and sufficiency of natural nutrients and minerals.

There are two types of biotreatability studies generally used to demonstrate landfarming effectiveness: (1) Flask Studies and (2) Pan Studies. Both types of studies begin with the characterization of the baseline physical and chemical properties of the soils to be treated in the landfarm. Typical physical and chemical analyses performed on site soil samples for biotreatability studies are listed on Exhibit V-12. The specific objectives of these analyses are to:

- Determine the types and concentrations of contaminants in the soils that will be used in the biotreatability studies.
- Assess the initial concentrations of constituents present in the study samples so that reductions in concentration can be evaluated.
- Determine if nutrients (nitrogen and phosphorus) are present in sufficient concentrations to support enhanced levels of bacterial activity.
- Evaluate parameters that may inhibit bacterial growth (e.g., toxic concentrations of metals, pH values lower than 6 or higher than 8).

After the characterization of the soil samples is complete, perform bench studies to evaluate biodegradation effectiveness. Flask (or bottle) studies, which are simple and inexpensive, are used to test for biodegradation in water or soils using soil/water slurry microcosms. Flask studies may use a single slurry microcosm that is sampled numerous times or may have a series of slurry microcosms, each sampled once. Flask studies are less desirable than pan studies for evaluation of landfarming effectiveness and are primarily used for evaluation of water-phase bioremedial technologies. Pan studies use soils, without dilution in an aqueous slurry, placed in steel or glass pans as microcosms that more closely resemble landfarming.

Exhibit V-12
Physical And Chemical Parameters For Biotreatability Studies

Parameter	Measured Properties
Soil toxicity	Type and concentration of contaminant and/or metals present, pH.
Soil texture	Grain size, clay content, moisture content, porosity, permeability, bulk density.
Nutrients	Nitrate, phosphate, other anions and cations.
Contaminant biodegradability	Total organic carbon concentration, volatility, chemical structure.

In either pan or flask studies, degradation is measured by tracking constituent concentration reduction and changes in bacterial population and other parameters over time. A typical treatment evaluation using pan or flask studies may include the following types of studies.

- *No Treatment Control Studies* measure the rate at which the existing bacteria can degrade constituents under oxygenated conditions without the addition of supplemental nutrients.

- *Nutrient Adjusted Studies* determine the optimum adjusted C:N:P ratio to achieve maximum degradation rates using microcosms prepared with different concentrations of nutrients.

- *Inoculated Studies* are performed if bacterial plate counts indicate that natural microbial activity is insufficient to promote sufficient degradation. Microcosms are inoculated with bacteria known to degrade the constituents at the site and are analyzed to determine if degradation can be increased by inoculation.

- *Sterile Control Studies* measure the degradation rate due to abiotic processes (including volatilization) as a baseline comparison with the other studies that examine biological processes. Microcosm soils are sterilized to eliminate bacterial activity. Abiotic degradation rates are then measured over time.

Review the CAP to determine that biotreatability studies have been completed, biodegradation is demonstrated, nutrient application and formulation have been evaluated and defined, and no potential inhibitors or toxic conditions have been identified.

Evaluation Of The Landfarm Design

Once you have verified that landfarming has the potential for effectiveness, you can evaluate the design of the landfarm. The CAP should include a discussion of the rationale for the design and present the conceptual engineering design. Detailed engineering design documents might also be included, depending on state requirements. Further detail about information to look for in the discussion of the design is provided below.

❍ *Land Requirements* can be determined by dividing the amount of soil to be treated by the depth of the landfarm soils. The depth of landfarms can vary between 12 inches and 18 inches depending on the capabilities of the tilling equipment to be used. Very powerful tillers can reach as much as 24 inches deep to aerate landfarm soils. Additional land area around the landfarm will be required for containment berms and for access.

❍ *Landfarm Layout* is usually determined by the configuration of and access to the land available for the landfarm. The landfarm can include single or multiple plots.

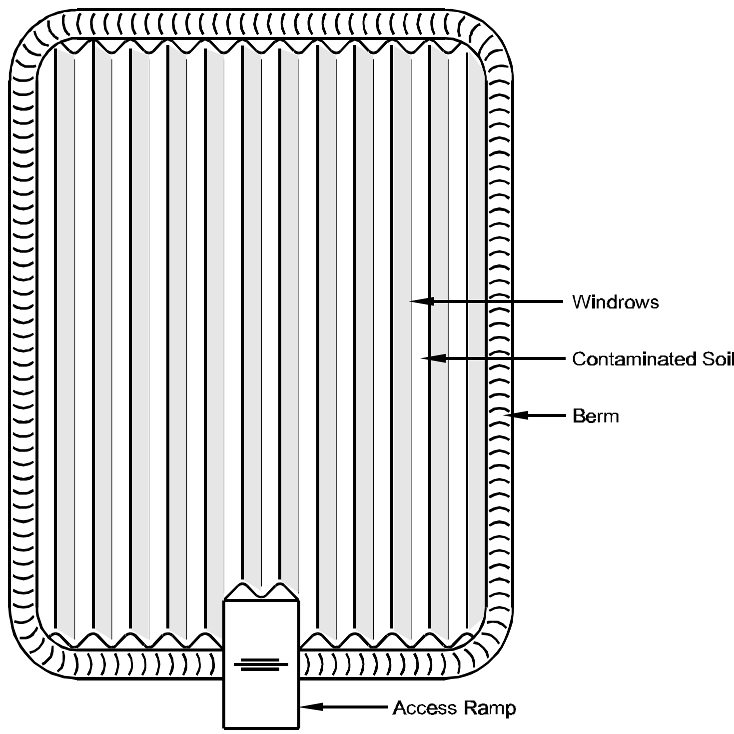
❍ *Landfarm Construction* includes: site preparation (grubbing, clearing and grading); berms; liners (if necessary); leachate collection and treatment systems; soil pretreatment methods (e.g., shredding, blending and amendments for fluffing, pH control); and enclosures and appropriate vapor treatment facilities (where needed). The construction design of a typical landfarm is shown as Exhibit V-13.

