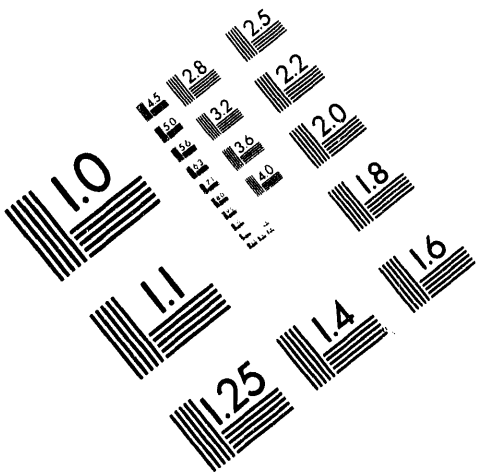

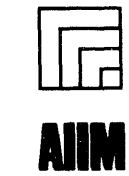

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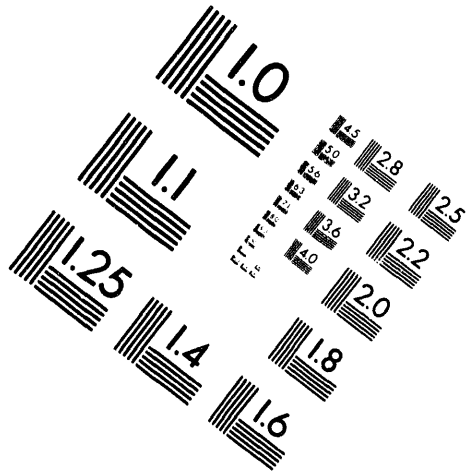

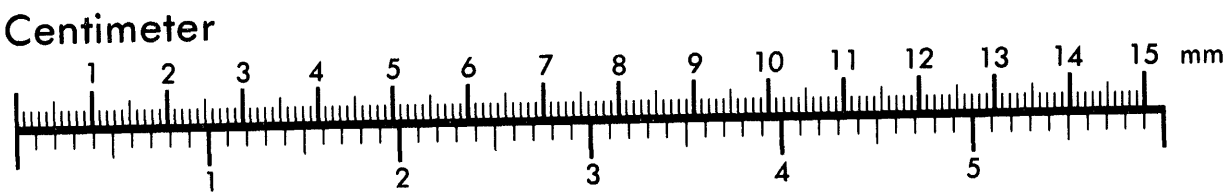

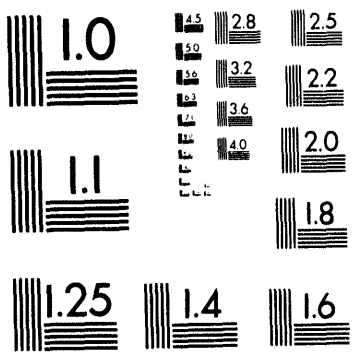

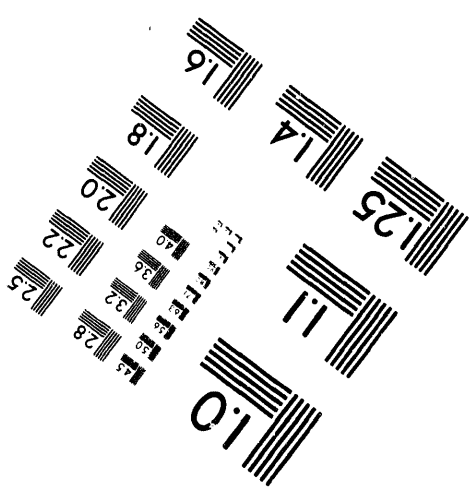

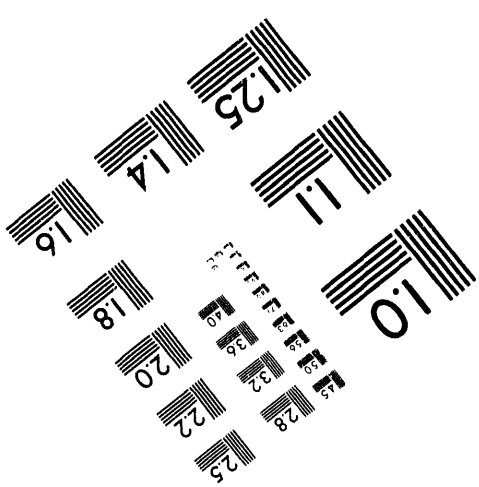

1 of 1

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IDENTIFICATION TITLE AND NUMBER
Characterization of Oil and Gas Waste Disposal Practices and Assessment of Treatment Costs
Engineering
DE-AC22-92-MT92007

PARTICIPANT NAME AND ADDRESS:
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Program Manager	Philip B. Bedient
Principal Investigator(s)	Philip B. Bedient
Technical Project Officer	Brent Smith U.S. Department of Energy Metairie Site Office 900 Commerce Road E. New Orleans, LA 70123
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CHARACTERIZATION OF OIL AND GAS WASTE DISPOSAL PRACTICES AND ASSESSMENT OF TREATMENT COSTS

Executive Summary

This project consists of 3 tasks: 1) Developing a Production Environmental Database (PED) with the purpose of investigating the current industry waste storage and disposal practices by different regions, states, and types of waste and investigating the environmental impacts associated with these practices; 2) Evaluating the suitability of available and developing technologies for treating the waste streams identified in Task 1 and identifying unit process configurations; and 3) Evaluating the costs associated with various degrees of treatment achievable by different treatment configurations.

Much of the data analyses for the PED were completed over the past three months. More specifically, the following correlations between well completions and selected environmental parameters have been conducted throughout the eight counties in Texas:

- Completions relative to land use
- Completions relative to proximity to a surface water body
- Completions relative to proximity to water supply wells
- Completions relative to ground water usage
- Completions relative to freshwater aquifer regions
- Completions relative to DRASTIC regions
- Completions relative to parklands

Reverse osmosis (R/O), the method chosen to desalinate produced water containing low to mid range concentrations of total dissolved solids (TDS), has been evaluated. The costs incurred when using this type of treatment have been calculated and related to the amount of contaminant found in the raw waste streams. The R/O system chosen to desalinate all of the produced waters will reduce the TDS concentration by 94 percent during one pass.

Package plant treatment has also been examined for the treatment of the produced waters. Capital as well as operation and maintenance costs were developed for this type of treatment. The package complete plants will accomplish the removal of suspended solids and heavy metals from the produced water. These plants contain sections for coagulation, flocculation, sedimentation, and filtration. These processes follow the addition of coagulants and cause the suspended solids and whatever heavy metals are sorbed to them to aggregate and settle or be filtered out of solution. Approximately, 600 mg/l of alum and 200 mg/l of ferric sulfate were chosen as the coagulants to be added to each produced water. This coagulant type and dosage was selected to be added to each of the produced waters to accomplish conventional treatment, regardless of the amount of contaminant found in the individual waste streams.

Introduction

This report covers work completed during the seventh quarter for the project. The project consists of three tasks: the first relates to developing a database of waste volumes and disposal methods used by the industry; the second and third tasks are aimed at investigating technologies that could be used for the treatment of produced waters and developing cost estimates for those technologies.

The remainder of this report describes progress related to the three tasks in the project. Overall, the majority of data analyses using information from the PED have been completed. A detailed correlation between well completions and a variety of environmental characteristics in the eight counties in Texas was developed. In terms of the treatment of produced water, much of the work in the past quarter was focused on analyzing the costs associated with treatment using reverse osmosis and package treatment plants.