❍ *Aeration Equipment* usually includes typical agricultural equipment such as roto-tillers. The most favorable method is to use a disking device towed behind a tractor so that aerated soils are not tamped by the tractor tires.

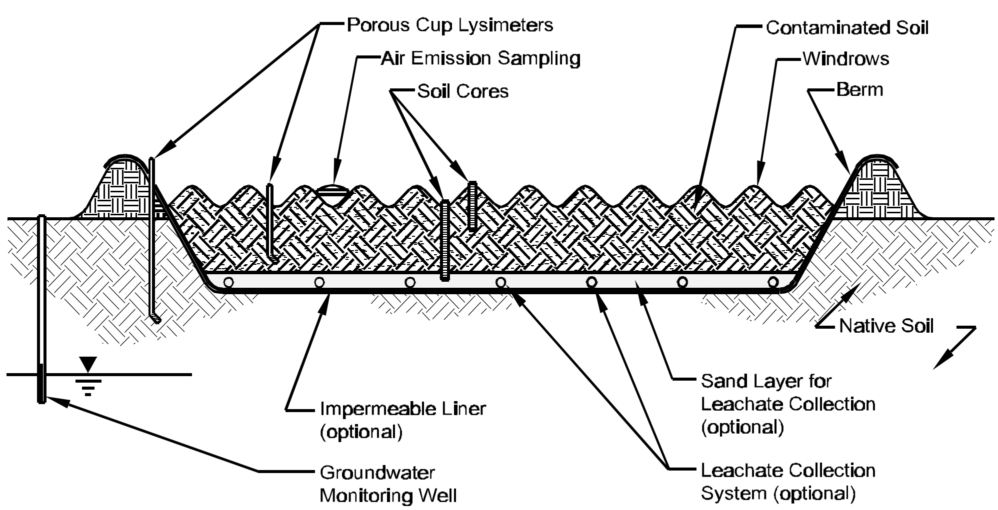
❍ *Water Management* systems for control of runon and runoff are necessary to avoid saturation of the treatment area or washout of the soils in the landfarm. Runon is usually controlled by earthen berms or ditches that intercept and divert the flow of stormwater. Runoff can be controlled by diversion within the bermed treatment area to a retention pond where the runoff can be stored, treated, or released under a National Pollution Discharge Elimination System (NPDES) permit.

❍ *Soil Erosion Control* from wind or water generally includes terracing the soils into windrows, constructing water management systems, and spraying to minimize dust.

Exhibit V-13
Construction Design Of A Typical Landfarm



PLAN VIEW
NOT TO SCALE



CROSS SECTION
NOT TO SCALE

- *pH Adjustment and Nutrient Supply* methods usually include periodic application of solid fertilizers, lime and/or sulfur while disking to blend soils with the solid amendments, or applying liquid nutrients using a sprayer. The composition of nutrients and acid or alkaline solutions/solids for pH control is developed in biotreatability studies and the frequency of their application is modified during landfarm operation as needed.

- *Site Security* may be necessary to keep trespassers out of the treatment area. If the landfarm is accessible to the public, a fence or other means of security is recommended to deter public contact with the contaminated material within the landfarm.

- *Air Emission Controls* (e.g., covers or structural enclosures) may be required if volatile constituents are present in the landfarm soils. For compliance with air quality regulations, the volatile organic emissions should be estimated based on initial concentrations of the petroleum constituents present. Vapors above the landfarm should be monitored during the initial phases of landfarm operation for compliance with appropriate permits or regulatory limits on atmospheric discharges. If required, appropriate vapor treatment technology should be specified, including operation and monitoring parameters.

Evaluation Of Operation And Remedial Progress Monitoring Plans

It is important to make sure that system operation and monitoring plans have been developed for the landfarming operation. Regular monitoring is necessary to ensure optimization of biodegradation rates, to track constituent concentration reductions, and to monitor vapor emissions, migration of constituents into soils beneath the landfarm (if unlined), and groundwater quality. If appropriate, ensure that monitoring to determine compliance with stormwater discharge or air quality permits is also proposed.

Operations Plan

Make certain that the plan for operating the landfarm described in the CAP includes the anticipated frequency of aeration, nutrient addition, and moisture addition. The plan should be flexible and modified based on the results of regular monitoring of the landfarm soils. The plan should also account for seasonal variations in ambient temperature and rainfall. In general, aeration and moisture and nutrient applications should be more frequent in the warmer, drier months. If the landfarm is covered with impervious sheeting (e.g., plastic or geofabric/textile), the condition of the cover must be checked periodically to ensure that it remains in place and that it is free of rips, tears, or other holes.