Project Description

The proposed effort consists of 3 tasks:

Task 1. Developing a Production Environmental Database (PED) with the purpose of investigating the current industry waste storage and disposal practices and investigating the environmental impacts associated with these practices. Task 1 is composed of subtasks as follows:

1. Estimate quantities of waste generated by oil and gas extraction by state, region, and type.

2. Develop a profile for the waste characteristics by state, region, and type.

3. Determine current industry waste storage and disposal practices by state, region, and type.

4. Develop the environmentally significant characteristics of the disposal methods used.

5. Determine the hydrogeologic, surface water and exposure point characteristics of "receptor environments" .

6. Investigate the predominant landuse patterns surrounding oil and gas activities.

7. Assess the environmental impacts of oil and gas activities on a state and regional basis.

8. Assess the differences in environmental impacts analyzed on a statewide and regional basis from those determined from site-specific data.

9. Analyze the data statistically to develop distributions for some of the parameters on a state, regional and nationwide basis.

10. Assimilate all the data in a database.

Tasks 2 and 3. Tasks two and three of this project address the impacts and costs of coproduced water disposal. Different disposal practices may require different levels of water treatment to avoid negative environmental impact. Physicochemical treatment unit processes for waste water will be evaluated with respect to their suitability in treating water that has been coproduced with oil and gas. Several treatment scenarios representing various configurations and combinations of unit processes will be evaluated. The costs of these scenarios will then be compared with the environmental impact associated with a designated disposal practice or use for the treated water. Water quality, will be expressed by the concentrations of specific target contaminants as well as several composite parameters. Contaminants of concern will be grouped based on the likely similarities of both the unit processes required to remove them, and their chemical makeup. Thus, an assessment of treatment technologies and costs for one parameter within such a group may be useful in assessing the treatment and cost for another contaminant.

Composite parameters, such as TOC, give an indication of the total concentration of several contaminants in water. In some instances , it may be useful to estimate treatment costs by attributing the chemical characteristics of a representative constituent compound (e.g. benzene) to a given composite parameter (e.g. total organic carbon). Alternatively a solution weighted average of the characteristics of several constituent contaminants might be used. Process performance, in terms of removal efficiency and effluent concentration, will be evaluated using simulation models for candidate processes. Existing cost information for these processes will be used in conjunction with performance calculations to generate trade off curves for water quality (environmental impact) and treatment cost.

Project Status

Task 1. Much of the data analyses for the PED were completed over the past three months. More specifically, the following correlations between well completions and selected environmental parameters have been conducted throughout the eight counties in Texas:

- Completions relative to land use
- Completions relative to proximity to a surface water body
- Completions relative to proximity to water supply wells
- Completions relative to ground water usage
- Completions relative to freshwater aquifer regions

- Completions relative to DRASTIC regions
- Completions relative to parklands

Based on the data analyses presented above, it was determined that the majority of well completions for the years 1988, 1990 and 1992 in Brazoria and Wise counties occurred in Cropland and Pasture classified land use areas. The majority of well completions for the other counties with the exception of Panola county, on the other hand, occurred in either herbaceous rangeland, mixed rangeland, or shrub and brush rangeland. Most well completions in Panola County occurred in mixed forest land use areas. The correlation between well completions and land use is shown in Table 1.

It was also determined that less than 25% of all well completions in the eight counties for the years 1988, 1990 and 1992 were within 100 m of a surface water body. However, more than 70% of well completions were within 1,000 m of a surface water body. The correlation between well completions and proximity to a surface water body are shown in Table 2.

Similarly, less than 25% of all well completions in the eight counties for the years 1988, 1990 and 1992 were within 500 m of a water supply well. No more than 71% of all wells were within 1,500 m. Interestingly enough, a higher percentage of well completions in Brazoria and Ector counties were within 1,000 m of a water supply well than for the other counties (see Table 3).

An analysis of ground water usage within a mile radius of well completions in the eight counties indicated that more than 30% of the ground water used in Lee, Webb and Wise counties was applied for domestic uses. In comparison, the majority of ground water use in Moore County was for irrigation (see Table 4).