Provision should be made for replacement of the cover in the event that its condition deteriorates to the point where it is no longer effective. Particularly in the more northern states, operations may be suspended altogether during the winter months.

Remedial Progress Monitoring Plan

Make certain that the monitoring plan for the landfarm is described in detail and includes monitoring of landfarm soils for constituent reduction and biodegradation conditions (e.g., CO_2, O_2, CH_4, H_2S), air monitoring for vapor emissions if volatile constituents are present, soil and groundwater monitoring to detect potential migration of constituents beyond the landfarm, and runoff water sampling (if applicable) for discharge permits. Make sure that the number of samples collected, sampling locations, and collection methods are in accordance with state regulations. A monitoring plan for a typical landfarm operation is shown in Exhibit V-14.

Soils within the landfarm should be monitored at least quarterly during the landfarming season to determine pH, moisture content, bacterial population, nutrient content, and constituent concentrations. The results of these analyses, which may be done using electronic instruments, field test kits, or in a field laboratory are critical to the optimal operation of the landfarm. The results should be used to adjust aeration frequency, nutrient application rates, moisture addition frequency and quantity, and pH. Optimal ranges for these parameters should be maintained to achieve maximum degradation rates.

Exhibit V-14
Typical Remedial Progress Monitoring Plan For Landfarming

Medium To Be Monitored	Purpose	Sampling Frequency	Parameters To Be Analyzed
Soil in the landfarm	Determine constituent degradation and biodegradation conditions.	Monthly to quarterly during the landfarming season.	Bacterial population, constituent concentrations, pH, ammonia, phosphorus, moisture content, other rate limiting conditions.
Air	Site personnel and population health hazards.	During first two aerations, quarterly thereafter or to meet air quality requirements.	Volatile constituents, particulates.
Runoff water	Soluble or suspended constituents.	As required for NPDES permit.	As specified for NPDES permit; also hazardous organics.
Soil beneath the landfarm	Migration of constituents.	Quarterly or twice per landfarming season.	Hazardous constituents.
Groundwater downgradient of landfarm	Migration of soluble constituents.	Once per landfarming season (annually).	Hazardous, soluble constituents.

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Checklist: Can Landfarming Be Used At This Site?

This checklist can help you to evaluate the completeness of the CAP and to identify areas that require closer scrutiny. As you go through the CAP, answer the following questions. If the answer to several questions is no and biotreatability studies demonstrate marginal to ineffective results, request additional information to determine if landfarming will accomplish cleanup goals at the site.

1. Soil Characteristics That Contribute To Landfarming Effectiveness

Yes No

❏ ❏ Is the total heterotrophic bacteria count > 1,000 CFU/gram dry soil?

❏ ❏ Is the soil pH between 6 and 8?

❏ ❏ Is the soil moisture between 40% and 85%?

❏ ❏ Is the soil temperature between 10°C and 45°C?

❏ ❏ Is the carbon:nitrogen:phosphorous ratio between 100:10:1 and 100:1:0.5?

❏ ❏ Does the soil divide easily and tend not to clump together?

2. Constituent Characteristics That Contribute To Landfarming Effectiveness

Yes No

❏ ❏ Are products to be treated primarily kerosene or heavier (i.e., not gasoline), or will air emissions be monitored and, if necessary, controlled?

❏ ❏ Are most of the constituents readily degradable?

❏ ❏ Are total petroleum constituents $\leq$ 50,000 ppm and total heavy metals $\leq$ 2,500 ppm?

3. Climatic Conditions That Contribute To Landfarming Effectiveness

Yes No

❏ ❏ Is the rainfall less than 30 inches during the landfarming season?

❏ ❏ Are high winds unlikely?

4. Biotreatability Evaluation

Yes No

❑ ❑ Has a biotreatability study been conducted?

❑ ❑ Were biodegradation demonstrated, nutrient application and formulation defined, and potential inhibitors or toxic conditions checked?

5. Evaluation Of Landfarm Design

Yes No

❑ ❑ Is sufficient land available considering the landfarm depth and additional space for berms and access?

❑ ❑ Are runon and runoff controlled?

❑ ❑ Are erosion control measures specified?

❑ ❑ Are the frequency of application and composition of nutrients and pH adjustment materials specified?

❑ ❑ Is moisture addition needed?

❑ ❑ Are other sub-optimal natural site conditions addressed in the landfarm design?

❑ ❑ Is the site secured?

❑ ❑ Are air emissions estimated and will air emissions monitoring be conducted?

❑ ❑ Are provisions included for air emissions controls, if needed?

6. Operation And Monitoring Plans

Yes No

❑ ❑ Is monitoring for stormwater discharge or air quality permits (if applicable) proposed?

❑ ❑ Does the operation plan include the anticipated frequency of aeration, nutrient addition, and moisture addition?

❑ ❑ Does the monitoring plan propose measuring constituent reduction and biodegradation conditions in the landfarm soils?

6. Operation And Monitoring Plans (continued)

Yes No

- ❏ ❏ Are air, soil, and surface runoff water sampling (if applicable) proposed to ensure compliance with appropriate permits?

- ❏ ❏ Are the proposed numbers of samples to be collected, sampling locations, and collected methods in accordance with state regulations?

- ❏ ❏ Is quarterly (or more frequent) monitoring for soil pH, moisture content, bacterial population, nutrient content, and constituent concentrations proposed?

Exhibit 41

Here are the five hottest days in Texas history

We all feel the heat as summer temperatures soar. Last summer brought the most consecutive days of record-breaking average temperatures in Texas. However, the June 2023 Texas heat wave swept across the state and broke records for the highest recorded temperatures. The hottest day in Texas this year nearly surpassed the all-time high temperature recorded in August 1936.

Learn more about the 2023 Texas heatwave, the hottest days in Texas history, and the best methods for saving energy during extreme heat.

Hottest temperature in Texas 2023

The Texas heatwave in June brought scorching temperatures throughout the state, with many areas reaching consecutive triple-digit highs. In 2022, the Big Bend region experienced 78 days of temperatures over 100 degrees Fahrenheit. This year, the Rio Grande Village in Big Bend nearly broke the hottest day in Texas history.

Experts explain the heat wave comes from climate change and high-pressure weather patterns. This pressure leads to dry soil and air that no longer provides cooling relief from evaporation.

Keep reading to learn more about the hottest temperatures recorded in Texas and find out which cities broke records in 2023.

Hottest temperatures recorded in Texas history

Dallas and Fort Worth – 113 degrees

Temperatures soared to astonishingly high numbers in Dallas and Fort Worth during a record summer on June 26 and 27, 1980. The average Texas high in June clocks in around 92 degrees, so these temperatures likely took Texans by surprise.

San Angelo, El Paso, and Waco – 114 degrees

The 2023 Texas heat wave led to a new record temperature in San Angelo. On June 19, the city tied its record high of 111 degrees. The next day, the city recorded a new daily high temperature reaching 114 degrees.

El Paso and Waco tied for one of the hottest days in Texas on June 30, 1994, and July 23, 2018, respectively. In 1994, El Paso temperatures hit an impressive 114 degrees. Twenty-four years later, Waco's summer temperature hit the same level.

Del Rio – 115 degrees

In the span of a week, Del Rio's summer heat wave soared to new extremes, breaking the city's hottest-day record three times. The week started with a new record of 111 degrees on June 18, 2023, followed by 113 degrees on June 20, 2023. The latest record-breaking temperature in Del Rio reached 115 degrees on June 21, 2023.

Midland-Odessa – 116 degrees

June 1994 is on our list again, with another scorching hot day on June 27. These extreme temperatures spanned several Texas regions, but Midland–Odessa experienced the highest temperature of 116 degrees.

Wichita Falls – 117 degrees

The summer of 1980 will go down in history as one of the toastiest summers on record in Texas. Wichita Falls reached 117 degrees on June 28, 1980 — but record-high temperatures in the triple digits lasted throughout the weekend.

Big Bend – 119 degrees

The Rio Grande Village in Big Bend National Park reached a new record high of 119 degrees on June 23, 2023. This record is only one degree away from the hottest temperature ever recorded in Texas.

Monahans and Seymour – 120 degrees

Two dates tie for the hottest day in Texas history. On August 12, 1936, Seymour clocked in intimidating temperatures reaching 120 degrees. Then on June 28, 1994, Monahans also reached 120 degrees. The heat wave of 1994 earned the most spots on this list, but the summer of 1936 is the earliest recorded super-hot day in history.

How to save energy during a heatwave

Texans are no strangers to scorching summer days and rely on well-functioning air conditioners to stay cool and comfortable. During a heat wave, the natural reaction is to lower the thermostat, which is not energy efficient and can result in higher energy bills. The closer the temperature inside your house is to outside, the less energy your home will use. Most heating and air systems can cool a house by around 15 to 25 degrees compared to the outside temperature. If temperatures reach 100, your home temperature will only reach about 75 degrees.

Conserving energy can help lower your electricity bills and reduce your environmental impact. According to the U.S. Energy Information Administration, most residential energy consumption comes from heating and cooling. There are many ways to save energy at home without touching the thermostat.

Run appliances during the morning or overnight to avoid peak energy hours.

Consider investing in energy-efficient appliances.

Use the microwave instead of the oven to heat food.

Use LED lightbulbs instead of traditional lightbulbs.

Turn off electronics, like the television, when not in use.

There are several simple ways to save energy in your home, especially during hot summer days. Texas is known for its heat, and residents have learned the importance of having a solid electricity plan to keep their energy bills from reaching record highs.

SaveOnEnergy is an online electricity marketplace that can help you search for, compare, and sign up for the best energy plan for you. If you're unsatisfied with your current Texas energy rate, you can switch energy providers quickly and easily. Call the number on your screen to learn more about energy plans near you.

Exhibit 42

Is there a limit to how hot it can get in West Texas?

Dan Grigsby

Let's take a look at why temperatures struggle to rise above a certain point.

MIDLAND, Texas — Temperatures have skyrocketed each afternoon over the past few days. Just east of us in San Angelo, the temperature rose all the way up to 113 degrees Fahrenheit on Tuesday afternoon, creating a new all-time record high for the city.

We likely won't get quite that hot here in Midland-Odessa, but it will still get warm enough to have people question the physical limitations of just how high of a temperature we can achieve.

It's not too uncommon to see temps reach around 110 F here in the summer. However, it becomes increasingly difficult to heat up beyond that point.

Conditions have to be near perfect for us to hit 115 F. In fact, the record high temperature for Midland is 116 F, set back on June 27, 1994. The state record is 120 F, which was achieved in Monahans the following day on June 28, 1994.