The correlation between well completions and freshwater aquifer regions was slightly more complicated. Essentially, well completions were compared to the occurrence of a freshwater supply depending on the depth of the wells and the depth of the base of the freshwater aquifer. Results indicated that the majority of well completions will encounter a freshwater aquifer which is less than 400 ft deep (with the exception of Webb county since there are no aquifers that shallow). The majority of wells in Brazoria, Ector, and Lee counties still encountered freshwater supplies even at depths of greater than 3,500 ft.

Data analyses indicated that the majority of well completions for the eight counties with the exception of Moore and Webb counties occurred in areas with DRASTIC indices greater than 80 (the range for the index is 64 to 155, with higher values indicating increased vulnerability to shallow ground water pollution). These data are shown in Table 6.

Finally, results from the analyses indicated that at most three wells were completed in 1988, 1990 and 1992 in the eight counties within parklands (see Table 7).

Tasks 2 and 3. Reverse osmosis (R/O), the method chosen to desalinate produced water containing low to mid range concentrations of total dissolved solids (TDS), has been evaluated. The costs incurred when using this type of treatment have been calculated and related to the amount of contaminant found in the raw waste streams. The R/O system chosen to desalinate all of the produced waters will reduce the TDS concentration by 94 percent during one pass. A second pass through the system will be executed for a portion of the waste streams that do not meet effluent quality standards after just one pass. Produced waters containing between 1,000 and 60,000 ppm of TDS will be treated with this process. The equations used in this examination of R/O treatment were developed by Remediation Technologies Inc. for the Gas Research Institute (GRI). GRI applied these equations to evaluate the costs associated with the R/O treatment of waste streams having characteristics similar to those found in the database developed for this study. These equations have been found to reasonably predict the cost of specific R/O systems that are currently operating. In general, the difference between the observed costs and the predicted costs was less than ten percent.

Package plant treatment has also been examined for the treatment of the produced waters. Capital as well as operation and maintenance costs were developed for this type of treatment. The package complete plants will accomplish the removal of suspended solids and heavy metals from the produced water. These plants contain sections for coagulation, flocculation, sedimentation, and filtration. These processes follow the addition of coagulants and cause the suspended solids and whatever heavy metals are sorbed to them to aggregate and settle or be filtered out of solution. Approximately, 600 mg/l of alum and 200 mg/l of ferric sulfate were chosen as the coagulants to be added to each produced water. This coagulant type and dosage was selected to be added to each of the produced waters to accomplish conventional treatment, regardless of the amount of contaminant found in the individual waste streams. Costs have been estimated for several of the unit processes using cost curves and tables developed by Robert Gumerman. These particular unit process evaluations were developed for the United States Environmental Protection Agency (USEPA) for the purposes of judging the different processes with respect to drinking water treatment. Conventional treatment using package complete treatment plants is one of these unit processes. The costs associated with each unit process that has been evaluated in this manner can be broken down into eight separate components. These components and the cost indices corresponding to each component are listed in Table 8. The value of these indices at the time that the cost curves were developed and the value of the same indices at the present time form a ratio that allows the costs of each component to be updated to the present day. These ratios have been used to update the costs associated with conventional treatment utilizing package plants and PTA aeration of produced waters to remove volatile organic compounds.

The cost analysis has been completed for each of the unit processes that will be used to treat the produced waters with the exception of the desalination of the waters with TDS levels above 60,000 parts per million (ppm). The depth of analysis varies from process to process due to the availability of cost and performance information specific

to the treatment of these particular waste streams by the chosen processes. Reverse osmosis, for instance assumes that the waste waters require a standard pre-treatment for scale inhibition and membrane fouling regardless of the specific make up of each waste stream and the maintenance materials cost component is calculated without specifying a particular type of membrane to be used. This is because the equations used to calculate the R/O costs were developed from an aggregate analysis of the costs observed for several different types of membranes. The GAC analysis, on the other hand, is very exact because of the availability of the large amount of data available on the subject.