Highs in that temperature range are rare because conditions must be perfect.

In order to see that kind of heat, we need a lot of incoming solar radiation. The max allowable amount occurs toward the end of June, when the sun rises highest in the sky and the days are longest, with the most hours of sunlight. This allows plenty of time for the sun to do its work in heating us up.

We get even warmer when there's little to no clouds in the sky. Clouds have a high albedo and act as a shield to reflect incoming sunlight back into space. We are often several degrees cooler on days with overcast skies compared to days in which there are no clouds.

Another factor that determines how warm we get is how dry the air is. Dry air, composed of nitrogen and oxygen, heats up about 4 times as quickly as liquid water. So, when you start adding humidity (aka water vapor) to the air, the heat capacity begins to rise. That is, it takes more energy to raise a unit of matter by a unit of temperature.

So dry air, or the absence of water, is a critical component for allowing temperatures to approach their theoretical maximum.

High atmospheric pressure is another important factor to consider. Pressure and temperature are directly proportional. As pressure increases, temperature begins to increase and vice versa due to a simple rule of physics known as Gay-Lussac's Law.

This can be observed not just in the atmosphere, but in the home as well. A good example is when you expose a can of aerosol to heat, the pressure inside the can increases, sometimes so much that the can may explode. This is why warning labels may say to keep it at room temperature.

In meteorology, the impact on temperature from high pressure is called compressional warming. Along with high solar radiation and dry air, compressional warming is a necessity for letting us reach our maximum allowable high temperature.

Although that figure isn't precisely known, it can't be too much warmer than the record of 116 F. The reason being is that there just isn't a whole lot more you can do to help heat us up other than the factors mentioned above.

In order for temperatures reach over 110 F, conditions really do need to be close to perfect in terms of having the minimum allowable water content in air and having the maximum allowable pressure and solar radiation.

And because there's a limit to how favorable conditions can be, so too is there a limit to how high temperatures get. That limit appears to be around 115 F. It gets exponentially harder for temps to rise after about 100 F, which is why we often see high temps plateau like they are now, at about 109 F.

With our current heat wave, almost everything is perfect — the air is extremely dry, the atmospheric pressure is high and the days are long.

However, there is one thing holding us back from being even warmer, and that is the clouds. There has been high cirrus clouds in place over the past few days, which have kept highs down slightly.

By the time the clouds dissipate, one of the other factors will likely move out of the realm of perfection, whether it be humidity or pressure. It's rare to have everything lined up perfectly at once, which is why temperatures above 110 F are rare. So, for this reason, it is unlikely, but still possible, that we will see temperatures warm even further.

Exhibit 43

Closure Table 2

Landfarm, Landtreatment, and Land Application permits: Standard Soil Sampling Closure Parameters

PARAMETER	LIMITATION
pH *EPA Method 9045C or equivalent*	6 to 10 standard units
Electrical Conductivity (EC) [1]	≤ 4.0 mmhos/cm
Sodium Adsorption Ratio (SAR) *Saturated Paste Method using EPA Method 300, 6010, 6020 or equivalent*	≤ 12
Cation-Exchange Capacity (CEC) *EPA Method 9080/9081 or equivalent*	Site Specific[2]
TPH *EPA Method 5035A/TX1005*	≤ 10,000 mg/kg or 1 % by weight
Total Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)[3] *EPA Method 5035A/8021/8260B or equivalent*	≤ 30 mg/kg
Metals (Total) *EPA Method 6010/6020/7471A or equivalent*	
Arsenic	≤ 10 mg/kg
Barium	≤ 10,000 mg/kg
Cadmium	≤ 10 mg/kg
Chromium	≤ 100 mg/kg
Lead	≤ 200 mg/kg
Mercury	≤ 10 mg/kg
Selenium	≤ 10 mg/kg
Silver	≤ 200 mg/kg

[1] LDNR Lab Procedures for Extraction and Analysis of E&P Waste or equivalent

[2] CEC limitation will be determined based on background analytical data

[3] BTEX testing is only required for landtreatment facilities.

Exhibit 44

AN ACT

relating to the regulation of the recycling of fluid oil and gas waste.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

SECTION 1. Section 122.004, Natural Resources Code, is amended to read as follows:

Sec. 122.004. COMMISSION RULES FOR TREATMENT AND BENEFICIAL USE. (a) The commission shall adopt rules to govern the treatment and beneficial use of oil and gas waste.

(b) Rules adopted under this section must:

(1) encourage fluid oil and gas waste recycling for beneficial purposes; and

(2) establish standards for the issuance of permits for commercial recycling of fluid oil and gas waste.

(c) In adopting rules under this section, the commission shall consider previously adopted rules for recycling fluid oil and gas waste.

(d) Rules adopted under this section for commercial recycling of fluid oil and gas waste must establish:

(1) minimum siting standards for fluid recycling pits;

(2) uniform technical, construction, and placement standards;

(3) uniform standards for estimating closure costs;

(4) minimum and maximum bonding and financial security amounts based on factors determined by the commission; and

(5) standards for sampling and analysis of fluid oil and gas waste.

(e) The commission shall approve or deny an application for a permit issued under rules adopted under this section not later than the 90th day after the date the complete application was received by the commission, unless a protest is filed with the commission, in which case the commission may extend the amount of time to approve or deny the application in order to allow for notice, public comment, and a public hearing on the application. If the commission does not approve or deny the application before that date, the permit application is considered approved and the applicant may operate under the terms specified in the application for a period of one year.

(f) An application requesting a variance from the standards adopted under this section must be evaluated and determined to be substantially similar to previous variances approved by the commission.

SECTION 2. This Act takes effect September 1, 2021.

______________________________ President of the Senate

______________________________ Speaker of the House

I certify that H.B. No. 3516 was passed by the House on April 27, 2021, by the following vote: Yeas 144, Nays 2, 1 present, not voting.

______________________________ Chief Clerk of the House

I certify that H.B. No. 3516 was passed by the Senate on May 21, 2021, by the following vote: Yeas 31, Nays 0.

______________________________ Secretary of the Senate

APPROVED: _____________________
Date

____
Governor

Exhibit 45

Texas Counties: Lane Miles, Certified County Roads

Compiled by
The County Information Program, Texas Association of Counties
Data source: Texas Department of Transportation. Annual Roadway Inventory Reports. (2022)

The County Information Program | County Profiles | Advanced Search | Town & City Search

The information contained in this report was obtained from The County Information Program's on-line database. The data contained in the database are obtained from official sources and are not the product of the CIP. The CIP, therefore, does not expressly or impliedly warrant the accuracy of the data. Questions regarding the accuracy, methodology, etc. should be directed to the original source of the information. The sources may be obtained from the CIP by contacting the County Information Program, Texas Association of Counties at (512) 478-8753.

Map This Dataset - Generates a map of all 254 counties using the data in this table.

Lane Miles, Certified County Roads	
Anderson	1,796.906
Andrews	561.515
Angelina	1,435.231
Aransas	331.598
Archer	826.230
Armstrong	848.410
Atascosa	1,531.562
Austin	1,197.570
Bailey	1,569.382
Bandera	864.672
Bastrop	1,919.466
Baylor	665.840
Bee	892.806
Bell	1,801.658
Bexar	2,948.684
Blanco	435.080
Borden	449.992
Bosque	1,331.506
Bowie	1,507.566
Brazoria	2,445.750
Brazos	953.418
Brewster	346.432
Briscoe	761.434

Brooks	221.170
Brown	1,512.730
Burleson	1,190.862
Burnet	961.214
Caldwell	853.012
Calhoun	441.022
Callahan	967.336
Cameron	1,451.394
Camp	486.298
Carson	1,216.324
Cass	1,915.161
Castro	1,783.228
Chambers	613.694
Cherokee	1,864.084
Childress	857.380
Clay	1,425.680
Cochran	1,012.326
Coke	528.848
Coleman	1,528.710
Collin	1,583.604
Collingsworth	1,101.854
Colorado	1,476.466
Comal	1,733.904
Comanche	1,489.042
Concho	763.332
Cooke	1,587.306
Coryell	1,253.566
Cottle	628.732
Crane	168.130
Crockett	760.214
Crosby	1,390.070
Culberson	1,032.204
Dallam	991.928
Dallas	197.356
Dawson	1,847.214
Deaf Smith	1,900.550
Delta	483.042
Denton	1,744.010
DeWitt	1,360.236

Dickens	804.510
Dimmit	348.336
Donley	701.958
Duval	810.397
Eastland	1,393.536
Ector	1,151.477
Edwards	554.462
Ellis	1,821.576
El Paso	1,465.642
Erath	1,671.262
Falls	1,511.448
Fannin	1,862.658
Fayette	1,726.978
Fisher	1,274.960
Floyd	1,943.514
Foard	650.446
Fort Bend	4,208.828
Franklin	636.287
Freestone	1,301.020
Frio	759.168
Gaines	2,112.136
Galveston	666.125
Garza	499.624
Gillespie	1,087.386
Glasscock	430.364
Goliad	634.532
Gonzales	1,377.532
Gray	1,201.778
Grayson	2,572.665
Gregg	511.566
Grimes	1,193.146
Guadalupe	1,301.262
Hale	2,650.324
Hall	842.508
Hamilton	1,125.546
Hansford	934.540
Hardeman	975.392
Hardin	1,051.598
Harris	13,259.324

Harrison	1,450.398
Hartley	512.200
Haskell	1,459.512
Hays	1,651.012
Hemphill	696.536
Henderson	1,662.692
Hidalgo	3,352.136
Hill	2,149.736
Hockley	2,268.285
Hood	934.456
Hopkins	1,680.732
Houston	1,454.540
Howard	1,024.224
Hudspeth	959.298
Hunt	2,119.630
Hutchinson	680.062
Irion	219.774
Jack	810.520
Jackson	974.656
Jasper	1,311.310
Jeff Davis	91.414
Jefferson	737.962
Jim Hogg	205.818
Jim Wells	1,105.241
Johnson	1,830.446
Jones	1,737.852
Karnes	1,092.320
Kaufman	1,743.776
Kendall	822.368
Kenedy	18.790
Kent	433.046
Kerr	894.506
Kimble	636.398
King	398.308
Kinney	126.192
Kleberg	358.414
Knox	802.866
Lamar	1,725.441
Lamb	2,387.590