Planned Activities

Task 1. Planned activities for task 1 is to finalize the data analysis for the PED. Some coverages remain to be developed. These include floodplains and injection and abandoned wells. Using land use and soil type information in each county, SCS curve numbers will be developed and combined with mean annual precipitation to develop coverages of mean annual infiltration. These infiltration coverages will be combined with well completions for analyses.

Tasks 2 and 3. The estimations of costs for the treatment of the representative waste streams to various levels of cleanliness with respect to various waste stream constituents will be completed and evaluated. An in depth explanation of all of the choices made regarding the treatment of the produced waters will be presented as well as an interpretation of each of the cost curves. A set of graphs will be assembled relating treatment costs as they vary with unit process capacity and raw waste stream contaminant level for every unit process. The level of the contaminant or contaminants that will be removed by each of the unit processes will be the level that is used to make the graphs mentioned previously. A complete set of flow charts describing the calculations used to estimate the costs for every unit process will be assembled.

Summary

In summary, collection and analysis of data for the PED is still ongoing. Much of the data collection effort is complete and most of the data have been incorporated into the GIS. Correlation of well completions with a number of environmental characteristics of the eight counties in Texas was completed. Cost estimates for the treatment and disposal of residuals using reverse osmosis and package treatment plants have been developed.

Report Distribution List

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Pittsburgh, PA 15236-0940

References

None at this time.

Publications

A journal article is currently under preparation.

Table 1. Well Completions Relative to Landuse

Brazoria County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
13	Industrial	2	5	9	5	14	1	6
21	Cropland and Pasture	54	36	65	24	67	12	67
31	Herbaceous Rangeland	3	1	2				
41	Deciduous Forest	4	5	9				
42	Evergreen Forest	4	2	4			4	22
43	Mixed Forest	16	5	9	5	14		
52	Lake	1	1	2				
53	Reservoir	1			2	6		
62	Nonforested Wetland	9					1	6
Total Completions			55		36		18	

Ector County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
11	Residential	3	5	1	2	1	1	1
12	Commercial and Services	1	5	1	1	<1	1	1
13	Industrial	<1	2	1	2	1		
14	Transportation and Utilities	<1			1	<1	1	1
17	Other Urban	2	5	1	3	1	2	1
31	Herbaceous Rangeland	6	26	7	34	16	19	12
32	Shrub and Brush Rangeland	42	151	39	104	50	90	55
33	Mixed Rangeland	43	194	49	61	29	48	29
75	Quaries and Gravel Pits	<1	1	<1	1	<1	1	1
76	Transitional Area	1	3	1	1	<1	1	1
Total Completions			392		210		164	

Lee County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
12	Commercial and Services	<1					1	3
21	Cropland and Pasture	49	48	53	18	45	8	21
32	Shrub and Brush Rangeland	2	16	18	2	5	1	3
33	Mixed Rangeland	19	9	10	8	20	12	32
41	Deciduous Forest	27	18	20	12	30	16	42
Total Completions			91		40		38	

Moore County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
21	Cropland and Pasture	64	25	46	17	47	7	21
31	Herbaceous Rangeland	32	27	50	19	53	26	79
33	Mixed Rangeland	2	2	4				
Total Completions			54		36		33	

Table 1. Well Completions Relative to Landuse

Panola County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
11	Residential	<1			1	1	2	2
13	Industrial	<1			2	1		
21	Cropland and Pasture	29	8	15	51	27	41	33
24	Other Agricultural Land	<1			1	1		
32	Shrub and Brush Rangeland	<1	1	2	2	1	1	1
41	Deciduous Forest	10	4	8	13	7	10	8
42	Evergreen Forest	7	5	10	9	5	5	4
43	Mixed Forest	50	33	63	109	58	62	50
53	Reservoir	1					1	1
61	Forested Wetland	<1	1	2				
62	Nonforested Wetland	<1					1	1
Total Completions			52		188		123	