Lampasas	896.726
La Salle	446.880
Lavaca	1,726.402
Lee	971.056
Leon	1,209.146
Liberty	1,964.642
Limestone	1,758.464
Lipscomb	841.494
Live Oak	1,004.024
Llano	1,042.640
Loving	86.612
Lubbock	2,394.890
Lynn	1,825.630
McCulloch	808.938
McLennan	2,145.423
McMullen	346.114
Madison	513.650
Marion	702.500
Martin	917.586
Mason	560.986
Matagorda	1,173.804
Maverick	332.693
Medina	1,600.866
Menard	261.122
Midland	974.870
Milam	1,581.340
Mills	881.506
Mitchell	908.730
Montague	1,554.690
Montgomery	5,949.700
Moore	673.426
Morris	520.510
Motley	476.086
Nacogdoches	1,528.354
Navarro	1,828.698
Newton	1,112.400
Nolan	954.602
Nueces	1,406.356
Ochiltree	1,336.752

Oldham	332.500
Orange	789.942
Palo Pinto	836.742
Panola	1,211.216
Parker	2,473.246
Parmer	2,126.986
Pecos	1,040.514
Polk	1,734.516
Potter	594.604
Presidio	375.284
Rains	522.720
Randall	1,616.988
Reagan	405.714
Real	298.282
Red River	1,216.062
Reeves	1,050.534
Refugio	356.266
Roberts	476.128
Robertson	1,029.520
Rockwall	207.306
Runnels	1,582.206
Rusk	1,921.598
Sabine	643.426
San Augustine	739.954
San Jacinto	965.008
San Patricio	1,216.468
San Saba	1,104.876
Schleicher	429.754
Scurry	1,262.272
Shackelford	479.090
Shelby	1,485.772
Sherman	862.016
Smith	2,354.316
Somervell	306.336
Starr	938.824
Stephens	699.804
Sterling	99.458
Stonewall	661.042
Sutton	357.348

Swisher	1,879.322
Tarrant	781.742
Taylor	1,370.368
Terrell	129.826
Terry	1,933.372
Throckmorton	618.902
Titus	850.752
Tom Green	1,272.534
Travis	2,864.022
Trinity	757.498
Tyler	1,099.358
Upshur	1,332.000
Upton	268.358
Uvalde	663.552
Val Verde	660.852
Van Zandt	2,120.846
Victoria	1,245.342
Walker	1,103.164
Waller	1,062.628
Ward	472.880
Washington	1,248.634
Webb	711.162
Wharton	1,821.712
Wheeler	1,160.436
Wichita	769.760
Wilbarger	1,158.366
Willacy	922.452
Williamson	3,167.322
Wilson	1,604.542
Winkler	276.782
Wise	1,881.278
Wood	1,555.750
Yoakum	982.583
Young	1,125.660
Zapata	353.412
Zavala	348.762

Data source: Texas Department of Transportation. Annual Roadway Inventory Reports.
Data year: 2022

Exhibit 46

Highways in Texas

Introduction | Bridge | Mobility | Pavement | Safety

TEXAS TRANSPORTATION PLAN 2050

The State of Highways in Texas

Highways make all parts of Texas accessible to commerce and the traveling public. Scroll down to learn more or click on the Highway component tabs above to learn more about the Texas highway system.

The State of Highways in Texas

Texas Highway Network

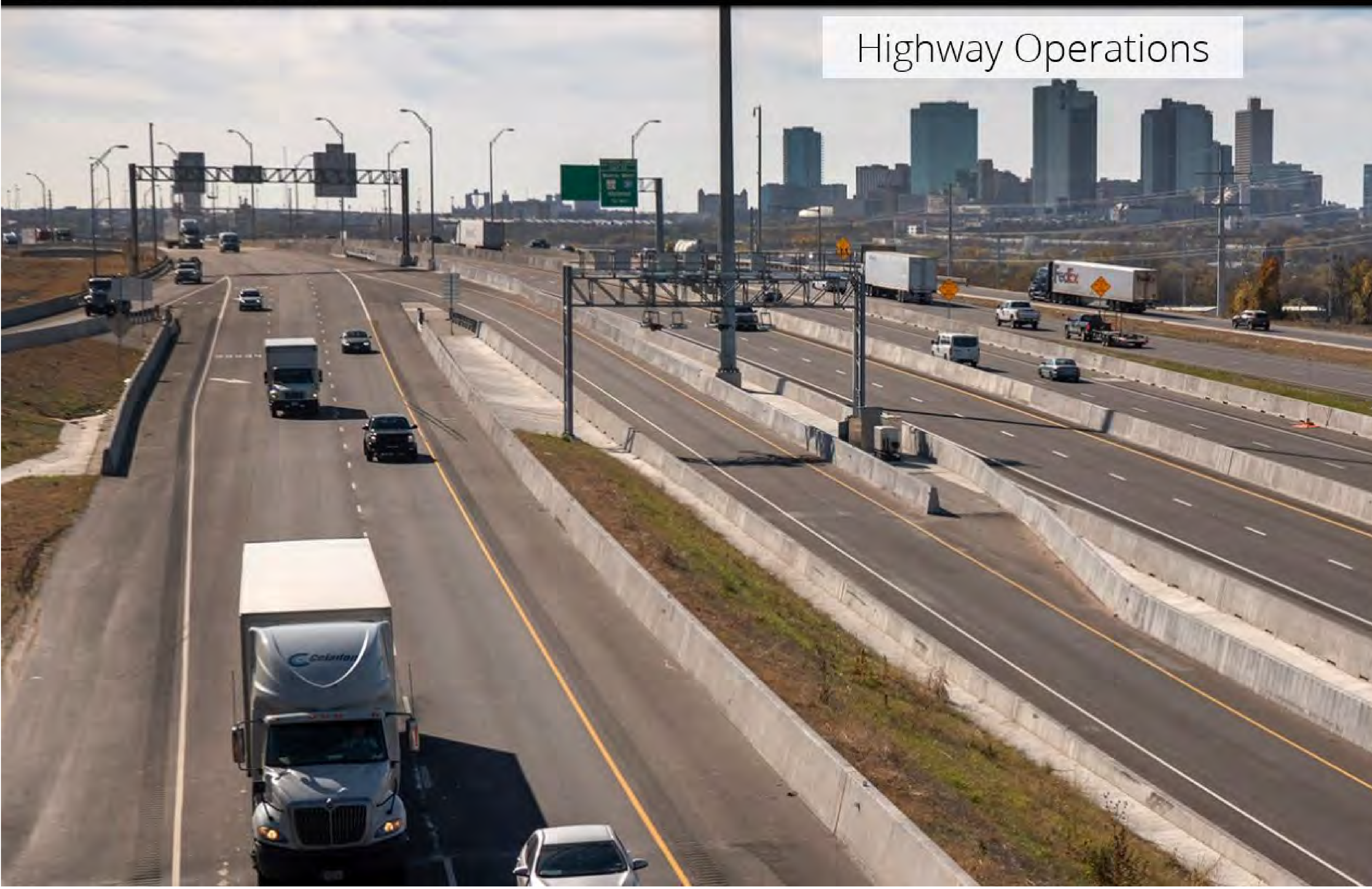
Texas has the largest highway network of any state in the country with 314,000 miles of public road. *(1)* If these roads were placed end-to-end they would extend from Earth to beyond the Moon.

The size of a roadway can be measured in a couple of different ways. Centerline miles are the total length of a road calculated by measuring the road's center line. Lane miles account for all of the lanes in a roadway. They are calculated by multiplying the centerline length by the number of lanes. Therefore, the lane miles of a roadway are usually greater than the centerline miles.

Photos: I-35 at SH 45 in Round Rock (cover). Loop 289 in Lubbock (right).

(1) TxDOT (2017). Roadway Inventory Annual Report.

The State of Highways in Texas



Highway Operations

Operations and maintenance of the highway system in Texas is complex. It includes highways that are designated as being part of the National Highway System (NHS) – both interstate and non-interstate – as well as highways that are not part of the NHS. These are categorized into two designations:

• On-state system: Highways owned, maintain and operated by TxDOT

• Off-state system: Highways not owned, maintained, operated by TxDOT.

The Texas Department of Transportation (TxDOT) preserves and maintains the on state-system network, which comprises a quarter of the state's centerline miles and some of its busiest roads. County and municipal governments manage most of the remainder of the Texas public road system (Figure 1).

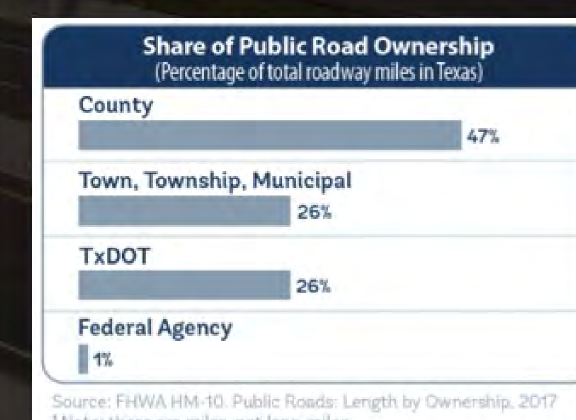


Figure 1. Share of Public Road Ownership *(2)*.

Photo: I-35W in Fort Worth.

(2) FHWA (2017). HM-10. Public Roads: Length by Ownership.

The State of Highways in Texas

- The 748 million daily vehicle miles traveled (VMT) in Texas are enough to travel from the earth to the moon and back again every minute of each day.
- About 72 percent of daily VMT occur on state-owned roads.
- Congestion in Texas cost the equivalent of nearly $12 billion in 2018 due to lost time and wasted fuel.
- The total hours lost to delay in 2018 is the equivalent to 66,000 person-years. *(3)*

In addition to programs such as Texas Clear Lanes that expand capacity, technology can help existing roads accommodate more vehicles more smoothly and safely. For example, TxDOT's use of intelligent transportation systems (ITS) infrastructure helps TxDOT manage capacity on the system, especially during peak demand. *(4)* Additionally, new vehicle technologies like connected or autonomous driving features may allow vehicles to safely travel closer together, creating additional road capacity. Conversely, automated vehicles may make driving more convenient and less expensive, causing an overall increase in VMT. *(5)*

Photo: FM 898 at U.S. 82 in Fannin County.

(3) Texas A&M Transportation Institute (2018). Texas' Most Congested Roadways 2018.

(4) TxDOT (2019). Texas Clear Lanes.

(5) Litman, T. (2019). Autonomous Vehicle Implementation Predictions: Implications for Transportation Planning. Victoria Transport Policy Institute.

Credits

Photos | TxDOT Communications Division