Pecos County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
13	Industrial	2	39	28	11	11	34	41
14	Transportation and Utilities	<1	1	1	1	1		
21	Cropland and Pasture	3	1	1	7	7	1	1
31	Herbaceous Rangeland	<1			1	1		
32	Shrub and Brush Rangeland	89	95	68	72	73	44	53
33	Mixed Rangeland	5	3	2	7	7	4	5
Total Completions			139		99		83	

Webb County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
11	Residential	<1					1	1
21	Cropland and Pasture	1	4	3	1	1	1	1
31	Herbaceous Rangeland	4	9	6			2	2
32	Shrub and Brush Rangeland	75	81	54	96	64	85	65
33	Mixed Rangeland	18	57	38	52	35	42	32
41	Deciduous Forest	<1			1	1		
Total Completions			151		150		131	

Wise County								
		% Total	1988		1990		1992	
LU-Code	Landuse	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
11	Residential	1					1	1
13	Industrial	<1					1	1
16	Mixed Urban	<1			1	1	2	2
21	Cropland and Pasture	40	49	51	40	38	28	33
31	Herbaceous Rangeland	11	11	11	10	9	5	6
32	Shrub and Brush Rangeland	1					7	8
33	Mixed Rangeland	30	20	21	40	38	26	31
41	Deciduous Forest	14	14	14	12	11	13	15
75	Quaries and Gravel Pits	1	1	1				
76	Transitional Area	<1	2	2	3	3	1	1
Total Completions			97		106		84	

Table 2. Well Completions Relatice to Proximity to Surface Water Bodies

Year	# Completions within given proximity				Total Completions	% Completions within given proximity			
	100 m	500 m	1000 m	1500 m		100 m	500 m	1000 m	1500 m
Brazoria County									
1988	14	35	50	53	55	25	64	91	96
1990	9	29	35	36	36	25	81	97	100
1992	3	13	17	18	18	17	72	94	100
Ector County									
1988	11	76	166	245	392	3	19	42	63
1990	8	32	80	123	210	4	15	38	59
1992	5	28	58	85	164	3	17	35	52
Lee County									
1988	4	40	80	89	91	4	44	88	98
1990	8	22	33	39	40	20	55	83	98
1992	6	24	35	37	38	16	63	92	97
Moore County									
1988	4	18	33	37	54	7	33	61	69
1990	0	4	15	28	36	0	11	42	78
1992	2	21	29	30	33	6	64	88	91
Panola County									
1988	6	23	40	49	52	12	44	77	94
1990	20	89	137	164	188	11	47	73	87
1992	16	59	92	112	123	13	48	75	91
Pecos County									
1988	7	35	64	83	139	5	25	46	60
1990	3	22	35	55	99	3	22	35	56
1992	4	21	43	61	83	5	25	52	73
Webb County									
1988	14	69	119	139	151	9	46	79	92
1990	16	66	114	131	150	11	44	76	87
1992	12	58	113	125	131	9	44	86	95
Wise County									
1988	22	70	95	96	97	23	72	98	99
1990	26	80	106	106	106	25	75	100	100
1992	10	57	81	84	84	12	68	96	100

Table 3. Well Completions Relative to Proximity to Water Supply Wells

Year	# Completions within given proximity				Total Completions	% Completions within given proximity			
	100 m	500 m	1000 m	1500 m		100 m	500 m	1000 m	1500 m
Brazoria County									
1988	1	12	26	39	55	2	22	47	71
1990	1	3	13	24	36	3	8	36	67
1992	0	2	9	12	18	0	11	50	67
Ector County									
1988	1	43	122	208	392	0	11	31	53
1990	0	5	23	64	210	0	2	11	30
1992	0	7	32	67	164	0	4	20	41
Lee County									
1988	0	4	10	28	91	0	4	11	31
1990	0	1	7	17	40	0	3	18	43
1992	0	0	3	14	38	0	0	8	37
Moore County									
1988	0	8	24	29	54	0	15	44	54
1990	0	6	11	15	36	0	17	31	42
1992	0	1	4	5	33	0	3	12	15
Panola County									
1988	0	1	7	8	52	0	2	13	15
1990	0	12	35	60	188	0	6	19	32
1992	0	4	22	35	123	0	3	18	28
Pecos County									
1988	0	6	22	39	139	0	4	16	28
1990	0	4	13	35	99	0	4	13	35
1992	0	0	7	11	83	0	0	8	13
Webb County									
1988	0	5	18	30	151	0	3	12	20
1990	2	3	5	14	150	1	2	3	9
1992	0	0	1	5	131	0	0	1	4
Wise County									
1988	0	4	13	26	97	0	4	13	27
1990	1	6	19	31	106	1	6	18	29
1992	0	7	16	30	84	0	8	19	36

Table 4. Well Completions Relative to Ground Water Usage

Use Code	Description	Water supply wells within 1 mile radius of all oil and gas well completions in the combined years 1988, 1990, and 1992															
		Brazoria County		Ector County		Lee County		Moore County		Panola County		Pecos County		Webb County		Wise County	
		# Wells	% of Total	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
C	commercial											1	1				
D	dewater							1	1								
H	domestic	16	13	38	11	28	35			13	19	7	10	14	32	39	38
I	irrigation	23	18	14	4	3	4	96	86	1	1	9	13	2	5	4	4
J	industrial-cooling							1	1								
N	industrial-unspecified	7	6	89	25			1	1	12	18	4	6	1	2	9	9
P	public supply	10	8	52	15	13	16	1	1	15	22	1	1	4	9	28	27
S	stock	9	7	86	24	14	18			1	1	12	17	12	27	1	1
T	institution													1	2	2	2
U	unused	61	48	36	10	2	3	11	10	23	34	20	28	7	16	20	19
Z	other							1	1								
	undefined	1	1	41	12	20	25			3	4	18	25	3	7		
Total water supply wells		127		356		80		112		68		72		44		103	

Table 5. Well Completions Relative to Freshwater Aquifer Regions

Brazoria County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Gulf Coast	outcrop	99	3200	55	100	36	100	17	94
Ector County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Ogallala	outcrop	23	200	87	22	44	21	40	24
Cenozoic Alluvium	outcrop	20	200	28	7	38	18	36	22
Edwards Trinity	outcrop	56		277	71	128	61	88	54
Edwards-Trinity	downdip	23	400	87	22	44	21	40	24
Dockum	downdip	100	1400	391	100	203	97	163	99
Lee County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Sparta	outcrop	13		1	1	0	0	0	0
Sparta	downdip	50	2000	88	97	40	100	36	95
Queen City	outcrop	10		2	2	0	0	1	3
Queen City	downdip	70	2000	89	98	40	100	37	97
Carrizo-Wilcox	outcrop	19		0	0	0	0	0	0
Carrizo-Wilcox	downdip	80	6000	91	100	40	100	38	100
Trinity	downdip	1	3500	0	0	0	0	0	0
Moore County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Ogallala	outcrop	93	400	50	93	35	97	27	82
Dockum	outcrop	1		0	0	0	0	0	0
Dockum	downdip	39	?	11	20	5	14	20	61
Panola County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Carrizo-Wilcox	outcrop	99		52	100	188	100	123	100
Carrizo-Wilcox	downdip	1	200	0	0	0	0	0	0
Pecos County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Cenozoic Alluvium	outcrop	21	200	26	19	41	41	15	18
Edwards Trinity	outcrop	72		109	78	54	55	65	78
Edwards-Trinity	downdip	14	400	7	5	23	23	10	12
Dockum	downdip	13	1000	4	3	9	9	5	6
Rustler	downdip	25	1500	18	13	16	16	24	29
Capitan	outcrop	12	3000	14	10	9	9	8	10
Webb County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Gulf Coast	outcrop	8	500	14	9	14	9	4	3
Carrizo-Wilcox	outcrop	1		0	0	0	0	0	0
Carrizo-Wilcox	downdip	54	6000	26	17	7	5	22	17
Wise County									
		% Total	Depth (ft below	1988		1990		1992	
Aquifer Formation 1	Occurance	Sfc. Area 2	land surface) 3	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
Trinity	outcrop	62		64	66	67	63	54	64
Trinity	downdip	26	300	17	18	27	25	14	17

Notes:

1) Aquifer formations are listed by increasing geologic age (i.e. increasing depth).
2) Percentage of total county surface area underlain by given aquifer formation.
3) Value given represents approximate depth to base of the aquifer formation or to the limit of usable water quality.

Table 6. Well Completions Relative to DRASTIC Regions

Brazoria County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79							
80	94							
95	109	44	28	51	25	69	8	44
110	124	47	22	40	8	22	8	44
125	139	9	5	9	3	8	2	11
140	154							
155								
Total Completions			55		36		18	

Ector County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79							
80	94	29	98	25	64	30	46	28
95	109	26	28	7	40	19	49	30
110	124	46	266	68	106	50	69	42
125	139							
140	154							
155								
Total Completions			392		210		164	

Lee County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79							
80	94	16.5	38	42	9	23	3	8
95	109	14	7	8	11	28	7	18
110	124	65	42	46	19	48	25	66
125	139							
140	154	5	4	4	1	3	3	8
155		<1	0	0	0	0	0	0
Total Completions			91		40		38	

Moore County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79	9	2	4	1	3	7	21
80	94	91	52	96	35	97	26	79
95	109							
110	124							
125	139							
140	154							
155								
Total Completions			54		36		33	

Table 6. Well Completions Relative to DRASTIC Regions

Panola County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79							
80	94							
95	109	56	19	37	110	59	96	78
110	124	21	11	21	36	19	8	7
125	139	23	22	42	42	22	19	15
140	154							
155								
Total Completions			52		188		123	

Pecos County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79	<1	0	0	0	0	0	0
80	94	14	5	4	5	5	1	1
95	109	82	130	94	88	89	79	95
110	124	4	1	1	0	0	0	0
125	139	1	3	2	6	6	3	4
140	154							
155								
Total Completions			139		99		83	

Webb County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64	1	1	1	3	2	2	2
65	79	65	78	52	77	51	69	53
80	94	29	52	34	63	42	55	42
95	109							
110	124	4	20	13	7	5	5	4
125	139							
140	154							
155								
Total Completions			151		150		131	

Wise County								
DRASTIC Index Range		% Total	1988		1990		1992	
Low	High	Area	# Wells	% of Total	# Wells	% of Total	# Wells	% of Total
	64							
65	79							
80	94							
95	109	100	97	100	106	100	84	100
110	124	<1	0	0	0	0	0	0
125	139							
140	154							
155								
Total Completions			97		106		84	

Table 7. Well Completions Relative to Parklands

County & Year	# Wells	Notes
Brazoria		
1988	1	San Bernard National Wildlife Refuge
1992	1	"
Ector	—	no parklands
Lee	0	
Moore	0	
Panola	—	no parklands
Pecos	—	no parklands
Webb	0	
Wise		
1988	1	Lyndon B Johnson National Grassland
1990	1	"
1992	2	"

Table 8. Cost Indices

COST COMPONENT	COST INDEX
Excavation and site work	ENR Skilled Labor Wage
Manufactured equipment	BLS General Purpose Machinery
Concrete	BLS Concrete Ingredients
Steel	BLS Steel Mill Products
Labor	ENR Skilled Labor Wage
Pipe and valves	BLS Valves and Fittings
Elec. equip. & instrumentation	BLS Electrical machinery
Housing	ENR Building

DATE
FILMED
10/18/94

END